City of Santa Clara
The Center of What's Possible

Planning Division

April 28, 2020

City of San José, Department of Planning, Building, and Code Enforcement
Attn: David Keyon, Environmental Project Planner
200 East Santa Clara Street, 3rd Floor Tower
San José CA 95113-1905

Re: Item 5.1, Mineta San José International Airport Master Plan Amendment. First Amendment to the Draft Environmental Impact Report for the Amendment to the Norman Y. Mineta San José International Airport Master Plan (PP 18-103)

Dear Mr. Keyon:

The City of Santa Clara has reviewed the Draft Environmental Impact Report and First Amendment to the Draft Environmental Impact Report (collectively, EIR) prepared for the Master Plan Amendment. Santa Clara has provided comments on both documents. We have also reviewed the transcript and audio/video recording of the March 11, 2020 Planning Commission hearing where those comments were discussed. We are providing additional comments regarding the following unresolved issues for your consideration.

Greenhouse Gas Emissions

Santa Clara appreciates that San José has committed to achieving Level 3+ Neutrality or its equivalent through implementation of mitigation measure GHG-1.1. However, Santa Clara notes Mitigation Measure GHG-1.1 no longer includes a requirement to publish an annual carbon footprint report, but a biennial report. Given that the first level of Airport Carbon Accreditation requires an annual carbon footprint report, and each subsequent accreditation level incorporates the prior levels' requirements, Santa Clara respectfully requests that Mitigation Measure GHG-1.1 be revised to include an annual reporting requirement as required by Airport Carbon Accreditation.

Hazards

Santa Clara has expressed concern regarding what entity is responsible for the increased 2 million gallons of fuel storage capacity and related Spill Prevention Control & Countermeasure (SPCC) Plan. This information is not provided in the EIR or clarified in the responses to comments. Santa Clara requests San José provide a clear response to this inquiry.

Transportation

San José continues to state transportation impacts need only be addressed by vehicle miles travelled (VMT). Although congestion is no longer a CEQA impact, San José is not absolved of the obligation to address the impact of increased congestion. San José's Transportation Analysis

Handbook and Valley Transportation Authority's Congestion Management Plan (CMP) Guidelines require study of CMP covered facilities and mitigation of impacts to covered facilities. The Transportation Impact Analysis (TIA) must identify the mitigation measures for which the project is responsible. Additionally, if a project causes an impact that cannot be mitigated to the CMP Auto LOS standard, a Deficiency Plan or "Multimodal Improvement Plan" must be prepared in addition to the TIA.

Our March 11, 2020 letter identified a number of impacts for which the mitigation measures or analysis required further clarification, but none has been provided. Therefore, Santa Clara reiterates its request that San José:

- Clarify what mitigation is intended for the Lafayette/Central Expressway intersection and explain what additional mitigation will be implemented if the planned mitigation measure/s are not adequate;
- Clarify whether full build-out of City Place is included in the Project's cumulative conditions analysis;
- Clarify what intersection improvements are intended or provide a Multimodal Improvement Plan for the De La Cruz and Central Expressway intersection; and
- Comment on the fact the EIR must include a mitigation measure requiring split phasing along Brokaw Road (at Coleman Avenue) to ensure consistency with the final EIR for the Gateway Crossing Project.

Noise

Santa Clara reiterates its concerns that the EIR fails to adequately analyze the potential for the Project to result in sleep disturbance and that the EIR should impose an absolute noise threshold. Santa Clara again retained Wilson Ihrig, and their analysis is attached to this letter.

1. **San Jose must consider sleep disturbance impacts.**

Throughout the administrative process, Santa Clara has raised the concern that the EIR fails to analyze the potential for the Project to impact sleep. San José failed to address this concern head on. It alleges that the CNEL measurement addresses this impact, but as explained below and in the Wilson Ihrig letter, it does not. San José also appears to take the position that it has complied with CEQA because, in assessing multiple noise metrics, it did all that CEQA requires. As discussed below, this approach evades CEQA's intent and is disingenuous because the additional metrics do nothing to analyze potential sleep impacts.

a. CEQA requires analysis of sleep disturbance.

In *Berkeley Keep Jets Over the Bay Committee v. Board of Port Commissioners* (2001) 91 Cal.App.4th 1344 (*Berkeley Keep Jets*), the court found that the noise analysis—which relied solely on CNEL—failed to provide information regarding the effect of the project on sleep. The court noted that CEQA provides the public a statutorily protected interest in quieter noise environments and mandates consideration of "*qualitative* factors as well as economic and technical factors." (*Id.* at pp. 1379-1380.) The court further explained that "the fact that

residential uses are considered compatible with a noise level of 65 decibels for purposes of land use planning is not determinative in setting a threshold of significance under CEQA." (*Id.* at p. 1381.) The court found that CEQA required the EIR to provide meaningful analysis of changes in noise levels due to increased nighttime flights and the impact on the community, including sleep disturbance—and that analysis of CNEL alone did not provide this information. (*Id.* at pp. 1381-1382.) Recently, *King & Gardiner Farms, LLC v. County of Kern* (2020) 45 Cal.App.5th 814 reaffirmed that noise analyses require consideration of qualitative factors, in addition to quantitative factors, and that agencies relying on a single quantitative metric do so at their own peril. (See *id.* at pp. 883, 893-894; see also *Mission Bay Alliance v. Office of Community Investment & Infrastructure* (2016) 6 Cal.App.5th 160, 195-196; *Taxpayers for Accountable School Bond Spending v. San Diego Unified School Dist.* (2013) 215 Cal.App.4th 1013, 1041.)

b. San José selected metrics that do not address the issue of whether the Project will result in significant sleep disturbance.

San José continues to allege the CNEL measurement addresses the issue of sleep disturbance because it weighs nighttime flights more heavily than daytime flights. However, CNEL is a measure of 24 hours; while it places greater significance on nighttime noise, it does not provide a picture of how nighttime noise specifically will change with and without Project conditions or how the Project will impact sleep disturbance. San José's analysis fails to connect the dots and explain how CNEL measurements capture whether sleep will be impacted. The Noise Study merely states the penalties included "*attempt* to account for increased human sensitivity to noise . . . where sleep is the most common activity." (*Ibid.*, emphasis added.) As stated in the EIR, only 1.84% of operations occurred during curfew hours in 2018. (DEIR, p. 264.) Therefore, it seems questionable whether this small percentage impacts the CNEL measurements in any meaningful way. However, even adding a few additional nighttime flights, particularly during curfew hours, could significantly impact sleep. As noted in the Wilson Ihrig letter, there will be an additional 14 nighttime flights per night in 2037, and based on information in the EIR, approximately 3 additional flights during curfew hours each night. The impacts of these flights on sleep disturbance must be analyzed but were not.

