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DEVELOPING A CRITERION FOR THE ANNOYANCE OF LOW FREQUENCY AIRCRAFT NOISE

S. Fidell

BBN Technologies, 21128 Vanowen Street, 91303, Canoga Park, CA, United States Of America

Tel.: 818-610-8212 / Fax: 818-716-8377 / Email: fidell@bbn.com

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ABSTRACT
Low frequency aircraft noise, such as that caused by thrust reverser application, start of takeoff roll, and (to a lesser extent) overflight noise, can create secondary emissions of windows, doors, and household paraphernalia. These rattling noises can annoy residents of airport neighborhoods independently from the noise of aircraft per se. One interpretation of the findings of recent studies of annoyance due to aircraft noise-induced vibration and rattling suggests a means for developing a criterion for the acceptability of such noise, in terms comparable to the familiar land use compatibility guidance of the U.S. Federal Interagency Committee on Noise.

1 - INTRODUCTION
Much of the data summarized in the dosage-response relationship described by Finegold, Harris and von Gierke (1994) about the annoyance of aircraft noise was collected from residents of neighborhoods underlying heavily used flight tracks. The common strategy of concentrating interviews among residents of overflown areas near runway ends was a consequence of the high noise levels created in such neighborhoods by aircraft approaching and (especially) departing airports. As newer aircraft engines for jet transports have lowered single event departure noise levels in airport neighborhoods in recent years, the annoyance of aircraft noise produced along runway sidelines and elsewhere has become of greater concern. Such noise, including that created during takeoff roll and application of thrust reversers, contains proportionally more low frequency energy than does overflight noise.
Although the annoyance of low frequency noise has been studied extensively in diverse settings (see bibliography), both in its own right and in combination with vibration, a general interpretive criterion useful for assessment of the annoyance of low frequency aircraft noise in residential areas has not yet gained currency. In the absence of a criterion to support systematic policy decisions, mitigation of the annoyance of low frequency aircraft noise in areas behind or to the sides of runways in several U.S. cities (notably Baltimore, Boston, Minneapolis, and San Francisco) has yet to be addressed in an *ad hoc* manner.

2 - GEOGRAPHIC ASSOCIATION
The results of two social surveys of the annoyance of aircraft-induced rattle and vibration have recently become available for interpretive analysis (see Fidell, Silvati, Pearsons, Howe, and Sneddon elsewhere in these Proceedings). One approach to interpreting the survey findings is as a geographic association between runway sideline distances and the prevalence of a consequential degree of annoyance with aircraft noise-induced rattle and vibration. Figures 1 and 2 show the locations of those survey respondents who were highly annoyed by rattle and those who were not. Figure 3 summarizes the prevalence of annoyance among respondents in terms of distances from their homes to the (extended) centerlines of the nearest runway.
Geographic associations are descriptive rather than causal, and may suffer site-specific limitations of interpretation. An alternate way to interpret the implications of annoyance of low frequency aircraft noise for policy-related purposes is by analogy with FICON's (1992) analysis of the annoyance of A-weighted measurements of transportation noise exposure. FICON asserts that the prevalence of a consequential

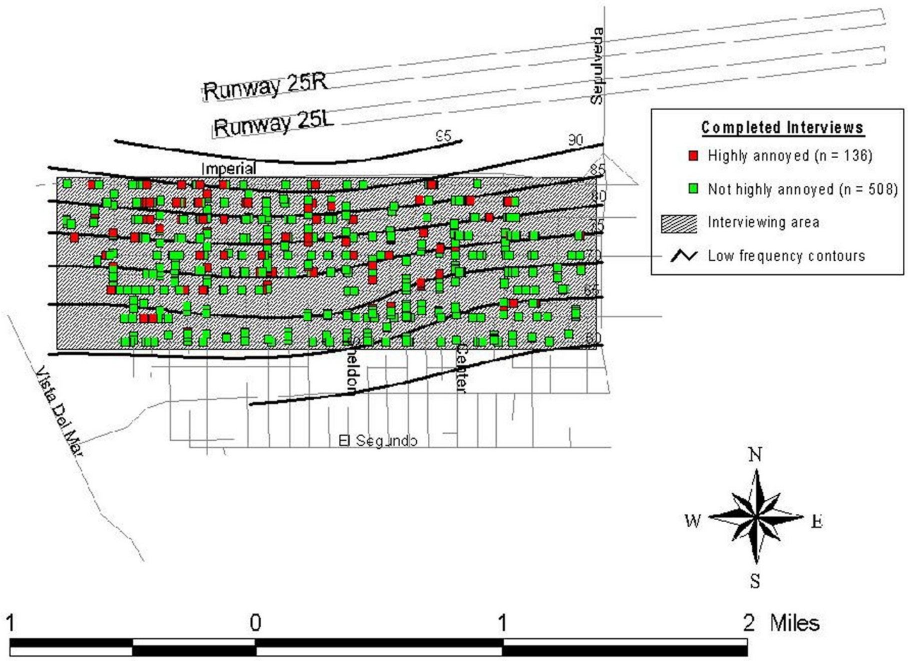

Figure 1: Locations of households of survey respondents in Los Angeles in which respondents were highly annoyed by aircraft-induced rattle and vibration.

