

# DNWVG

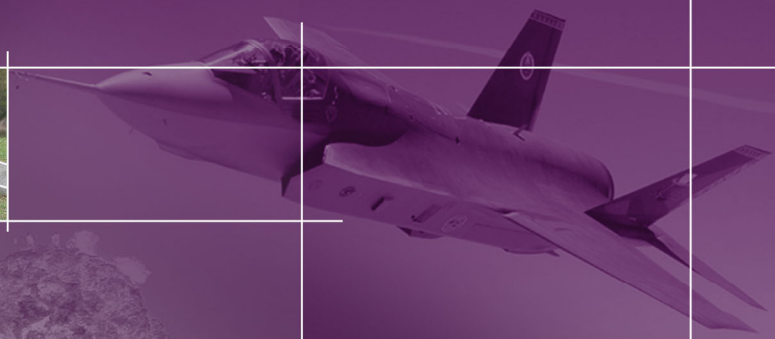
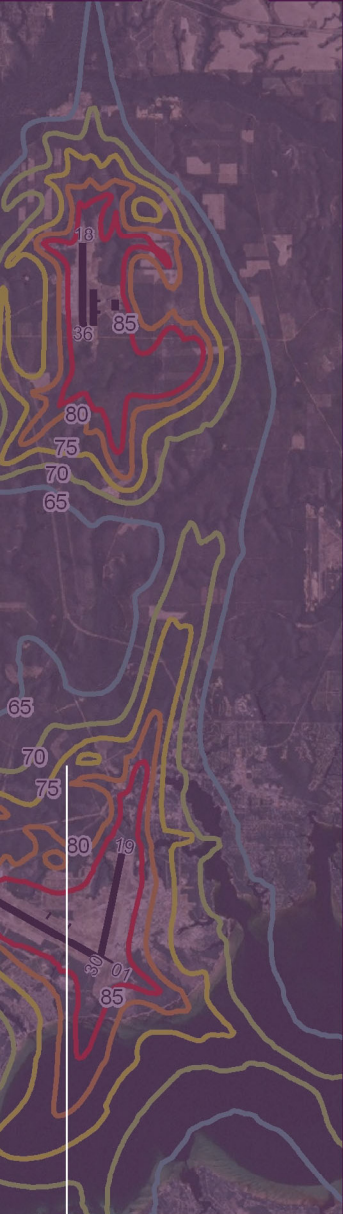
DEPARTMENT OF DEFENSE  
NOISE WORKING GROUP

## TECHNICAL BULLETIN

### Community Annoyance Caused By Noise From Military Aircraft Operations

December 2009

Long term community annoyance from aircraft noise is typically the greatest adverse effect of low altitude, subsonic overflights of residential populations. Understanding annoyance is essential to successful public relations in the vicinity of air installations and operating areas, and to informed decisions on changes to the military operations.



## INTRODUCTION

This aircraft noise annoyance bulletin is one of a series of bulletins issued by the DoD Noise Working Group (DNWG) under the initiative to educate and train DoD military, civilian and contractor personnel, and the public on noise issues.

In compliance with the requirements of the National Environmental Policy Act of 1969 (NEPA), the DoD predicts the environmental impacts of all major proposed changes in military operations, including the effects of the noise expected from such actions on exposed communities. The reaction of people to a given noise environment is extraordinarily complex. This is particularly evident when evaluating the potential health effects of people exposed to aircraft noise, with its intermittent nature and character, and where noise levels fluctuates significantly with time. Another important element is the complex psychological and physiological reaction of people to the noise environment, as well as their attitude toward the source of the noise. Further exacerbating this complex issue is the possibility that short-term community response can be different than the long-term community reaction. The concept of “community annoyance” was developed to provide one comprehensive term to describe the overall community response to noise, including both degradation of outdoor activities and interference with indoor activities.

The primary effect of recurring aircraft noise on exposed communities is “long-term” annoyance. The scientific community has adopted the use of long-term annoyance as a primary indicator of community response, because it attempts to account for all negative aspects of effects from noise, including sleep disturbance, speech interference and distraction from other human activities.