San José claims *Berkeley Keep Jets* does not apply because the agency there relied on CNEL alone. San José claims the EIR here is distinguishable because it provides supplemental metrics. In addition to CNEL, the EIR used time above and single-event noise level metrics to analyze noise impacts. San José's argument is disingenuous because the additional metrics do nothing to address sleep disturbance.

The time above analysis determines how many minutes per day the noise level will exceed 75 or 85 dBA at certain grid points. However, the EIR clearly states the time above analysis "is provided to indicate relative changes in the potential for *speech interference*." (DEIR, p. 276, emphasis added.) Therefore, this analysis provides no qualitative or quantitative assessment with respect to sleep disturbance. Also, the minutes per day analysis provides no information regarding nighttime changes (i.e., to what extent time above occurs at night). (DEIR, p. 278.) Further, because the DEIR ties the threshold of significance for time above to CNEL significance, it does not provide an independent metric.

Finally, with respect to single-event noise level (SEL) values, the EIR concludes there will be no change in SEL values as compared to existing/baseline conditions because the Project does not include any modifications to runway usage and/or flight tracks. By framing the threshold of significance in terms of unchanging SEL values, rather than in terms of the impact of an increased number of SEL events, the EIR continues to obscure any impact related to sleep disturbance. The Wilson Ihrig letter explains that nighttime flights could increase ten-fold without resulting in a change to the SEL because SEL "only considers the noise from aircraft one at a time." The Wilson Ihrig letter further explains that 7-13 percent of the population is estimated to be awoken by each single event noise (i.e., flight) and that there will be an increase in nighttime flights by 36 percent between 2018 and 2037. Additionally for every 2 people woken up, the sleep of 3 others will be disturbed, though they do not wake up. The impact of the additional nighttime flights on the portion of the population that will be woken up or have their sleep disturbed must be assessed. The Wilson Ihrig letter explains that SEL information can be used in an analysis that actually assesses sleep disturbance—but no such analysis was performed.

Because none of the metrics described above provide a picture of the potential of the Project to impact sleep, the EIR has failed to analyze impacts related to sleep disturbance. It is clear this is a major issue of concern given that it is raised in numerous comment letters. Rather than analyze the issue, San José improperly selected metrics and thresholds of significance that allowed it to skirt the issue.

2. San Jose should not rely exclusively on a relative CNEL threshold.

Santa Clara continues to have concerns that the EIR does not include an absolute noise threshold, above which any increase in noise will be deemed significant. During the Planning Commission meeting, John Hesler, of David J. Powers & Associates, Inc., incorrectly alleged the EIR contains an absolute noise threshold of 65 CNEL. In fact, the DEIR relies on a relative CNEL threshold of significance, which finds that a change in cumulative noise exposure in noise-sensitive areas where the existing/baseline noise exposure is 65 CNEL or greater is only considered significant if the Project results in a change in CNEL of 1.5 dB or greater. (DEIR, p. 276.) As discussed in Santa Clara's January 13, 2020 letter, this threshold of significance will allow cumulative noise levels to incrementally increase with each Master Plan Amendment, thereby eventually resulting in significant increases in noise levels but no mitigation obligations.

Further underscoring the fact that no "absolute" threshold exists, Table 4.13-9 demonstrates that the Project will increase noise levels at areas within the 65 CNEL contour, but such impacts are not determined to be significant. (DEIR, p. 280.) Table 4.13-9 also shows that Washington School will change from 64.5 dB to 65.6 dB due to the Project. Likewise, this impact is not deemed significant, despite increased noise levels above 65 dB. (*Ibid.*) Thus, there is no absolute threshold applied at 65 dB.

Mr. Hesler also alleged during the Planning Commission meeting that any sensitive uses that fall within the future 65 CNEL will be treated. We are unable to find any support for this assertion in the EIR. Rather, the EIR and Noise Study note that the Acoustical Treatment Program concluded in 2009. Please confirm that treatment for any sensitive uses that fall within the future 65 CNEL will be an enforceable requirement.

* * * * *

Thank you for your consideration of and attention to the City of Santa Clara's comments on the EIR for the Airport Master Plan Amendment.

Sincerely,

FOR Andrew Crabtree
Director of Community Development

cc: Brian Doyle, City Attorney, City of Santa Clara
Deanna Santana, City Manager, City of Santa Clara
Manuel Pineda, Assistant City Manager, City of Santa Clara

WILSON IHRIG
ACOUSTICS, NOISE & VIBRATION

CALIFORNIA
WASHINGTON
NEW YORK

WI #19-108

27 April 2020

Mr. Andrew Crabtree
Community Development Director
City of Santa Clara
1500 Warburton Avenue
Santa Clara, CA 95050

Subject: Amendment to Norman Y. Mineta San José International Airport Master Plan
First Amendment to the Draft Environmental Impact Report
City of San José PP 18-103, SCH #2018102020
Comments Statements at 3/11/20 Planning Commission Meeting - Noise

Dear Mr. Crabtree,

In January, we reviewed and assisted you in commenting on the following documents pertaining to the *Amendment to Norman Y. Mineta San José International Airport Master Plan Draft Environmental Impact Report*:

1. *Amendment to Norman Y. Mineta San José International Airport Master Plan Draft Environmental Impact Report*
   City of San José PP 18-103, SCH #2018102020, November 2019 ("DEIR")

2. *Norman Y. Mineta San José International Airport Noise Assessment for the Master Plan Environmental Impact Report*
   October 2019 ("Noise Assessment")

In February, the City of San José released the following which contains responses to the comments made on the DEIR:

3. *Amendment to Norman Y. Mineta San José International Airport Master Plan First Amendment to the Draft Environmental Impact Report*
   City of San José PP 18-103, SCH #2018102020, February 2020 ("First Amendment")

On March 10th, we provided comments on some of the responses in the *First Amendment* to our DEIR noise comments. The issues we raised in our March 10th letter were addressed orally at the City of San José Planning Commission Meeting the following day, March 11th, by one of the preparers of the

DEIR. This letter provides commentary on the statements addressing issues raised by the City of Santa Clara about the noise analysis. To do this, we have reviewed both an audio/visual recording of the meeting and a transcript of the same provided by the firm that provides closed captioning services to the City of San José. The cover to the transcript notes that it is not an official record of the meeting, and, in fact, it contains numerous incorrect transliterations. Whenever quoted below, the quotes are based on the audio/visual recording, not the transcript, and represent the exact words spoken to the best of my ability. The audio/visual recording was accessed through this hyperlink:

4. https://www.youtube.com/watch?v=fyZv0hLlwxc

1 CNEL Inadequate Metric to Assess Effect of Nighttime Flights on Sleep Disturbance

In contending that the DEIR does address sleep disturbance, the speaker stated,

> The first thing is that Santa Clara contended that the use of the CNEL . . . fails to address the impact of noise from nighttime flights on sleep disturbance. The CNEL does, in fact, address this issue because each flight that occurs at the airport between 7:00 pm and 10:00 pm is counted as three flights, and each flight to and from the airport that occurs between 10:00 pm and 7:00 am is counted as if 10 flights had occurred, and that weighting is purposely done recognizing that flights that occurred during those hours have a much greater potential to cause sleep disturbance. So, that is built right into the CNEL.