degree of annoyance in a community is the most useful general indication of adverse effects of transportation noise, and identifies a dosage-response relationship intended to support policy decisions about the tolerability of noise exposure.

As shown in Figure 4, the predictor variable in this relationship is a measure of 24 hour time-weighted average sound level (Day-Night Average Sound Level, or DNL), while the predicted variable is the prevalence of a consequential degree of annoyance in residential populations. The arrows in Figure 4 indicate the prevalence of annoyance associated with various policy points.

Although the predictive relationship seen in Figure 4 is no more causal than a geographic association, the member agencies of FICON have adopted common opinions about the compatibility of various land uses with airport operations, and about the levels of A-weighted noise exposure that warrant federal participation in the funding of noise mitigation measures such as acoustic insulation and purchase of homes.

3 - DOSAGE-RESPONSE RELATIONSHIP

An approach structured in the same manner as FICON's was developed to aid interpretation of expected low frequency aircraft noise effects in the vicinity of a new runway under construction in Minneapolis. A relationship between a measure of low frequency aircraft noise and the prevalence of annoyance was constructed from the results of the two social surveys cited earlier, shown in Figure 5. The predicted variable of this relationship is similar to that of FICON's relationship: the prevalence of a consequential degree of annoyance with aircraft noise-induced rattle and vibration in respondents' homes. The predictor variable is a single event low frequency maximum sound level rather than a time weighted average, however, since windows and household paraphernalia rattle in real time.

The rationale for adopting such an approach to interpreting the effects of low frequency aircraft noise in communities is straightforward. For environmental assessment purposes in the U.S., aircraft noise is measured not for its own sake, but because FICON considers it to be a useful predictor of the prevalence of annoyance. For sources other than aircraft overflights, existing policies concerning noise levels specified for land use compatibility and federal participation in noise mitigation can be linked in terms of equivalent prevalence of annoyance to values of A-weighted noise exposure.

Since dosage-response relationships are not self-interpreting for purposes of reaching policy decisions, it remains to be seen what levels of low frequency aircraft sound levels may eventually be identified as tolerable by various agencies, and what rationales may be offered for their selection. If consistency with prior practice is of importance, however, an approach similar to that identified here is likely to be an attractive option.

Figure 2: Locations of households of survey respondents in Minneapolis in which respondents were highly annoyed by aircraft-induced rattle and vibration.

ACKNOWLEDGEMENTS

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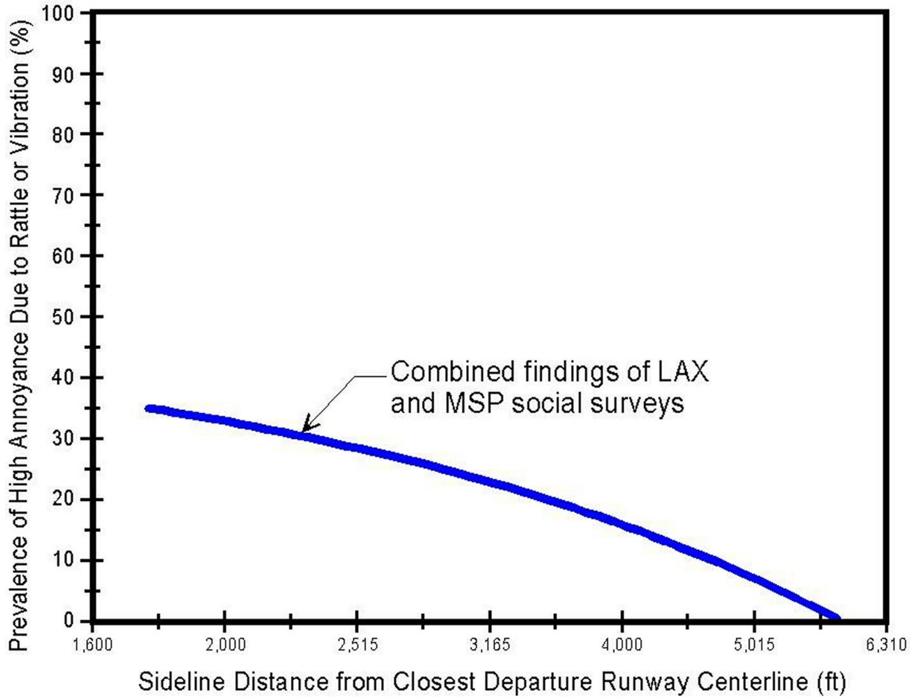

Figure 3: Relationship between sideline distance of households to runway and the prevalence of high annoyance in combined findings of LAX and MSP social surveys.

