



TECHNICAL INFORMATION PAPER

Measuring the Impact of Noise on People

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The most common way to measure the impact of noise on residents is to estimate the number of people residing within the noise contours. This is done by overlaying noise contours on census block maps or on maps of dwelling units. The number of people within each 5 DNL range (e.g., from 65 to 70 DNL, from 70 to 75 DNL, etc.) is then estimated.

This is the approach required in F.A.R. Part 150 noise compatibility studies. While it has the advantage of simplicity, it has one disadvantage: it implicitly assumes that all people are equally affected by noise, regardless of the noise level they experience. Clearly, however, the louder the noise, the greater the noise problem. As noise increases, more people become concerned about it, and the concerns of each individual become more serious.

AVERAGE COMMUNITY RESPONSE TO NOISE



Although individual responses to noise can vary greatly, the average response among a group of people is much less variable. This enables us to generalize about the average impacts of aircraft noise on a community despite the wide variations in individual response.

Individual human response to noise is highly variable and is influenced by many factors. These include emotional variables, feelings about the necessity or preventability of the noise, judgments about the value of the activity creating the noise, an individual's activity at the time the noise is heard, general sensitivity to noise, beliefs about the impact of noise on health, and feelings of fear associated with the noise.

Physical factors influencing an individual's reaction to noise include the background noise in the community, the time of day, the season of the year, the predictability of the noise, and the individual's control over the noise source.

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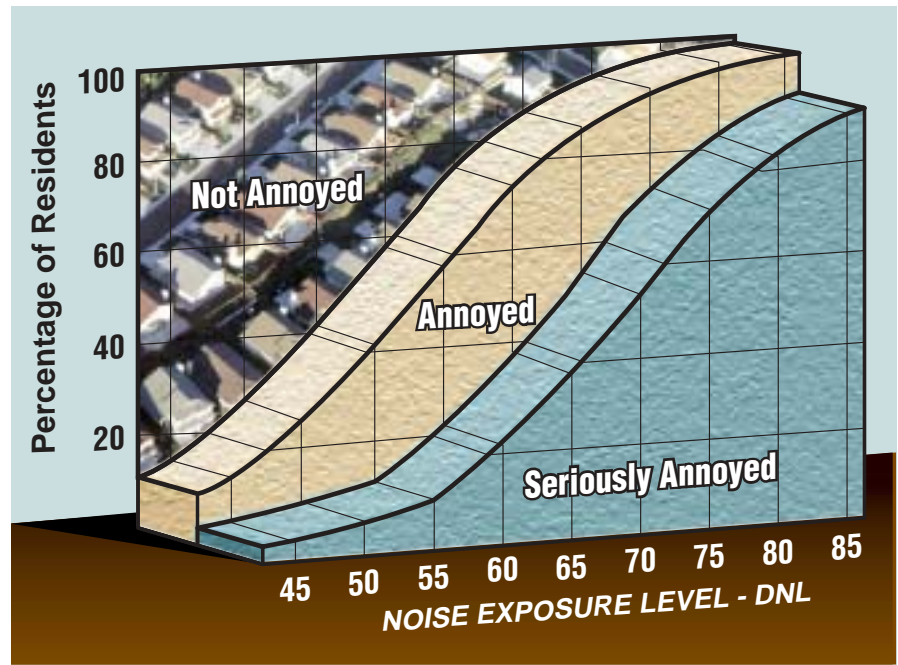
Many studies have examined average community response to noise, focusing on the relationship between annoyance and noise exposure. (See DORA 1980; Fidell et al. 1989; Finegold et al. 1992 and 1994; Great Britain Committee on the Problem of Noise 1963; Kryter 1970; Richards and Ollerhead 1973; Schultz 1978; U.S. EPA 1974.) These studies have produced similar results, finding that annoyance is most directly related to cumulative noise exposure, rather than single-event exposure.

