Federal Interagency Committee on Aviation Noise

FICAN on the Findings of the Minneapolis-St. Paul International Airport (MSP) Low-Frequency Noise (LFN) Expert Panel

April 2002

Background

On June 27, 2001, FICAN met with the 2 of the 3 members of the MSP LFN Expert Panel (S. Fidell and A. Harris) to discuss the findings of their study of the subject on behalf of the Minneapolis Metropolitan Airports Commission (MAC) and the City of Richfield, MN (Richfield). In December 1998, Richfield and MAC agreed to undertake detailed studies of existing and potential impacts of low-frequency aircraft noise in communities around MSP. This agreement also established an Expert Panel along with a Policy Committee to oversee the work of the Expert Panel. The Federal Aviation Administration (FAA), the Metropolitan Council, the Minnesota Pollution Control Administration, and the Metropolitan Airport Sound Abatement Council served as advisory members of the Policy Committee.

The Expert Panel was directed to perform the following tasks:

1. Review the literature on audibility, noticeability, and the effects of low-frequency noise on individuals and communities.
2. Identify relevant noise effects and descriptors.
3. Determine existing and predicted low-frequency noise levels in the vicinity of MSP runways.
4. Identify criteria for acceptability of low-frequency noise in residences.
5. Determine low-frequency noise reduction provided by typical residential construction in the vicinity of MSP.
6. Determine low-frequency noise reduction provided by residences subsequent to treatment in the MSP Residential Sound Insulation Program.
7. Evaluate the acceptability of low-frequency noise environments in residences without and with treatment in the MSP Residential Sound Insulation Program.
8. Determine the types of treatment required to improve the noise reduction and achieve compatibility of the low-frequency noise environment.
9. Prepare reports for the Policy Committee documenting work of the Expert Panel.
10. Measure noise in the vicinity of MSP for comparison with calculated values from the Integrated Noise Model (INM).

The tenth task was added to the work program in response to a request from the FAA that the study should include some physical measurement of the phenomena in question. The Expert Panel completed its work in September 2000 and submitted to the Policy Committee a three-volume report with annotations indicating consensus or absence of consensus [MSP LFN Expert Panel, 2000].

Findings

At the FICAN meeting on June 27, 2001, the MSP LFN Expert Panel summarized the significant points about low-frequency aircraft noise where the members of the Expert Panel agree. The

Expert Panel identified four areas of agreement as being important to the discussions with FICAN members: (1) effects of low-frequency noise; (2) a descriptor for low-frequency noise; (3) the relationship between low-frequency noise and annoyance; and (4) acceptability criteria for low-frequency noise. The four technical areas are presented in succeeding sections of this report accompanied by the Expert Panel consensus finding followed by the FICAN response. The FICAN responses take into account the wealth of information presented in the Expert Panel reports along with other pertinent standards, technical reports, and journal articles.

<u>Effect of Low-Frequency Aircraft Noise</u>

MSP LFN Expert Panel Consensus. Low-frequency aircraft noise has been identified as a cause of significant levels of rattle-related annoyance in areas near air carrier airports. Prior to the work at MSP, issues of low-frequency aircraft noise were identified at San Francisco International Airport (SFO), Baltimore-Washington International Airport (BWI), Boston-Logan International Airport (BOS) and Los Angeles International Airport (LAX).

The primary effect of current and anticipated low-frequency aircraft noise on the residents near MSP is rattle-related annoyance. Low-frequency aircraft noise (apart from that of low altitude, high-speed military aircraft) poses no known risk of adverse public health effects, nor a risk of structural damage. Under the expected circumstances of residential exposure, low-frequency aircraft noise will not interfere with indoor speech, nor is this low-frequency noise itself likely to awaken people.