While the speaker does correctly state the mathematics of CNEL calculation and is correct that the weighting is intended to reflect the higher sensitivity that the population has to nighttime noise, the point of his argument – that relying on the CNEL to assess the potential for sleep disturbance is justified because of the nighttime weighting – is expressly what the court held is <u>inadequate</u> for the purpose of analyzing and assessing noise from nighttime aircraft operations:

> The environmental impact report (EIR) for an airport expansion failed to address adequately the potential disturbance to area residents resulting from increased nighttime air cargo operations and <u>should not have relied exclusively on the Community Noise Equivalent Level (CNEL)</u> regardless of the change in noise to quiet neighborhoods; the EIR contained no quantitative discussion of ambient noise levels in any nearby community and <u>no meaningful analysis of noise levels over and above the existing ambient noise level at a given location and the community reaction to aircraft noise, including sleep disturbance, and the probability of being repeatedly awakened by multiple single-event sounds</u> that could be calculated.[1] [Emphasis added.]

As the cited court opinion states and we have stated previously, the calculations and analysis being requested are fairly straightforward, especially given that the noise insulation characteristics of many Santa Clara residences are known to the airport because they have been acoustically insulated

[1] *Berkeley Keep Jets Over the Bay Com. v. Board of Port Cmrs.* (2001) 91 Cal.App.4th 1344, 111 Cal.Rptr.2d 598.

through the airport's Acoustical Treatment (ACT) Program. [DEIR at p 265; First Amendment at p. 29.]

2 Other Metrics Not Used to Assess Sleep Disturbance

The speaker countered the comment that the DEIR relied solely upon the CNEL to assess sleep disturbance by stating the following:

> There is another statement in the letter from Santa Clara that the noise analysis relied solely on the CNEL in terms of what is significant and what is not. They pointed out to a court case that occurred in 1991 [sic] called *Berkeley Keep Jets Over the Bay*. It was a CEQA case where the court found that the use of CNEL alone was insufficient to tell the whole story about noise impacts. But in this case, in this EIR we did not rely solely on the CNEL. We, in fact, used supplemental metrics including what they call the *Time Above* - how many minutes per day the noise is above a certain level. That's a nice indicator of things going up and down. We also looked at the Single Event Noise Level.

With respect to the Time Above metric, the DEIR states:

> Time Above: A time above (TA) analysis is provided to indicate relative changes in the potential for speech interference. . . . There are no generally recognized or officially adopted significance criteria for this descriptor. However, as discussed below, the analysis for this EIR shows that at the Airport, and for the analyzed Project, there is a significant correlation between the magnitude of the predicted CNEL increases or decreases at the reference grid locations and the relative magnitude of the predicted TA increases or decreases at the same locations. Therefore, for purposes of this EIR the determination of significance with respect to CNEL values will be considered a determination of significance for the TA analysis. [DEIR at p. 276.]

The TA metric may not be claimed to supplement the CNEL analysis with respect to sleep disturbance because (i) it is purportedly included to analyze speech interference, not sleep disturbance, (ii) the DEIR states that there is no recognized threshold of significance for any assessment, and (iii) the DEIR expressly equates TA significance with CNEL significance, so it is not used as an independent metric. Additionally, the Time Above analysis results that are presented in Table 4.13-10 of the DEIR do not differentiate between daytime and nighttime hours. The Time Above analysis was not used in any way to assess the impact of additional nighttime flights on sleep disturbance.

With respect to the Single Event Noise Level (SEL), the analysis in the DEIR only considers whether or not SEL levels in the area would change as a result of the project. It concludes that they would not because ". . . the Project does not include any modifications to runway usage and/or flight tracks." [DEIR at p. 278.] This would be true even if the number of nighttime flights were to increase ten-fold because, as the "Single Event Level" name captures, it only considers the noise from aircraft one at a time.

A 1994 research paper entitled *Community Annoyance and Sleep Disturbance: Updated Criteria for Assessing the Impacts of General Transportation Noise on People* concluded:

> According to most published studies and the 1992 report of the Federal Interagency Committee on Noise, day–night average sound level is still considered the most adequate noise descriptor for use in environmental impact analyses to assess the overall impact of noise from general transportation, including civilian and military aircraft operations. Until additional data become available, the new USAF logistic curve presented in [this paper] is recommended for use in environmental impact analyses as the nominal relationship between the day–night average sound level of environmental (general transportation) noise and the percentage highly annoyed of a residential population.
>
> The 10-dB nighttime penalty levied against sounds during the hours from 22.00 to 07.00 is specifically intended to account for the intrusiveness of nighttime noise and its potential for disturbing sleep. However, flight operations with a large number of nighttime noise events may require that supplemental information, such as an estimate of sleep disturbance, be included in environmental impact analyses. Under those circumstances, the relationship presented in [this paper] is recommended until appropriate field research requires and supports a change.[2] [emphasis added]

The "relationship" referred to in the last sentence is a mathematical function that indicates the percentage of the population that is awoken for indoor SEL levels between 25 and 105 dBA. Using the number of Commercial Airline operations for 2018 and 2037 presented in Table 3.2-3 of the DEIR and the SEL information for assessment site "RMS 10 – Residential, Santa Clara" in Table 14 of Appendix J (Noise Assessment, p. 26), one may estimate that the aircraft-weighted average outdoor SEL is 88.7 dBA. To estimate the indoor level, one may use the average house noise reduction recommended by the E.P.A. of 27 dBA (windows closed). This yields an indoor estimate of 62 dBA. However, the DEIR notes that City of San José sponsored an Acoustical Treatment Program for many residences and schools affected by operations at Mineta Airport from 1993 to 2009. The DEIR does not say how much the noise reduction was increased (this would be difficult because it would vary by area), but for the RMS-10 location let's conservatively assume it was 10 dB. With this level in insulation, the indoor SEL would be 52 dBA. Using the relation for percent awakening in the Finegold paper for the SEL range of 52 to 62 dBA indicates that 7% to 13% of the population will be woken.