Annoyance has been found to increase along an S-shaped or logistic curve as cumulative noise exposure increases, as shown in **Exhibit A**. This graph shows the percentage of residents either somewhat annoyed or seriously annoyed by noise of varying DNL levels. It was developed from research in the early 1970s (Richards and Ollerhead 1973). It is interesting that the graph indicates that at even extremely low noise levels, below 45 DNL, a very small percentage of people remain annoyed by aircraft noise. Conversely, the graph shows that while the percentage of people annoyed by noise exceeds 95 percent at 75 DNL, it only approaches, and does not reach, 100 percent even at the extremely high noise level of 85 DNL.



EXHIBIT A

ANNOYANCE CAUSED BY AIRCRAFT NOISE IN RESIDENTIAL AREAS



Source: Richards and Ollerhead 1973, p.31



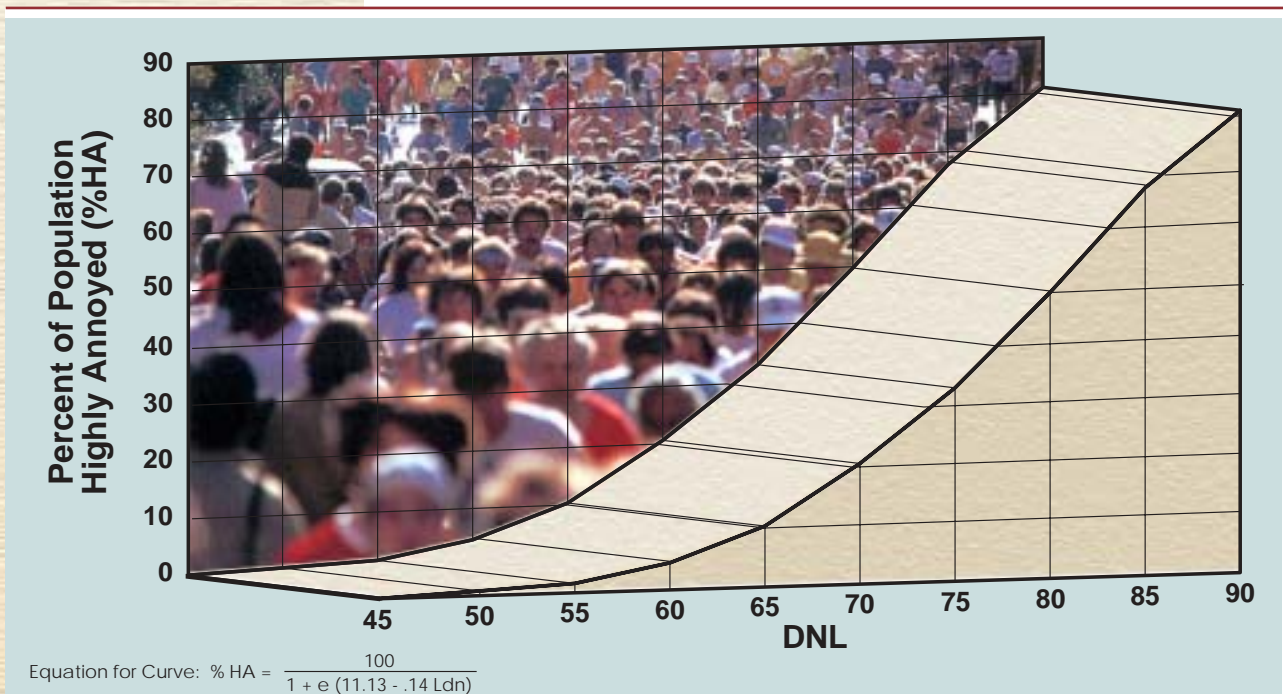
Starting at 65 DNL, the percentage of people expected to be highly annoyed increases steeply from 11.6 percent up to 68.4 percent at 85 DNL.



A similar graph is shown in **Exhibit B**. Developed by Finegold et al. (1992 and 1994), it is based on data derived from a number of studies of transportation noise (Fidell 1989). It shows the relationship between DNL levels and the percentage of people who are highly annoyed. Known as the “updated Schultz Curve” because it is based on the work of Schultz (1978), it represents the best available source of data for the noise dosage-response relationship (FICON 1992, Vol. 2, pp. 3-5; Finegold et al. 1994, pp. 26-27).