FICAN Response. FICAN concurs with the findings that low-frequency noise from civil aircraft will not pose a public health risk, risk of structural damage, or an increase in indoor speech interference. These findings are consistent with the extensive Federal research on the civil supersonic transport (SST), which would produce much higher levels of low-frequency noise than the subsonic aircraft operating at MSP. The issue of low-frequency aircraft noise and its impact on structures and people was explored in detail as part of the environmental assessment of the introduction of Concorde supersonic transport operations into the United States. Potential impacts were found to be negligible. Field studies found that the noise-induced vibrations as a result of Concorde overflights cause little or no structural damage. In addition, the Concorde sound pressure levels at low frequencies were found to be well below the EPA threshold for potential health impact.

The Expert Panel assumption that noise-induced vibration (from any source) may heighten reaction to the event is consistent with the position expressed by the World Health Organization (WHO) in its new guidelines [WHO, 1999]. The FICAN also notes studies of other transportation sources, such as trains, that found a similar relationship [Öhrström, 1997]. However, it is not a foregone conclusion that the presence of vibration increases annoyance. For example, the Expert Panel's reports make reference to laboratory studies that discovered that even minor amounts of rattle increased judged annoyance by 5 dB. The FICAN's own experience with studies of sleep disturbance demonstrated that discoveries made in laboratories frequently are not replicated in subsequent field studies [FICAN, 1997]. With respect to noise induced vibration and annoyance, a NASA study of helicopter noise did not find any increase in annoyance in which the events, based on measured noise levels, should have produced appreciable rattle [Powell and Shepherd, 1989].

It is also important to note that the FAA had used criteria that included both window rattling and wall vibration in the approval of low-frequency noise mitigation for BWI. In 1997, the FAA and the Maryland Aviation Administration (MAA) jointly funded a study of low-frequency takeoff noise at BWI [HMM&H, 1998]. The findings of the joint study were presented to FICAN in October 1998 and subsequently became the technical grounds supporting the Federal grant approval at BWI to mitigate the effects of low-frequency takeoff noise in close-in homes.

The FAA offered technical advice to the Policy Committee during the development of the MSP study plan that drew on the experience of the BWI Study. Among the advice was to use the "Hubbard criteria" cited in the BWI study [Hubbard, 1982]. Hubbard examined the role of house vibrations in reactions to environmental noise, reviewed some human perception criteria, and suggested criteria in sound pressure level (SPL) for whole body perception of vibration in floors, walls, and windows. Hubbard's criteria included a tactile threshold in terms of acceleration level as a function of the one-third-octave band. One of the FAA's conclusions on the extent of the effect of low-frequency noise at BWI was based upon the number of takeoffs that exceeded two (windows and walls) of the three vibration perception criteria described in the Hubbard article. The Expert Panel findings do not address why this FAA precedent was ignored.

Finally, the MSP study failed to demonstrate that the phenomena would occur in the selected communities due to the absence of direct measurements of vibration. During the MSP study development, the FAA had recommended the inclusion of measurements as recommended by the American National Standard Institute (ANSI) [S3.29-1983 (R1996)]. The ANSI standard provides recommendations on the magnitude of vibration, in the frequency range 1-80 Hz, that are perceptible and regarded as tolerable by occupants. It includes multiplying factors for building type, time of day, and source characteristics. The standard further establishes root-mean-square (rms) acceleration as the quantity for measuring continuous vibration as it impacts humans. Acceleration measurements were part of the joint FAA and MAA study of low-frequency noise effects at BWI. No such measurements were conducted at MSP. FICAN finds that the absence of physical measurement leaves unanswered whether perceptible vibration occurs and calls into question the findings of the residential survey on the presence of rattle due to aircraft noise. The credibility of the residential survey is addressed in FICAN's response to the third technical issue on the relationship between low-frequency noise and annoyance.