Using the number of Commercial Airline operations for 2018 and 2037 presented in Table 3.2-3 of the DEIR and the distribution of flights during the day, evening, and night given in Appendix J (Noise Assessment, p. 18), one may estimate that there are currently 37 nighttime operations now, and there will be 51 nighttime operations in the future. This is an increase of 14 flights or 36%. For the 7% to 13% of the population that is awoken, this should be assessed for significance.

Finally, other data presented in the Finegold paper indicates that for every 2 people that awake, there are 3 people whose sleep is disturbed by arousal, though they do not actually awake.

In conclusion on this point, the Finegold paper presents that type of research that could be used to truly assess sleep disturbance using SEL information presented in the DEIR taking into account the

[2] Lawrence S. Finegold, C. Stanley Harris, and Henning E. von Gierke, "Community Annoyance and Sleep Disturbance: Updated Criteria for Assessing the Impacts of General Transportation Noise on People", Noise Control Eng. J. 42 (1), 1994 Jan–Feb.

increased number of nighttime operations. In contrast, the SEL analysis presented in the DEIR must necessarily conclude by virtue of its logical form alone that any increase in nighttime operations could not cause a sleep disturbance impact. This is at odds with both the intent and the letter of the *Berkeley Keep Jets Over the Bay* ruling.

3 Additional Comments on Sleep Disturbance

The DEIR only contains the compound noun "sleep disturbance" three times: Once when describing the Lmax metric [DEIR at p. 254], once making the argument that the CNEL is adequate for assessing sleep disturbance [DEIR at p. 255], and once when discussing the Airport Noise Control Program that was adopted in 1984 [DEIR at p. 262]. Nowhere is the propensity for increased nighttime aircraft operations to cause sleep disturbance explicitly considered as the City of Santa Clara has requested.

Interestingly, when describing the Lmax descriptor, the DEIR states ". . . when used with other information presented in this EIR, [the Lmax] is particularly useful in assessing the potential for noise-caused interference with speech communications [and] the potential for sleep disturbance." [DEIR at p. 254]. Unfortunately, the DEIR did not use the Lmax in conjunction with other information to assess sleep disturbance.

* * * * *

Please contact us if you have any questions on the above regarding the DEIR, Noise Assessment, and First Amendment, as well as the responses to our March 10th letter during the March 11th Planning Commission Meeting.

Very truly yours,
WILSON IHRIG

Derek L. Watry
Principal

mineta sjia mp deir - noise - comments plng comm mtg - wilson ihrig.docx

Community Annoyance and Sleep Disturbance: Updated Criteria for Assessing the Impacts of General Transportation Noise on People

Lawrence S. Finegold, C. Stanley Harris, and Henning E. von Gierke[a)]

(Received 1993 November 22; revised 1993 November 26)

The question of prediction of sleep disturbance and annoyance due to transportation noise has been addressed. Two sets of previously published data have been reanalyzed. This project was initiated as part of a long-term U.S. Air Force research program on the effects of aircraft noise on humans. It is concluded that day–night average sound level is still the most adequate noise descriptor for use in environmental impact analyses to assess the annoyance and overall impact of noise from general transportation, including civilian and military aircraft operations. A new logistic curve adopted in 1992 for general use by U.S. federal agencies, is recommended for use in environmental impact statements as the nominal relationship between day–night average sound level and the percent age of a general residential population predicted to be highly annoyed by the noise. A power curve, using A-weighted sound exposure level, is recommended for predicting nighttime sleep disturbance from general transportation noise.

Primary subject classification: 66.1, Secondary subject classification: 68.3

1. Introduction

Technical justifications are presented for two exposure-response relationships for predicting the percentage of a population expected to be highly annoyed (%HA) as a result of transportation noise and for predicting sleep disturbance in response to transportation noise. The two exposure-response curves were adopted in 1992 by the Federal Interagency Committee on Noise[1] (FICON) for use by federal agencies in aircraft noise-related environmental impact analyses and are recommended for prediction of the effects of general transportation noise on people. The curves were described previously in general form[2–4] and have already been used in Environmental Impact Statements.[5] The recommendations in this paper are based on reanalyses of two sets of previously published data. For predicting annoyance, a slightly different approach is taken to the analysis of new data added to the data used to develop the original 1978 Schultz curve[6] in contrast to the approach used for the analysis reported by Fidell *et al.*[7,8] A brief discussion of aircraft noise effects versus the effects of other general transportation noises is also included. Finally, a recommendation is presented for predicting nighttime sleep disturbance for cases where specific situations merit additional environmental impact analysis beyond the prediction of overall community annoyance. The recommended sleep disturbance curve is based on a reanalysis of the percentage of expected awakenings versus A-weighted sound exposure level (SEL) data from the 1989 Pearsons *et al.* review.[9] The curves discussed here are recommended for predicting community annoyance and sleep disturbance in environmental impact assessments of the effects of general transportation noise, particularly aircraft noise, until a sufficient quantity of new data is available to warrant a reexamination of the curves.

2. Background

In the United States, the National Environmental Policy Act (NEPA) requires the use of the best available prediction models in environmental analyses, such as Environmental Impact Statements, to assess health, welfare, and other potential impacts from noise exposure and for land-use management and planning recommendations. Since the U.S. Environmental Protection Agency "Levels Document"[10] and related publications,[11–15] the day–night average sound level (DNL) and an exposure-effect relationship for the percentage of a population reporting in social surveys to be "highly annoyed" by general transportation noise has generally been accepted as the best overall indicator of the impact of environmental noise in residential communities. Early versions of this relationship were superseded by the now-classical analysis in 1978 by Schultz[6] of 12 major social surveys of community annoyance due to transportation noise. Notwithstanding the methodological questions, data interpretation differences, and the problem of community reponse bias, the Schultz synthesis of the social survey results prior to 1978 has been used worldwide as the nominal response curve for characterizing the average community response to environmental (i.e., general transportation) noise. Because the original Schultz curve was published in 1978, a project was initiated to revisit the Schultz curve and determine if that exposure-response relationship should be updated on the basis of additional data from new, techni-

[a)] *Lawrence S. Finegold is a Research Psychologist with the U.S. Air Force Armstrong Laboratory, Wright-Patterson Air Force Base, Ohio 45433-7901. His particular areas of interest are community annoyance, sleep disturbance, and human health effects.*

C. Stanley Harris recently retired after 30 years as a Research Psychologist in the U. S. Air Force Armstrong Laboratory. During this time, he published over 75 articles, including research on the vestibular system, task performance under noise, infrasound, vibration, and community annoyance.