According to the Environmental Protection Agency (EPA), annoyance is a psycho-social response to an auditory experience, which has its roots in the unpleasantness of noise, the disruption by noise of ongoing activities, and/or the meaning or message carried by a given noise. Annoyance is a broad term that includes any negative subjective reaction on the part of an individual or group. For analysis of noise impacts from DoD operations, “long term” community annoyance is exposure produced by separate noise events or operations over a period of at least a month, and that the population has had at least six months to habituate to major changes in their noise exposure.

## BACKGROUND

Because noise intrudes to varying degrees on many human activities, community annoyance from the noise generated by military operations has long been regarded by policy makers to be the environmental impact that demands the most attention.

Numerous laboratory studies and field surveys have been conducted to measure annoyance and to account for a number of the variables, many of which are dependent on a person's individual circumstances and preferences. Laboratory studies of individual response to noise have helped isolate a number of the factors contributing to annoyance. These include, but are not limited to intensity level, spectral characteristics, duration, pitch, pulsation, information content, and particularly, the degree of interference with activity. Social surveys of community response to noise have allowed the development of general dose-response relationships that can be used to estimate the proportion of people who will be highly annoyed by a given noise level. The results of these studies have formed the basis for criteria established to define areas of compatible land use both in the U.S. and in many other countries.

A wide variety of responses have been used to determine intrusiveness of noise and disturbances of speech, sleep, audio/video entertainment, and outdoor living, but the most useful metric for assessing people's responses to noise is the percentage of the population expected to be "highly annoyed." The concept of "percent highly annoyed" has provided the most consistent response of a community to a particular noise environment. Daily average sound levels are typically used for the evaluation of community noise effects, including long-term annoyance. In general, scientific studies and social surveys have found a correlation between the percentages of exposed people who are highly annoyed and the level of average noise exposure measured by the Day-Night Average Sound Level (DNL) metric.

The classic analysis was performed by T.J. Schultz, who in 1978 synthesized the aircraft, street/expressway, and railroad noise data from many social surveys that employed different response scales. He defined "highly annoyed" respondents as those respondents whose self-described annoyance fell within the upper 28% of the response scale where the scale was numerical or un-named. For surveys where the response scale was named, Schultz counted those who claimed to be highly annoyed, combining the responses of "very annoyed" and "extremely annoyed." Schultz's definition of "percent highly annoyed" (%HA) became the basis for Federal policy on environmental noise.

Figure 1, commonly referred to as the "Schultz Curve," represents the synthesis of 161 social surveys. The DNL is shown on the X axis and the percent highly annoyed on the Y axis. The results of the social surveys show considerable scatter. On an individual basis, the data points vary widely for any given noise level. Still, Schultz's definition of %HA became the touchstone of Federal policy on environmental noise.