<u>Descriptors of Low-Frequency Aircraft Noise and Low-Frequency Noise Dose</u>
MSP LFN Expert Panel Consensus. Areas experiencing high levels of low-frequency aircraft noise cannot be identified by analyses based on DNL, an A-weighted metric that intentionally ignores low-frequency noise. As a result, it was necessary to select descriptors to identify low-frequency aircraft noise and low-frequency aircraft noise dose while also being sure that the descriptors discriminate against mid-frequency and high-frequency noise. No existing measure of low-frequency noise was clearly a predictor of aircraft-noise induced rattle and also readily obtained from field measurements. After careful evaluation of available methods the Low-frequency Sound Level (LFSL), defined as the sum of the maximum sound levels in the 25 to 80 Hz one-third octave bands, was selected as the best descriptor for low-frequency aircraft noise. The octave bands comprising LFSL include those frequencies that reflect the potential for rattle and are significant components of aircraft noise. Subsequently, the measure of effective low-

frequency aircraft noise level dose (LFSL dose) was defined as the arithmetic average of the greatest LFSLs of aircraft noise events in excess of LFSL = 60 dB.

During its evaluation of potential descriptors of low-frequency noise, the Expert Panel determined that the Low-frequency Level (L_{LF}) defined by ANSI Standard S12.9, Part 4 was not appropriate. It has not been used to describe aircraft noise. The low-frequency portion of the standard is designed for "essentially continuous sounds with strong low-frequency content." It is not clear that aircraft noise meets this requirement. A further impediment to use of S12.9 is the frequency range used, 16, 31.5 and 63-Hz octave bands. Neither existing aircraft noise databases nor standard field instrumentation includes all these bands.

FICAN Response. The FICAN is not comfortable with the proposed measure on several grounds. First, LFSL is an artificially constructed single event noise metric that is the arithmetic average of the maximum sound levels in the one-third octave bands from 25 to 80 Hz during a given event. In other words, the metric will often be made up of one-third octave-band frequency data measured at different times during a particular event. No other noise metric used in airport noise analysis is artificially constructed in such a manner. The FICAN finds little scientific justification for this artificial construction.

Another concern is that the ANSI standard for evaluating low-frequency noise was rejected by the Expert Panel because it depends upon obtaining sound pressure levels in the 16 Hz one-third-octave band, which are not typically available through aircraft noise certification. This does not seem to be a sufficient reason to reject its use when field measurements would be required in any future study of low-frequency noise impact around airports. As ANSI standards undergo intense technical scrutiny before adoption, it makes little sense to invent a new metric when a potentially suitable metric already exists. An ANSI standard should serve as the foundation for low-frequency analyses on a national level unless/until it can be proven to be inadequate.

The proposed threshold (LFSL=60 dB) is very nebulous as judged by the lack of clarity in its valuation and its origin in residential surveys that will be questioned in the next section. As noted by the Expert Panel, "the value is intended to represent the maximum low-frequency sound level that occurs a few times a day in neighborhoods near runways." "A few times a day" is so vague as to make the metric almost meaningless. Would a "few less times a day" assuage the situation? How can an authority prioritize mitigation actions when all there is to judge the situation is "a few more" or "a few less" times a day? The factors of amplitudes of the events, times of day, and number of occurrences are all equally important in order to fairly assess noise impact as demonstrated in the current Federal criteria based upon DNL. However, these factors, especially number of occurrences, are not part the proposed metric.

Finally, it is important to remember that LFSL is a surrogate for assessing the effect of perceptible vibration, as it is not a direct, physical measurement of the vibration phenomena. For this reason, the FAA had suggested to the Policy Committee that the study should include rms acceleration measurements but to also examine the measurements taken against the "Hubbard criteria" as FAA and MAA had done in the BWI study. As none of these measurements were taken at MSP, it is impossible to determine whether window rattling and other noise-induced vibrations would actually occur at the LFSL threshold of 60 dB or higher.

Relationship between Low-Frequency Noise and Annoyance

MSP LFN Expert Panel Consensus. A social survey conducted at MSP identified the relationship between LFSL and the prevalence of high annoyance due to rattle. The relationship identified at MSP was similar to a relationship previously identified at LAX, although the LAX relationship was drawn from a greater range of LSFL doses.