Henning E. von Gierke retired in 1988 as the director of the Biodynamics and Bioengineering Division of the U.S. Air Force Aerospace Medical Research Laboratory. He provided national and international leadership for research and standards activities relating to the effects of noise on people.

© 1994 Institute of Noise Control Engineering

cally improved community annoyance studies. This project was initiated as part of the long-term U.S. Air Force (USAF) research program on the effects of aircraft noise on humans.[3,16]

Sleep disturbance is not routinely included as a separate environmental effect in noise impact analyses because the 10-dB nighttime penalty levied against sounds during the hours from 22.00 to 07.00 was specifically intended to account for the intrusiveness of noise during those normal sleeping hours and the potential of intrusive noise to disturb sleep. However, sleep disturbance is addressed when warranted by the circumstances of planned environmental actions, as a supplement to the predicted degree of population annoyance. However, there has been no accepted exposure-response relationship for predicting sleep disturbance in response to general transportation noise that adequately reflects the data obtained from laboratory and field studies. In response to this need, published research data on the relationship between environmental noise and sleep disturbance were examined to determine if an appropriate exposure-response relationship could be developed. Although the curves resulting from these analyses were included in the FICON report[1] and quoted in other publications,[2–4] publication of the justification for the algorithms and the shape of the curves is presented here for the first time.

3. Community Annoyance in Response to General Transportation Noise

Detailed results of the major community annoyance database update sponsored by the USAF Armstrong Laboratory are summarized here in a slightly different manner than in Refs. 7 and 8. A somewhat different relationship is proposed for practical use in environmental noise impact analyses. As reported by Fidell *et al.*,[7,8] an additional 292 data points from 11 social surveys (13 data sets) published since 1978 and the four "addenda" studies from Schultz were added to the original Schultz 161 exposure-reponse data points, for a new total of 453 data points. The additional data resulted in nearly tripling the size of the database for predicting annoyance due to general transportation noise exposure.

Fidell *et al.* used five screening criteria for deciding which data to include in their analysis. An additional criterion, not used by those authors, is proposed here: namely, whether or not a significant correlation exists between the day–night average sound levels and the related population

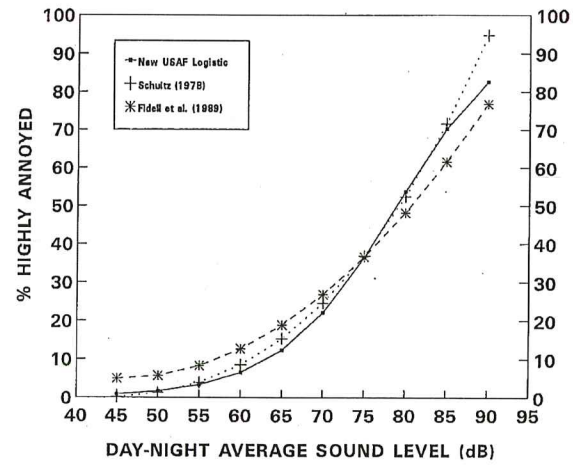

Fig. 1 – New USAF logistic curve (400 data points), Schultz (Ref. 6) third-order polynomial (161 data points) and Fidell et al. *(Refs. 7 and 8) quadratic curve (453 data points).*

annoyance ratings. Using this additional criterion, we reanalyzed the Fidell *et al.* data. The result was that six data sets (from five separate studies) were excluded because they did not show a significant correlation between day–night average sound level and the percentage of the population reporting to be highly annoyed (%HA). This exclusion resulted in a loss of 53 data points (12% of the original data points), leaving 400 data points as the new total. Data sets excluded from the Fidell *et al.* data are listed in Table 1.

The second issue concerns the choice of an algorithm to describe the relationship between day–night average sound level and population annoyance. The 1978 Schultz curve used a third-order polynomial for the original 161 data points. Fidell *et al.* identified the following quadratic fit as being the most parsimonious equation, based on the full 453 data points:

$$\%\mathrm{HA}=78.9181-3.2645\,L_{\mathrm{dn}}+0.0360\,L_{\mathrm{dn}}^{2}. \qquad (1)$$

This article recommends the following logistic fit as the prediction curve of choice, based on the final 400 data points:

$$\%\mathrm{HA}=100/[1+\exp(11.13-0.14\,L_{\mathrm{dn}})]. \qquad (2)$$

The original Schultz curve (third-order polynomial—161 data points), the Fidell *et al.* curve (quadratic—453

TABLE 1 – Data sets with nonsignificant correlations between day–night average sound level and annoyance [from Fidell *et al.* (Refs. 7 and 8)].

Study	Correlation coefficient (Pearson r)	r^2	Number of data points	Probability level
Hall, aircraft only (1977)	0.586	0.343	9	>0.05
Rylander, traffic only (1977)	0.556	0.309	6	>0.05
Rylander, tramway only (1977)	0.454	0.206	6	>0.05
Decatur Airport (1983)	0.894	0.799	4	>0.05
Burbank Airport (1985)	−0.142	0.020	20	>0.05
Westchester Airport (1985)	0.246	0.061	8	>0.05

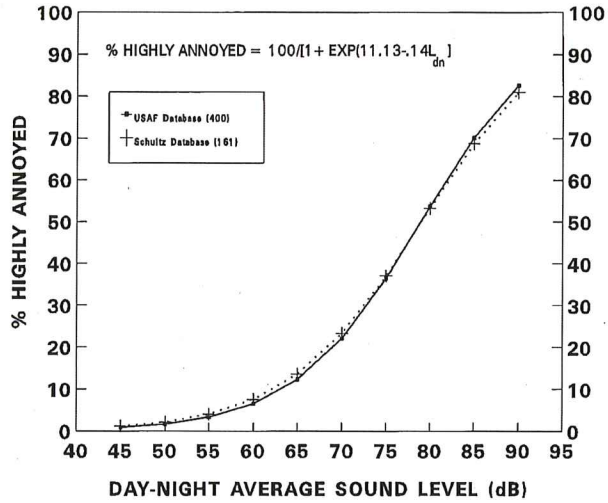

Fig. 2 – Logistic fit to 400 community annoyance social survey data points and 1978 Schultz (Ref. 6) curve.