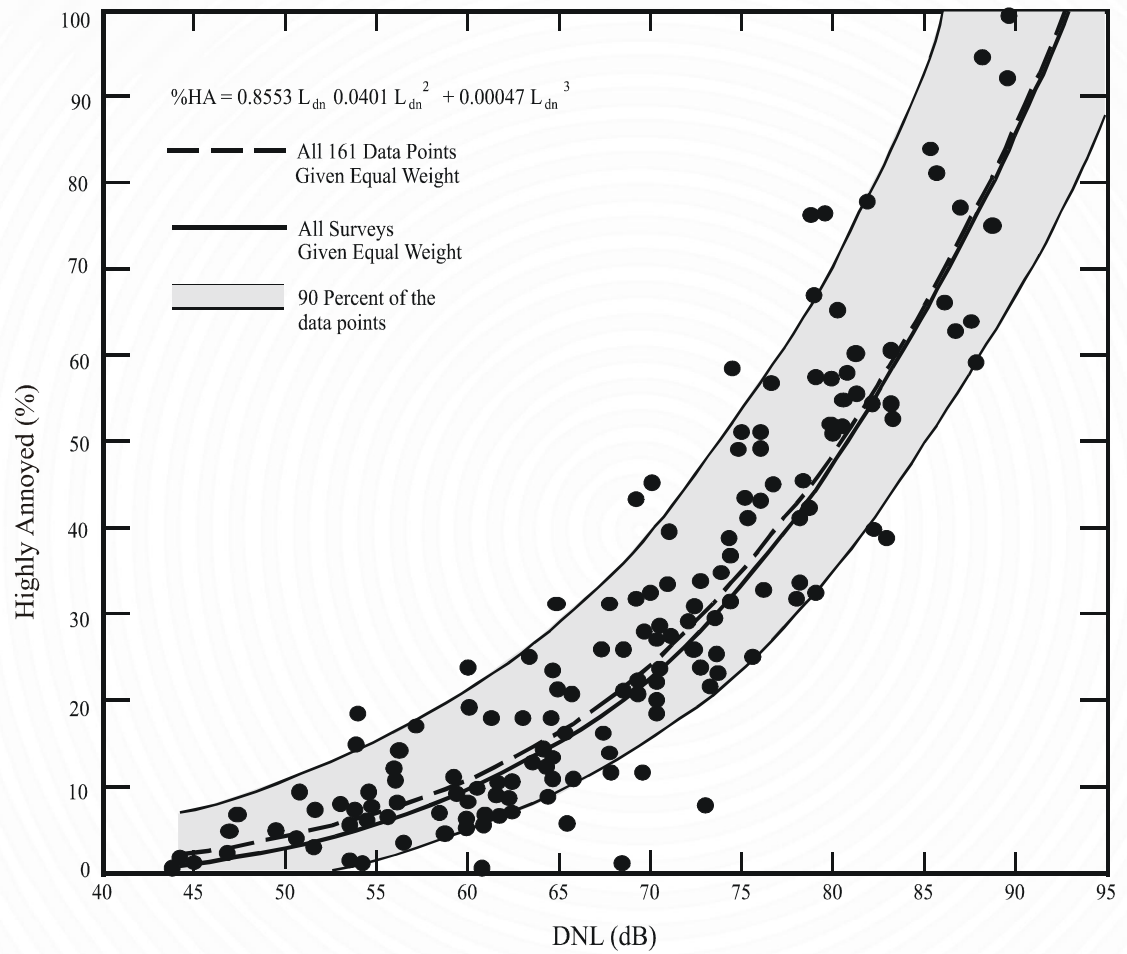


Figure 1. Original "Schultz Curve"

Approximately one decade after publication of the Schultz Curve, the U.S. Air Force commissioned a study to update this important tool. Additional survey data resulted in nearly tripling the size of the original Schultz Curve database for predicting annoyance from general transportation noise exposure. Figure 2 shows the scatter of the %HA for all 453 data points. The wide data point spread is generally attributed to the varying personal factors that influence the manner in which individuals react to noise.