The updated Schultz Curve shows that annoyance is measurable beginning at 45 DNL, where 0.8 percent of people are highly annoyed. It increases gradually to 6.1 percent at 60 DNL. Starting at 65 DNL, the percentage of people expected to be highly annoyed increases steeply from 11.6 percent up to 68.4 percent at 85 DNL. Note that this relationship includes only those reported to be “highly annoyed.” Based on the findings shown in **Exhibit A**, the percentages would be considerably higher if they also included those who were “moderately annoyed.”

PERCENTAGE OF POPULATION HIGHLY ANNOYED BY GENERAL TRANSPORTATION NOISE



PERCENT HIGHLY ANNOYED AT SELECTED NOISE LEVELS

DNL	45	50	55	60	65	70	75	80	85	90
%HA	0.8%	1.6%	3.1%	6.1%	11.6%	20.9%	34.8%	51.7%	68.4%	81.3%

Source: Finegold et al. 1992 and 1994.

THE DEVELOPMENT OF WEIGHTING FUNCTIONS

Recognizing the tendency of annoyance response rates to increase systematically as noise increases, researchers in the 1960s began developing weighting functions to help estimate the total impact of noise on a population (CHABA 1977, p. B-1). The population impacted by noise at a given level would be multiplied by the appropriate weighting function. The higher the noise level, the higher the weighting function. The results for all noise levels would be added together. The sum would be a single number purported to represent the net impact of noise on the affected population.

The CHABA report (p. VII-5) recommended the use of the original Schultz Curve as the basis for developing weighting functions. It recommended that weighting functions be developed by calculating the percentage





Based on the response curve shown in Exhibit A, the weighting functions can be considered as roughly equivalent to the proportion of people likely to be either highly annoyed or somewhat annoyed by noise.

of people likely to be highly annoyed by noise at various DNL levels. These values were then converted to weighting functions by arbitrarily setting the function for 75 DNL at 1.00. Functions for the other noise levels were set in proportion to the percent highly annoyed. The results of applying these weighting functions to a population was known as the “sound level-weighted population” impacted by noise, or the “level-weighted population.”

UPDATED LEVEL-WEIGHTED POPULATION FUNCTIONS

As discussed above, the original Schultz Curve has been updated to take into account additional studies of community response to noise. The updated curve is shown in **Exhibit B**. Coffman Associates has updated the weighting functions developed by CHABA (1977, p. B-7) to correspond with the updated Schultz Curve. **Table 1** shows the percentage of people likely to be highly annoyed by aircraft noise for 5 DNL increments ranging from 45 to 80 DNL. It also shows weighting functions for use in calculating level-weighted population. These were developed by setting the function for the 75 to 80 DNL range at unity (1.000). The other functions were computed in proportion to the values for “percent highly annoyed.”

TABLE 1

PERCENT HIGHLY ANNOYED AND WEIGHTED FUNCTION BY DNL RANGE

DNL RANGE	AVERAGE PERCENT HIGHLY ANNOYED	WEIGHTING FUNCTION
45-50	1.19%	0.028
50-55	2.36%	0.055
55-60	4.63%	0.107
60-65	8.87%	0.205
65-70	16.26%	0.376
70-75	27.83%	0.644
75-80	43.25%	1.000

Based on the response curve shown in **Exhibit A**, the weighting functions can be considered as roughly equivalent to the proportion of people likely to be either highly annoyed or somewhat annoyed by noise.





The response to noise among a group of people varies systematically with changes in noise levels. As noise increases, the proportion of people disturbed by noise increases.

EXAMPLE USE OF LEVEL-WEIGHTED POPULATION

In airport noise compatibility planning, the level-weighted population (LWP) methodology is particularly useful in comparing the results of different noise analysis scenarios. Since the percentage of people who are highly annoyed increases with increasing noise levels, the LWP values may differ between operating scenarios even though the total population within the noise impact boundary is equal. An example below illustrates the LWP methodology. Scenarios A and B show the effects of two airport operating scenarios. While the population subject to noise above 65 DNL is the same for both, Scenario B has a lower LWP because fewer people are impacted by the higher noise levels.