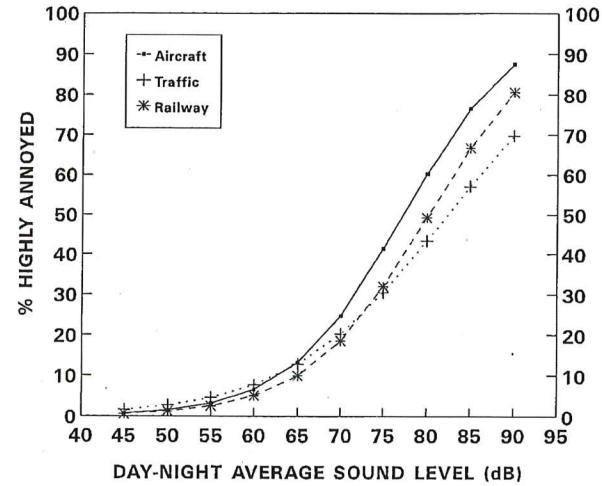

Fig. 3 – % highly annoyed vs DNL from aircraft, road traffic, and railway noise, based on data from Fidell et al. *(Refs. 7 and 8).*

data points) and the USAF updated community annoyance curve (logistic—400 data points), according to Eq. (2), are presented in Fig. 1. Figure 2 shows the logistic curve for the USAF 400 data-point set along with a logistic fit to the original Schultz database. None of these curves differ significantly from each other. However, the new USAF logistic fit, Eq. (2), is preferred because (1) it gives the same predictive utility as both the original Schultz curve and the Fidell *et al.* curve; (2) it allows the prediction of annoyance to approach but not reach 0% or 100%; (3) it approaches a 0% community annoyance prediction at a day–night average sound level of approximately 40 dB, rather than having the anomaly of showing an increase in annoyance at day–night average sound levels less than 45 dB like the Fidell *et al.* curve; (4) the use of a logistic function has a history of success in federal environmental impact analyses for over a decade; and (5) it is based on the most defensible social survey database.

Additionally, use of a logistic function was endorsed by the Committee on Hearing, Bioacoustics and Biomechanics (CHABA) of the National Academy of Sciences.[17] In the opinion of the authors, these advantages make the logistic function the algorithm of choice. The effort to develop a revised community annoyance prediction curve based on a considerably expanded database has validated the general approach which has been used since 1978. With the new curve presented here [Eq. (2) and Fig. 2], there will be even more support for the ability to predict annoyance due to general transportation noise, including noise from aircraft overflights.

4. Aircraft Noise Versus Other Transportation Noise Sources

Virtually all community noise impact analyses based on self-reports of annoyance since the late 1970s have been based on a combination of aircraft and other general transportation noise sources.[15] However, since Schultz published his exposure-response relationship in 1978, controversy has continued over whether all types of transportation noise should be combined under the rubric of "general transportation noise." Many researchers see evidence that aircraft noise is rated as being more annoying than other types of transportation noise, such as railroad and highway noise.

As has been pointed out elsewhere,[18–22] some of the differences observed in published social surveys of population annoyance in response to aircraft noise versus other types of transportation noise sources could be due to methodological differences in the studies, variability in the criterion for reporting high annoyance, community response biases, and because the acoustical measurements were seldom reported with the desired accuracy. One reason why it is difficult to compare published data on human responses to noise exposure levels from various sound sources is that there are, typically, large differences in sound exposure for living and sleeping areas in a home from aircraft overflight noise compared with the sound exposure from road traffic noise. Noise from an aircraft overflight virtually surrounds a home, entering the living and sleeping areas through the roof and two or more sides of the dwelling, while street traffic noise enters predominantly through only one or two sides of the dwelling. This difference in sound exposure within a home is, typically, not accounted for, or discussed, in social surveys when researchers estimate the noise exposure of subjects.

The analysis by Miedema[23] of data recompiled from selected social surveys shows a higher level of community annoyance in response to aircraft noise than to noise from ground transportation sources. Miedema chose to use separate curves for aircraft, highway, road traffic, and rail noise. The considerably expanded database developed by Fidell *et al.* also provides evidence that there is a slightly stronger annoyance reaction to aircraft noise than to other transportation noise sources. In the analysis reported here of that database, for the 400 final data points from a total of 22 different international community annoyance surveys, 173

data points were for aircraft noise, 170 were for traffic noise, and 57 were for railway noise. Figure 3 shows logistic fits to each of the three data sets. As can be seen from this figure, the percent highly annoyed for traffic and railway noise is not as high as the percent highly annoyed predicted for aircraft noise at the higher values of day–night average sound level. However, these differences must be viewed with caution because of the relatively few data points available at the higher day–night average sound levels for the traffic and railroad conditions. The magnitude of the difference in annoyance in response to the three different transportation noise sources should be addressed in future annoyance studies.

5. Sleep Disturbance Due to General Transportation Noise

The details of the sleep disturbance review, also sponsored by the USAF Armstrong Laboratory, have been reported by Pearsons *et al.*[9] The Pearsons *et al.* report, which included a discussion of relevant noise exposure descriptors and dependent variables for measuring sleep disturbance, reassessed the data presented in two previous reviews by Lucas[24] and Griefahn,[25] plus seven additional studies. In all, data were examined for 21 original sleep disturbance studies from a total of 53 studies considered.

Pearsons *et al.* concluded that there was too great a difference in the results of published laboratory versus field sleep disturbance studies to warrant determination of a curve to relate aircraft noise to behavioral awakening. They identified several concerns about the use of existing data for predicting sleep disturbance. The present authors agree with the concerns of Pearsons *et al.*; however, a practical (interim) sleep disturbance curve is sometimes needed for compliance with the requirements of NEPA. Therefore, a further analysis of the Pearsons *et al.* data seemed appropriate. In addition to the analysis presented here, and in response to the concerns discussed by Pearsons *et al.*, the USAF is currently sponsoring additional field studies of sleep disturbance as a consequence of nighttime aircraft operations.[16,26]

In the reanalysis presented here of the Pearsons *et al.* data, the following analytical approach was taken: given the highly variable and incomplete databases described in their review, the published values for both laboratory and field study data were averaged within 5-dB intervals to reduce the variability. The data were grouped both because of the variability within the data set and, more importantly, because the number of data points differred greatly as a function of sound exposure level. There were far fewer data points at the higher sound exposure levels than at the lower ones. Any regression based on the actual data points would be biased by the large number of points at the lower sound exposure levels. By averaging the percentage of awakenings in 5-dB intervals across the range of sound exposure levels from approximately 30 to 110 dB, each class interval was given equal weight regardless of the number of data points in the interval. If the data had been evenly distributed across the whole range of sound exposure levels, then this grouping by class interval would produce results very