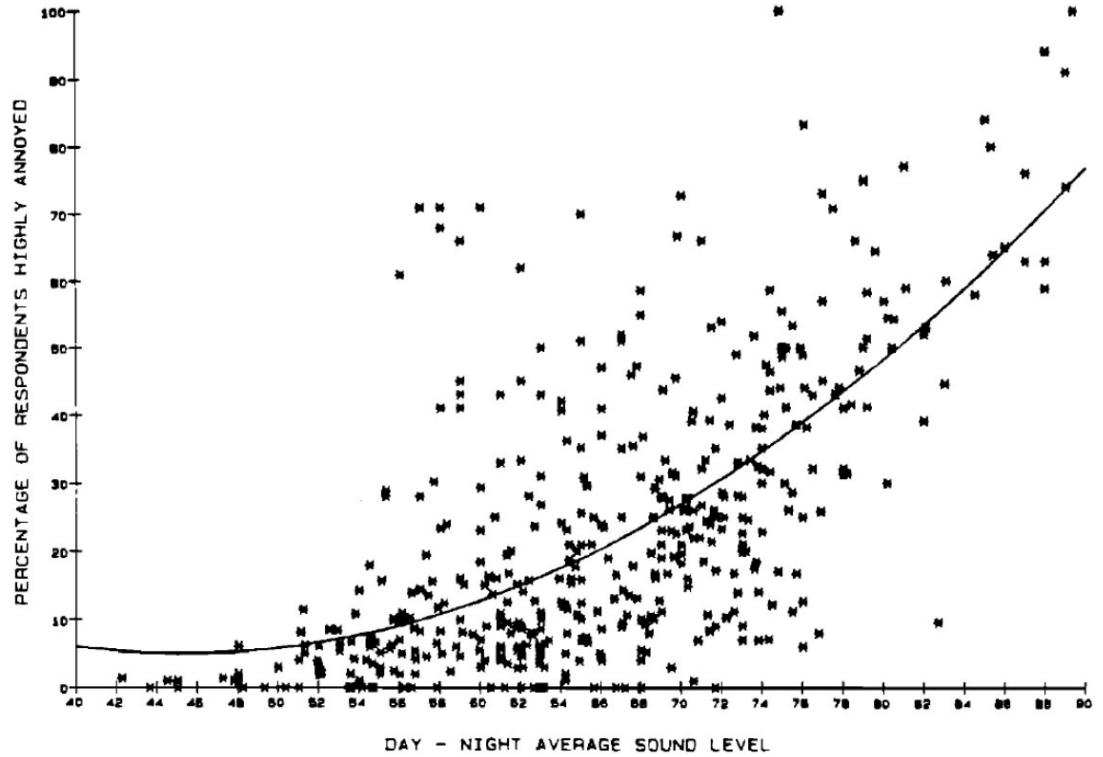


Figure 2. All 453 Data Points Used in Updated Dose Response Curve

Using the new data set, a new prediction curve was developed, and adopted by the U.S. Federal Interagency Committee on Noise (FICON) in 1992 for use by Federal agencies in aircraft noise-related environmental impact analyses. It was also adopted as part of the American National Standards Institute (ANSI) Standard on community responses to environmental noises. Figure 3 presents the updated curve in comparison to the original Schultz Curve.