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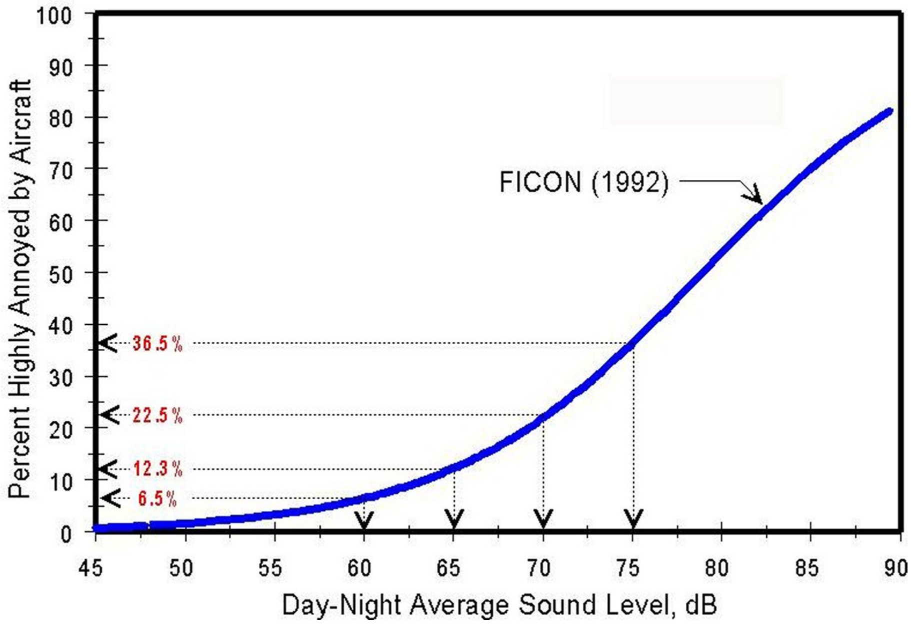

Figure 4: Relationship of A-weighted noise exposure to the prevalence of a consequential degree of annoyance, as identified by the U.S. Federal Interagency Committee on Noise (1992).

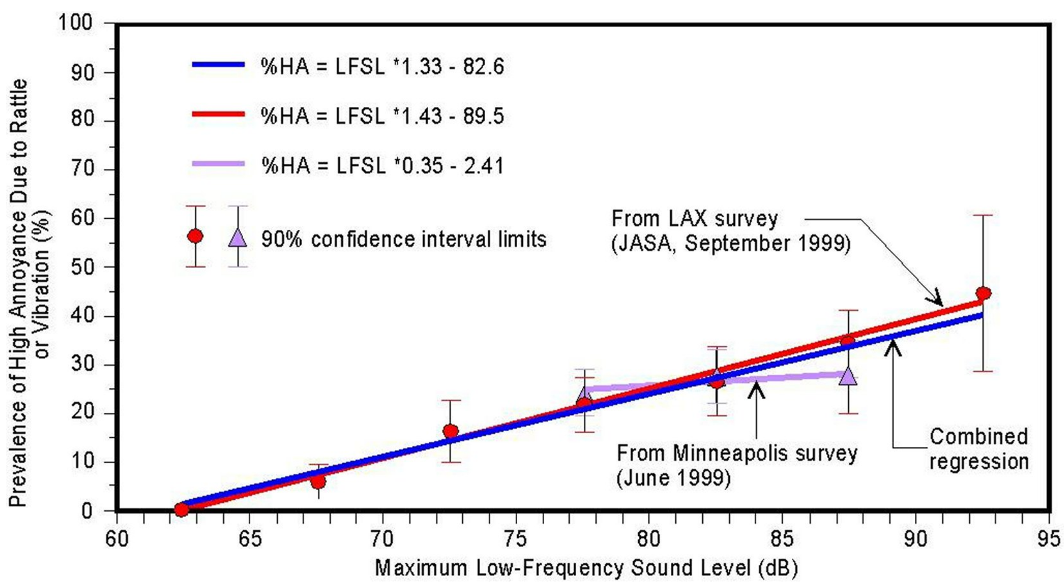

Figure 5: Relationship between percentage of respondents highly annoyed by vibrations or rattling sounds made by aircraft and low-frequency sound levels.