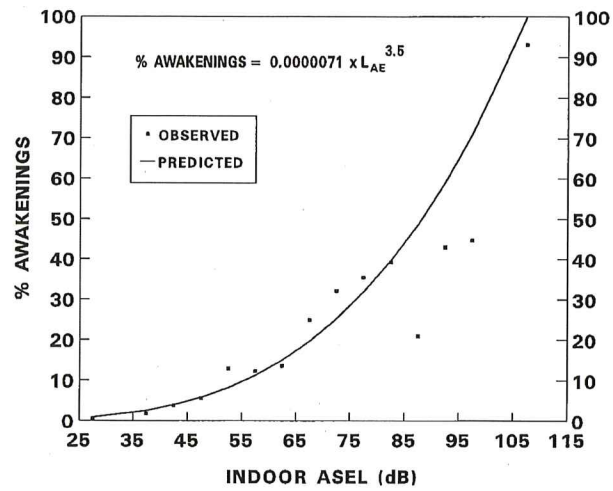

Fig. 4 – Proposed sleep disturbance curve based on data from Pearsons et al. *(Ref. 9); percent awakenings vs indoor A-weighted sound exposure level (ASEL).*

similar to that obtained by using the individual sound exposure levels.

There were 17 intervals in the Pearsons *et al.* database, but two intervals had zero cases. Therefore, the regression fit was conducted on the 15 remaining sound exposure level intervals versus the mean percentage of awakenings in the particular interval. The result of this analysis was the following expression, also shown graphically in Fig. 4:

$$\% \text{ Awakenings} = 7.1 \times 10^{-6}\ L_{AE}^{3.5}, \qquad (3)$$

where L_{AE} is indoor A-weighted sound exposure level.

A recent sleep disturbance field study around the four largest British airports,[27–29] published after the Pearsons *et al.* review,[9] included outdoor noise measurements and collection of in-home sleep disturbance data. The main conclusion reported by Ollerhead *et al.* was that "...below outdoor event levels (i.e., A-weighted sound exposure levels, Ed.) of 90 dB (corresponding approximately to maximum A-weighted sound levels of 80 dB, Ed.), aircraft noise events are most unlikely to cause any measurable increase in the overall rates of sleep disturbance experienced during normal sleep." The results of the UK study indicated that there is probably only a very low level of nighttime sleep disturbance associated with airport operations and agreed closely with the field study data reviewed in the Pearsons *et al.* study. Figure 5 shows the relationship between sleep disturbance and outdoor aircraft A-weighted sound exposure levels from the UK study reports.[27–29] Note that the dependent variable is percent "arousal rate," not actual awakenings, and that only some percentage of arousals result in awakenings. Ollerhead *et al.*[28] used 40% (within a 10% confidence interval) as their awakening-to-arousal ratio. In view of the UK field study results, the curve presented here may overestimate the probability of nighttime sleep disturbance, possibly because of the inclusion of data from both laboratory and field studies in the Pearsons *et al.* review in the present analysis. The Ollerhead *et al.*[28,29] results appear quite similar to the data from the few field studies described in the Pearsons *et al.* report.

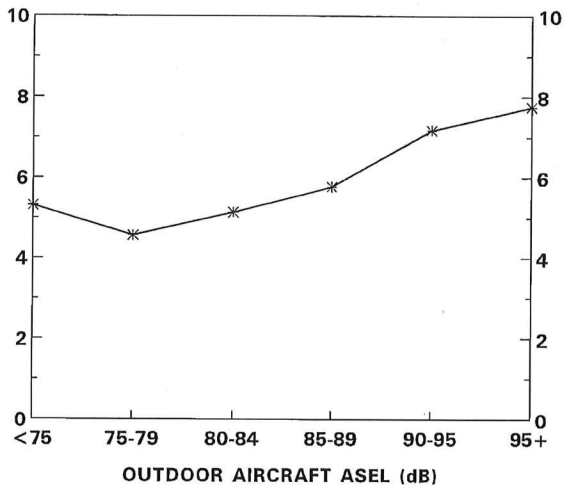

Fig. 5 – Relationship between sleep disturbance (arousal rate) and outdoor aircraft sound exposure levels from UK CAA field study (Ref. 28).

The curve presented in Fig. 4 is proposed for use in environmental impact analyses[1,2] until sufficient data from additional field studies are available. Of course, outdoor sound exposure levels must be translated into indoor sound exposure levels to apply the curve in Fig. 4, either by applying the actual noise reduction of the building structure(s) or by applying the average house noise reduction recommended by the Environmental Protection Agency for typical U.S. construction: 17 dB for windows-opened conditions and 27 dB for windows-closed conditions.[10]

6. Conclusions

According to most published studies and the 1992 report of the Federal Interagency Committee on Noise, day–night average sound level is still considered the most adequate noise descriptor for use in environmental impact analyses to assess the overall impact of noise from general transportation, including civilian and military aircraft operations. Until additional data become available, the new USAF logistic curve presented in Eq. (2) and Fig. 2 is recommended for use in environmental impact analyses as the nominal relationship between the day–night average sound level of environmental (general transportation) noise and the percentage highly annoyed of a residential population.

The 10-dB nighttime penalty levied against sounds during the hours from 22.00 to 07.00 is specifically intended to account for the intrusiveness of nighttime noise and its potential for disturbing sleep. However, flight operations with a large number of nighttime noise events may require that supplemental information, such as an estimate of sleep disturbance, be included in environmental impact analyses. Under those circumstances, the relationship presented in Eq. (3) and Fig. 4 is recommended until appropriate field research requires and supports a change.

7. References

[1] Federal Interagency Committee on Noise (FICON), "Federal agency review of selected airport noise analysis issues," Spectrum Sciences and Software, Inc., Fort Walton Beach, FL (Aug., 1992).

[2] Henning E. von Gierke and Kenneth McK. Eldred, "Effects of noise on people," Noise/News International **1**, 67–89 (June, 1993).

[3] Lawrence S. Finegold, "U.S. Air Force research program on the effects of aircraft noise on humans: Current status and future directions," in *Proceedings of Noise & Man '93*, edited by M. Vallet (L'Institut National de Recherche sur les Transports et leur Sécurité, Arcueil, France, 1993), Vol. 2, pp. 229–231 (July, 1993).