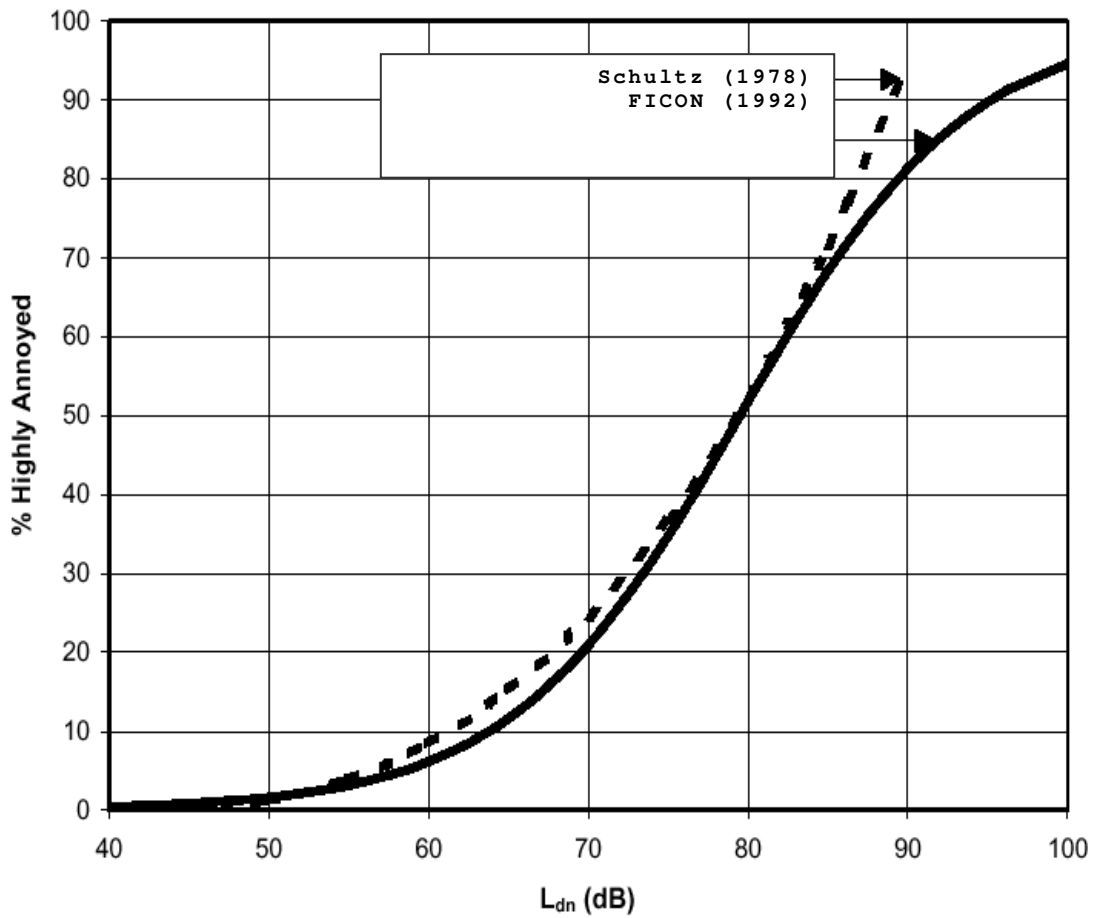


Figure 3. Response of Communities to Noise; Comparison of Curve Fits Original and Current

Since 1992, environmental planners have relied heavily on the FICON Curve (updated Schultz Curve) for predicting the community annoyance produced by noise from transportation noise sources. Notwithstanding the methodological questions, errors in measurement of both noise exposure and reported annoyance, data interpretation differences, and the problem of community response bias, the relationship has historically been the most widely accepted interpretation of the social survey literature on transportation noise-induced annoyance.

The FICON Curve also serves as a means for predicting the annoyance of subsonic aircraft operations in more remote areas under Military Training Routes (MTRs), Military Operating Areas (MOAs), weapon ranges, refueling tracks and other Special Use Airspace.

## DISCUSSION

To understand annoyance it is also necessary to appreciate the complexity of the factors that influence the relationship between aircraft noise and community reaction including:

Reactions to individual transportation sources (air, road, and rail),

Habituation,

Background noise environment (urban vs. rural),

Non-acoustic factors, and

Community Attitudes and Experience.

Reactions to individual transportation sources

The original Schultz curve and the subsequent update assumed that the relationship between percent highly annoyed and DNL was independent of the noise source. In essence, the Schultz curve assumes that the effects of long-term annoyance on the general population are the same, regardless of whether the noise source is road, rail, or aircraft. In the years after the classical Schultz analysis, additional social surveys have been conducted to better understand the annoyance effects of various transportation sources. This additional research found separate, non-identical curves for aircraft, road traffic, and railway noise. The additional research suggests that the percentage of people highly annoyed by aircraft noise alone may be higher than previously thought, and higher than the truck and rail noise curves.

While the FICON recommended further research to investigate the differences in perceptions of aircraft noise, ground transportation noise (highways and railroads), and general background noise, they found that the updated Schultz Curve remains the best available source of empirical dosage effect information to predict community response to transportation noise without any segregation by transportation source. This position is still held by DoD and the other Federal agencies that comprise the Federal Interagency Committee on Aircraft Noise (FICAN).

Habituation

A dictionary definition of habituation is “the gradual decline of a response to a stimulus resulting from repeated exposure to the stimulus.” For example, a novel sound in one’s environment, such as a new ring tone, may initially draw attention or even become distracting. After becoming accustomed to this sound, less attention is paid to the noise and the degree of response to the sound will diminish. This diminished response is “habituation.” Some people are highly noise sensitive compared to others. Repetitive loud noises over a period of time become less intrusive to most (but not all) people, because they habituate to their noise environment. Those citizens who are least able to habituate generally comprise the “highly annoyed” group, who are more likely to register complaints with airport and elected officials. The length of time required for individuals to habituate to repetitive noise and their degree of habituation varies considerably within each exposed community.