TABLE 2

LEVEL-WEIGHTED POPULATION METHODOLOGY - EXAMPLE

DNL Range	SCENARIO A			SCENARIO B		
	LWP Factor	Population	LWP	LWP Factor	Population	LWP
65-70	.376	x 2,000	= 752	.376	x 3,000	= 1,128
70-75	.644	x 1,400	= 902	.644	x 700	= 451
75+	1.000	x 600	= 600	1.000	x 300	= 300
Total		4,000	2,254		4,000	1,879

SUMMARY

The response to noise among a group of people varies systematically with changes in noise levels. As noise increases, the proportion of people disturbed by noise increases. This relationship has been estimated and is presented in the “updated Schultz Curve” shown in **Exhibit B**.

The data in the updated Schultz Curve can be used to develop weighting functions for computing the numbers of people likely to be annoyed by noise. This is especially useful in comparing the net impact of different noise scenarios.





References

CHABA 1977. *Guidelines for Preparing Environmental Impact Statements on Noise, Report of Working Group 69 on Evaluation of Environmental Impact of Noise*. Committee on Hearing, Bioacoustics, and Biomechanics, Assembly of Behavioral and Social Sciences, National Research Council, National Academy of Sciences, Washington, DC.

Directorate of Operational Research and Analysis (DORA) 1980. *Aircraft Noise and Sleep Disturbance: Final Report*. DORA Rep. 8008, Civil Aviation Authority, London, 1980. Cited in Kryter 1984, p. 434.

Federal Interagency Committee on Noise (FICON) 1992. *Federal Agency Review of Selected Airport Noise Analysis Issues*.

Fidell, S. et al. 1989. *Updating a Dosage-Effect Relationship for the Prevalence of Annoyance Due to General Transportation Noise*. HSD-TR-89-009. Wright-Patterson AFB, Ohio: U.S. Air Force, Noise and Sonic Boom Impact Technology. Cited in FICON 1992.

Finegold, L.S. et al. 1992. "Applied Acoustical Report: Criteria for Assessment of Noise Impacts on People." Submitted to *Journal of Acoustical Society of America*. June 1992. Cited in FICON 1992.

Finegold, L.S. et al. 1994. "Community Annoyance and Sleep Disturbance: Updated Criteria for Assessing the Impacts of General Transportation Noise on People." *Noise Control Engineering Journal*, Vol. 42, No. 1, January - February 1994.

Great Britain Committee on the Problem of Noise, 1963. *Noise, Final Report*. Presented to Parliament by Lord Minister for Science by Command of Her Majesty. H.M. Stationery Office, London, July 1963. Cited in Newman and Beattie 1985, p. 23.

Kryter, K.D. 1970. *The Effects of Noise on Man*. Academic Press, New York. Cited in Newman and Beattie 1985, p. 22.

Kryter, K.D. 1984. *Physiological, Psychological, and Social Effects of Noise*, NASA Reference Publication 1115.





Newman, Steven J. and Kristy R. Beattie, 1985. *Aviation Noise Effects*. Prepared for U.S. Department of Transportation, Federal Aviation Administration, Office of Environment and Energy, Washington, D.C., Report No. FAA-EE-85-2, March 1985.

Richards, E.J. and J.B. Ollerhead, 1973. "Noise Burden Factor — A New Way of Rating Noise," *Sound and Vibration*, Vol. 7, No. 12, December.

Schultz, T.J. 1978. "Synthesis of Social Surveys on Noise Annoyance." *Journal of the Acoustical Society of America*, Vol. 64, No. 2, pp. 377-405. Cited in FICON 1992.

U.S. Environmental Protection Agency (EPA), 1974. *Information on Levels of Environmental Noise Requisite to Protect Health and Welfare with an Adequate Margin of Safety*. EPA, Office of Noise Abatement and Control, Washington, DC, March 1974.