FICAN Response. The FICAN agrees that a social survey is a valuable tool in the examination of the effects of noise and in drawing out measures of annoyance. However, the FICAN has strong misgivings about the questionnaire used in this study and the commingling of data collected in El Segundo, CA with data collected in Richfield, MN. For example, the sequence of questions[1] goes directly from asking the resident how much they are annoyed by aircraft noise to a series of questions on airplanes making vibrations or rattling sounds in the home. Thus, the survey did not seem to afford the residents the opportunity to indicate whether other sources, such as wind or road traffic, could also cause vibration or rattling in the home. Coupled with the absence of any physical measurement of vibration in the home, it raises concern that some response bias may be present in the MSP study to elicit evidence of perceptible vibration when none exists. The problem of "false positive" results exists in almost any scientific experience. Separate studies by the UK, NASA and USAF of sleep disturbance due to aircraft all discovered several incidents of study subjects indicating they were awakened by aircraft events when there were none [Ollerhead, et. al. 1992; Fidell, et. al., 1994; and Fidell, et. al., 1995].

The FICAN also questions whether it is appropriate to commingle survey results made near LAX with those of MSP. The FAA had many times expressed concern to the Policy Committee that no rms acceleration measurements were obtained in either of the field tests near MSP or LAX as part of the study. The absence of rms acceleration measurements of vibration calls into question whether the findings on residential reaction to low-frequency noise are applicable. To assume that these findings are applicable, one must assume that the residential structures in El Segundo, CA near LAX have similar responses to aircraft noise excitations as those homes in Richfield, MN. As the climates of these two communities are drastically different, structural qualities, such as stiffness and tightness, should be substantially different. These structural qualities contribute to how the structure responds to external excitation. Without the inclusion of the LAX data points, the relationship between prevalence of high annoyance and low-frequency noise dosage discovered in the MSP study would rest on just 3 data points that exhibit very little if any slope from horizontal, i.e., there is no change in annoyance with increase in low-frequency noise dosage.

Acceptability Criteria for Low-Frequency Noise

MSP LFN Expert Panel Consensus. The Expert Panel recommended criteria for acceptability of low-frequency noise in residential areas at levels of prevalence of annoyance equivalent to criterion levels A-weighted exposure. This approach was also used by the Urban Mass Transportation Administration (UMTA) when setting its noise compatibility criteria. FICON (1992) identified a dosage-response relationship of noise exposure and high annoyance. The percentages of highly annoyed persons associated with DNL 65 dB and 75 dB are 12.3% and 36.5%, respectively. The MSP social survey identified the LFSL doses associated with 12.3%

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[1] pp. 35-39, MSP LFN Expert Panel Findings Report, Volume II.

and 36.5% as 70 dB and 87 dB, respectively. The Expert Panel recommended that LFSL doses below 70 dB be identified as compatible with residential use without any remedial actions and LFSL doses above 87 dB be identified as incompatible with residential use and not susceptible to remedial treatment. Where the LFSL dose is between 70 dB and 87 dB, remedial treatment was identified as appropriate.

FICAN Response: It is premature to consider adopting LFSL and the impact criteria without further research. In addition to the substantive problems with some of the findings and methods as described in the previous sections of this paper, further research is necessary to address the complex interaction between (1) building construction, (2) the contribution of loudness to annoyance, and (3) the contribution of rattle to annoyance.

Ideally, the research would be conducted in real houses located within the critical distances from runways. Panels of subjects would be asked to rate the annoyance of individual aircraft events. Suggested physical measures would include (1) exterior 1/3 octave spectra down to a few Hz, (2) vibration measurements on window, wall and floor, and (3) experimenter judgment of subjective rattle [Schomer and Neathammer, 1985]. Statistical analysis would establish what combination of physical measures gave the best prediction of annoyance judgments. Use of several houses would establish the reliability of measures across construction. The final step in this proposed research would be introduction of noise insulation in a stepwise fashion, beginning first with the most rattle-prone features, windows and doors, and subjective evaluations by the same subjects.

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