The opening of the new Denver Airport in the mid 90’s provides a good example of habituation. Rather than a gradual shift of operations from Denver’s Stapleton Airport to the new Denver International Airport, the entire shift of all operations occurred overnight. The first year noise complaints exceeded 200,000, many coming from people residing 20 or more

miles from the airport. Over time complaints have dwindled to almost none. This initial public response to the sudden noise shift was predictable, as was the eventual habituation of the majority of exposed citizens.

The noise histories of airports around the world consistently show that shifting flight tracks or introducing new corridors over noise sensitive areas for the first time provoke the strongest opposition to new airports and the expansion of existing airports. While this discussion draws on aviation noise for examples, similar shifts or changes in other military operations that produce noticeable or intrusive noise levels is equally predictable.

It is generally assumed that the noise exposures of interest for policy-making purposes are recurring and that the population has had sufficient time to habituate to major changes in their community-wide noise exposure. Thus, community annoyance is the aggregate community response to long-term, steady-state exposure conditions. Case studies indicate that no matter how large the protection area around a new or expanding airport, there will be considerable noise complaints until the majority of the newly impacted population becomes habituated. Overall, it is clear that habituation is an important factor that should be considered when determining threshold levels of annoyance and activity interference from aircraft noise.

### Rural vs. Urban Environments

A fundamental characteristic of noise from aircraft overflight and from many other military operations is that high sound levels typically occur for short periods of time. These events are experienced against a background sound level that varies considerably, depending on the local environment, be it non-urban (rural) or urban. The background noise level is a slowly varying combination of all the nearby and distant noise sources. Transportation, construction, military or industrial, and other human activity are the main background noise contributors in an urban or suburban area. In a rural setting, wind, moving water, and animals comprise a larger part of the background sound level, and human activity comprises less of the total. People are generally unaware of the background noise level unless they specifically try to listen for it. Because background noise levels depend so much upon activities of people, and especially on ground traffic, the level varies from one community to another, but is typically lower at night in all settings.

A given noise event will be perceived by most people to be more intrusive if heard against a lower background noise level, and thus, will generally be more noticeable or intrusive in a quiet non-urban (or rural) community than in a busy urban area.

It seems intuitive that most people are more aware of a noise event if it stands out clearly above the general background noise level. However, with regard to aviation noise, the findings and conclusions of the various studies conducted to date are not consistent, perhaps because, aircraft noise levels near airports are typically so much higher than the background noise level that the absolute magnitude of the background noise may be immaterial.

### Non Auditory Contributors to Annoyance

As shown in Figure 2, the large scatter among the data drawn from the various surveys reflects the low correlation coefficients for individuals' reactions. Thus, considerable uncertainty is associated with the equation representing the relationship between %HA and DNL. Base on this wide variation of data in the survey results, noise exposure explains only about half of the observed variance in annoyance. Thus, researchers generally agree that non-acoustical factors also play a major role in annoyance responses to transportation noise.



Since research studies to date have not produced a process to accurately attribute annoyance responses to acoustic and non-acoustic factors, it is not possible to accurately predict annoyance responses to aircraft noise exposure in any specific community.

Several studies have identified a number of non-acoustic factors that influence individual annoyance responses. These factors can be categorized as either emotional and physical variables:

Emotional Variables include:

- Feelings about the necessity or preventability of the noise,
- Judgment of the importance and value of the activity that is producing the noise,
- Activity at the time an individual hears the noise,
- Attitude about the environment,
- General sensitivity to noise,
- Belief about the effect of noise on health, and
- Feeling of fear associated with the noise.

Physical Variables include:

- Type of neighborhood,
- Time of day,
- Season,
- Predictability of noise,
- Control over the noise source, and
- Length of time an individual is exposed to a noise.

### Community Attitudes and Experience

Individual and community attitudes toward the source of noise, previous exposure levels and trends, may influence perceptions that noise levels are higher or lower than they actually are. Some of these perceptions are fueled by: relationships with the installation, increasing quality of life standards as time progresses, ability to relate to the noise sources, and other factors; particularly the type or necessity of operations.