[4] Lawrence S. Finegold, "Current status of sleep disturbance research and development of a criterion for aircraft noise exposure," J. Acoust. Soc. Am. **94**, Pt.2, 1807 (1993).

[5] U.S. Department of Defense (DoD), Department of the Air Force, "Draft supplemental Environmental Impact Statement: Military and civil aircraft operations at Westover Air Reserve Base, Massachusetts," U.S. DoD, U. S. Air Force and Spectrum Sciences and Software, Inc., Robbins AFB, GA (1993).

[6] Theodore J. Schultz, "Synthesis of social surveys on noise annoyance," J. Acoust. Soc. Am. **64**, 377–405 (August, 1978).

[7] Sanford Fidell, David S. Barber, and Theodore J. Schultz, "Updating a dosage-effect relationship for the prevalence of annoyance due to general transportation noise" (Technical Report HSD-TR-89-009) Human System Division (HSD/YAH), U.S. Air Force Systems Command, Brooks AFB, TX (December, 1989).

[8] Sanford Fidell, David S. Barber, and Theodore J. Schultz, "Updating a dosage-effect relationship for the prevalence of annoyance due to general transportation noise," J. Acoust. Soc. Am. **89**, 221–233 (January, 1991).

[9] Karl S. Pearsons, David S. Barber, and Barbara G. Tabachnick, "Analyses of the predictability of noise-induced sleep disturbance" (Technical Report HSD-TR-89-029) Human Systems Division (HSDY/YAH U.S. Air Force Systems Command), Brooks Air Force Base, TX (October, 1989).

[10] Environmental Protection Agency, "*Information on levels of environmental noise requisite to protect public health and welfare with an adequate margin of safety*" (EPA/ONAC Rep. No. 550/9-74-004) (EPA, Washington, DC 1974).

[11] Environmental Protection Agency, "*Impact characterization of noise, including implications of identifying and achieving levels of cumulative noise exposure*" (EPA Rep. No. NTID 73.4) Report of Task Group 3 (H. E. von Gierke, Chairman) (EPA, Washington, DC, 1973).

[12] Environmental Protection Agency, "Protective noise levels: Condensed version of EPA levels document" (EPA/ONAC Rep. No. 550/9-79-100) (EPA, Washington, DC, 1978).

[13] William J. Galloway and Dwight E. Bishop, "Noise exposure forecasts: Evaluation, extensions and land use interpretations (FAA Rep. No. 70-9), U.S. Federal Aviation Administration, Washington, DC (1970).

[14] Henning E. von Gierke, "Noise—How much is too much?" Noise Control Eng. **5**, 24–34 (July-August, 1975).

[15] Henning E. von Gierke, "Guidelines for preparing environmental impact statements on noise" (Report of Working Group 69, Committee on Hearing, Bioacoustics, and Biomechanics, Assembly of Behavioral and Social Sciences, National Research Council), National Academy of Sciences, Washington, DC (1977).

[16] L. S. Finegold, S. A. Fidell, N. H. Reddingius, and B. A. Kugler, "NSBIT Program: Development of assessment system for aircraft noise and research on human impacts due to aircraft noise," *Proc. INTER-NOISE 90*, edited by H. G. Jonasson (Noise Control Foundation, Poughkeepsie, NY),Vol. II, pp. 1115–1120 (ugust, 1990)

[17] W. J. Galloway, "Assessment of community response to high-energy impulsive sounds" (Report of Working Group 84, Committee on Hearing, Bioacoustics, and Biomechanics, Assembly of Behavioral and Social Sciences, National Research Council), National Academy of Sciences, Washington, DC (1981).

[18] Sanford Fidell, Theodore J. Schultz, and David M. Green, "A theoretical interpretation of the prevalence rate of noise-induced annoyance in residential populations," J. Acoust. Soc. Am. **84**, 2109–2113 (December, 1988).

[19] Truls Gjestland, "Aircraft noise annoyance," *Proc. INTER-NOISE 89*, G. C. Maling, Jr. (Noise Control Foundation, Poughkeepsie, NY, 1989), Vol. II, pp. 903–908.

[20] David M. Green and Sanford Fidell, "Varability in the criterion for reporting annoyance in community noise surveys," J. Acoust. Soc. Am. **89**, 234–243 (January, 1991).

[21] Karl. D. Kryter, "Community annoyance from aircraft and ground vehicle noise," J. Acoust. Soc. Am. **72**, 1222–1242 (October, 1982).

[22] Karl D. Kryter, Physiological, Psychological, and Social Effects of Noise (NASA Rep. No. RP-1115, NTIS No. N84-29465), NASA Langley Research Center, Hampton, VA (July, 1984).

[23] Henk Miedema, "Response functions for environmental noise in residential areas" (Publication No. 92.021), Nederlands Instituut voor Praeventieve Gezondheidszorg TNO, Leiden, The Netherlands (June, 1993).

[24] Jerome S. Lucas, "Noise and sleep: A literature review and a proposed criterion for assessing effect," J. Acoust. Soc. Am. **58**, 1232–1242 (December, 1975).

[25] Barbara Griefahn, "Research on noise-disturbed sleep since 1973" (ASHA Report No. 10) in *Proceedings of the Third International Congress on Noise as a Public Health Problem* (Freiburg, West Germany, 1980), pp. 377–390.).

[26] Sanford Fidell, Karl Pearsons, Richard Howe, and Lawrence S. Finegold, "Design of a large-scale, in-home study of noise-induced sleep disturbance," J. Acoust. Soc. Am. **94**, No. 3, Pt. 2, 1808 (September, 1993).

[27] C. J. Jones and J. B. Ollerhead, "Aircraft noise and sleep disturbance: A field study," in *Proceedings of EURO-NOISE '92* R. Lawrence, Ed. (Imperial College, London), pp. 119–127 (September 1992).

[28] J. B. Ollerhead, C. J. Jones, R. E. Cadoux, A. Woodley, B. J. Atkinson, J. A. Horne, F. Pankhurst, L. Reyner, K. I. Hume, F. Van, A. Watson, I. D. Diamond, P. Egger, D. Holmes, and J. McKean, "Report of a field study of aircraft noise and sleep disturbance," A study commissioned by the UK Department of Transport for the UK Department of Safety, Environment and Engineering, Civil Aviation Authority, London, England (December, 1992).

[29] John B. Ollerhead and Ceril Jones, "Aircraft noise and sleep disturbance: A UK field study," in *Proceedings of Noise & Man '93,* edited by M. Vallet (L'Institut National de Recherche sur les Transports et leur Sécurité, Arcueil, France), Vol. 1, p. 55 (July, 1993).