The general perception of the community towards the purpose of operations that generate noise complaints is very important. A study performed for the Massachusetts Airport Commission (MAC) in 1978 concluded that the public will tolerate higher noise levels if they are generated by military rather than civilian operations. Especially in the U.S., immediately after the events of September 11, 2001, the sight of military aircraft over U.S. cities generated a sense of safety and generated few noise complaints. The same phenomenon can be seen from air ambulance or law enforcement aircraft operations.

Some studies have found that fewer complaints occurred at airports with a history of cooperation between the community and the airport. When community members feel that the airport operator (whom they blame for the annoying sound) is unresponsive to their complaints, noise becomes a catalyst that reminds people of the airport's unresponsiveness,

motivating some to complain when noise is only noticeable rather than intrusive. Conversely, if people believe that good faith efforts are being made to address noise problems, their attitude is likely to be more neutral and they will be less like to complain when noise events are less than intrusive. This phenomenon is generally applicable to all military facilities that conduct operations that expose nearby populations to noise.



## FINDINGS/CONCLUSIONS

DNWG is not aware of any research to suggest that there is a better metric than DNL to relate to annoyance. However, there remains significant controversy over the use of the dose-response annoyance curve first developed by Schultz, and later updated by others. While the curve is presented as a smooth definitive relationship between DNL and annoyance, the fact is that there is an extraordinary amount of scatter in the data used to develop the curve. Investigations that report a distinct percentage of the population that will be highly annoyed at a given DNL may incorrectly be interpreted as having a more precise meaning than should be taken from the data. Furthermore, recent research tends to support the idea that the dose-response curves are different for aircraft, road and rail noise sources. An area of research that remains to be investigated is the relationship between single event noise levels and annoyance. The expanding use of airport noise monitoring systems, flight tracking systems and Geographic Information Systems (GIS) may make the evaluation of annoyance and single event noise rich for further examination.

DNWG, like FICAN, regards the updated Schultz Curve as the best available source of empirical dosage effect information to predict community response to transportation noise without any segregation by transportation source for the foreseeable future. Means for predicting the immediate annoyance of individual overflights, other intermittent operations that produce noise, the long term annoyance of sonic booms near supersonic Military Operations Areas (MOAs), and the long term annoyance of exposure to sporadic low altitude, high speed flights near Military Training Routes (MTRs) remain less well developed. However, the updated Shultz Curve also serves as a means for predicting the annoyance from subsonic aircraft operations in more remote areas near MTRs, MOAs, weapon ranges, and refueling tracks.

Given that the individual percent highly annoyed data points that went into the synthesis of the Shultz Curve ranged from about 5% to over 70% at DNL 65 dB, and that recent research indicates that the percentage of people highly annoyed by aircraft noise may be higher than previously thought, caution should be exercised when interpreting synthesized data from different studies and any assumptions that the level of annoyance in any particular community near a military facility will closely match the average annoyance shown by the original or the updated Shultz Curve. In other words, it is inadvisable to predict that a specific percentage of the population affected by your operations will be highly annoyed at a given DNL.

The most common and direct method for estimating the annoyance associated with aircraft noise exposure in a community is by social survey. Methods of predicting community annoyance have advanced to the point that valid assessments can be made of the long term annoyance from changes in aircraft noise generally encountered in neighborhoods near military installations. Using the relationship between %HA and DNL shown in Figure 3 above, the %HA can be estimated for a two conditions, and hence any increase in %HA can be estimated. Table 1 below shows how %HA can provide a different perspective on the effects of noise to supplement the DNL analysis.

At Location 1, for example, the DNL increase of 14 dB (from 50 dB to 64 dB) is the highest increase at any location, but is ranked only seventh in terms of an increase in %HA with a value of 9%. At Location 15 the ending DNL is the highest with a value of 75.5 dB, but the increase in %HA is higher at Location 10 with a value of 18% (versus 16%) even though the ending DNL at this location is 73 dB. Again, it is important to emphasize that the absolute

values of %HA in any particular community, as predicted by the average relationship in Figure 3, should only be used as general indicators of the actual community annoyance, providing a basis from which the predicted increases in %HA can be assessed.

**Table 1. An Example of Supplemental Analysis of Annoyance**

Location	Starting DNL, dB	%HA from Schultz Curve*	Ending DNL, dB	Change in DNL, dB	Increase in %HA
1	50.0	2%	64.0	14.0	9%
2	50.0	2%	58.0	8.0	3%
3	50.0	2%	47.0	-3.0	-
4	55.0	3%	62.0	7.0	5%
5	55.0	3%	57.5	2.5	2%
6	55.0	3%	60.0	5.0	3%
7	60.0	6%	68.0	8.0	12%
8	60.0	6%	67.0	7.0	10%
9	60.0	6%	58.5	-1.5	-
10	65.0	12%	73.0	8.0	18%
11	65.0	12%	64.0	-1.0	-
12	65.0	12%	71.0	6.0	13%
13	70.0	22%	74.5	4.5	13%
14	70.0	22%	72.0	2.0	5%
15	70.0	22%	75.5	5.5	16%

The typical presentation of exposure in DNL is thus complemented by estimates of the percentage increase in highly annoyed people in the community. This type of analysis also reveals that there are people who are highly annoyed by aircraft noise when the exposure is less than DNL 65 dB, which would not be as evident when just looking at DNL contours. Note also that Locations 4 and 8 with identical increases in DNL (7 dB) show much different changes in annoyance due to the higher starting DNL exposure at Location 8.

A factor that must be considered in such an analysis is that the relationship between annoyance and DNL is based on long-term exposure to the noise. It is likely that the response of the affected community is tempered by habituation to the noise climate, which was discussed above. Thus, the supplemental analysis of annoyance identifies the possible long-term reactions of the residential communities, while their immediate reactions to the implementation of the project may be more severe.

The supplemental analysis of annoyance is intended to evaluate the effect of an increase in DNL not decrease in DNL. In Table 1, for example, Locations 3, 9, and 11 do not have values of increases in %HA because the ending DNL is lower than the starting DNL. It is reasonable to conclude that since noise exposure is a factor, then an increase in noise should

produce some increase in the amount of people highly annoyed. But, it is not reasonable to conclude that a decrease in noise exposure will result in a decrease in the number of people highly annoyed, because the factors affecting these people may be non-acoustic.

Base officials should anticipate sharp increases in noise complaints from affected populations in response to any change in mission that will result in a rapid increase in public exposure to new operations that produce noticeable or intrusive noise levels. When conditions permit these changes to be introduced gradually, thus allowing sufficient time for some habituation to occur, officials can expect the number of complaints from affected populations to be lower. Clearly, habituation is an important factor that should be considered when possible, in determining threshold levels of annoyance and activity interference from operations that produce high noise levels.

There is considerable evidence that community reactions to noise are strongly influenced by the public's perception of circumstances surrounding the flights, the type of flight and the reason for its occurrence, and that these factors should be considered when anticipating the public response to mission change alternatives.

The degree of community response to noise exposure is not totally dependent on exposure levels. Where the community annoyance level is primarily driven by acoustic exposure, reductions in exposure can be expected to lead to reductions in annoyance. However, in communities where annoyance is driven more by non-acoustic factors, such as negative attitudes toward the mission or the military in general, there may be little or no reduction in annoyance associated with reductions in exposure. This is an important distinction when planning mission changes that have noise ramifications. Where community annoyance has historically been more associated with non-acoustic factors, strong community opposition to proposed or actual mission changes should be anticipated. Regardless of the source of community annoyance, DoD officials should consider addressing changes in noise exposure not just with noise abatement and mitigation measures, but also with non-acoustic measures, such as assisting affected communities, where possible, with their community improvement initiatives.

## REFERENCES

A complete list of references supporting the information in this Technical Bulletin is available in a document entitled: "Improving Aviation Noise Planning, Analysis and Public Communication with Supplemental Metrics – Guide to Using Supplemental Metrics." Copies of this document are available upon request from the DNWG.





Available online at:

<https://www.denix.osd.mil/portal/page/portal/denix/environment/DNWG>



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