A Review of US Aircraft Noise Regulatory Policy

Sanford Fidell

Postal:
Fidell Associates, Inc.
23139 Erwin Street
Woodland Hills,
California 91367
USA

Email:
sf@fidellassociates.com

Why do Federal aircraft noise regulatory policies only rarely accomplish their own goals?

Introduction

Vigorous community opposition to aircraft noise exposure is more the rule than the exception at airports worldwide, particularly when efforts are made to increase airport capacity or change operational patterns. Since the introduction of commercial jet service in the late 1950s, these disputes have often been highly contentious, to the point of intense political debate and costly litigation. Beranek (2008) provides a notable account of one of the earliest US airport noise controversies. The ongoing, national-level debate in the United Kingdom over the addition of a runway to a London-area airport is a current example. Noise-related airport-community controversies are ongoing at airports in many US cities, including Chicago, Ft. Lauderdale, Minneapolis, all of the major New York airports (not to mention East Hampton), Phoenix, and Santa Monica.

The contentiousness of airport-community controversies arises in large part from disparities in the distribution of costs and benefits of air transportation. Most of the noise-related costs of air transportation but relatively few of its benefits accrue to overflown populations near airports. Other interests, including those of the traveling public, airlines, and airports, enjoy more of the benefits of air transportation but bear few of its costs.

National aircraft noise regulatory practices rarely succeed in accurately predicting or securing public acceptance of aircraft noise exposure in airport-vicinity communities. Weaknesses of aircraft noise regulation are traceable in large part to obsolete and overly simplified policies that ignore nonacoustic influences on community response. This review of US aircraft noise regulation describes its origins, rationale, complexities, and limitations.

The review extends to modern technical understandings that may help improve the efficacy of aircraft noise regulation. It is now possible to systematically derive regulatory thresholds for noise exposure values from two parameters: (1) the percentage of the population of a hypothetically average community to be protected from exposure to highly annoying aircraft noise and (2) the percentage of all communities to which such protection is intended to apply (Fidell et al., 2014.)

Some Legislative, Political, and Judicial Background

Commercial aviation in the United States has been favored as a public good by the US Congress in much the same way that it once viewed railroads and highways. Government subsidies to aviation have included lucrative airmail contracts in the 1920s; creation of nationwide, federally funded aerial navigation and air traffic control systems; limitation, until 1978, of commercial airline competition by maintenance of barriers to entry; much military and other aviation research; and export financing. When the Civil Aeronautics Board regulated airfares, airlines even had a federal guarantee of return on investment!

Airports have long enjoyed the use of federal and municipal capital for infrastructure construction; access to federal trust funds for mitigating noise impacts; and tax-advantaged municipal bond markets for project financing, even after starting to convert themselves in the 1980s from municipal utilities into shopping malls with runways nearby.

Because regulatory agencies in the United States are creatures of legislatures, aircraft noise has consequently been regulated with a light touch. The US Congress has, with few exceptions, provided policy direction that has yielded a playing field steeply tilted in favor of aviation interests. Public Law 85-726, the much-amended 1958 legislation that originally established the Federal Aviation Administration (FAA) as an independent agency, assigned a "dual mandate" to the agency: not only to regulate the national air transportation network for purposes of safety and efficiency but also to actively *promote* civil aviation. Although Congress relieved the FAA of this inherent conflict of interest in the 1996 Department of Transportation Reauthorization Act, the agency has yet to revise its noise regulatory policies to reflect the revised Congressional direction.

US airports also received generally favorable treatment, at least until a 1962 Supreme Court ruling in Griggs vs. Allegheny County assigned liability for noise damages exclusively to airport proprietors rather than to airlines (owners of the noise sources) or to the federal government (responsible for directing the movements of the noise sources while in flight). The ruling freed airlines and the FAA from liabilities for adverse environmental effects of exposure to commercial aircraft noise while leaving airports deeply enmeshed in aircraft noise disputes. Today's aircraft noise regulatory environment would be very different had the Supreme Court ruled otherwise.

Aircraft Noise Metrics

Airport-community disputes of all kinds generally center on aircraft noise exposure. The baroque set of aircraft noise metrics that has been proposed over several decades for quantifying aircraft noise is a tribute to the collective imagination of generations of acousticians, environmental noise researchers, academics, consultants, politicians, and technocrats. Schultz (1972), Bennett and Pearsons (1981), and Mestre et al. (2011), among others, have cataloged the alphabet soup of noise rating schemes intended to predict community response to aircraft noise. The focus on aircraft noise measurement in airport-community controversies is sometimes so close that the underlying purpose for quantifying aircraft noise is overlooked. Aircraft noise is not measured simply for measurement's sake but as a means to an end. For regulatory purposes, aircraft noise is measured to quantitatively predict its effects ("impacts" in the environmental analysis vernacular) on noise-exposed populations. If aircraft noise did not disturb sleep, interfere with speech, and annoy people, however, few would find it worth the bother and considerable expense of measurement in the first place. It follows that any noise metric that does not support a reliable prediction of community response to noise does not play a useful role in aircraft noise regulation.

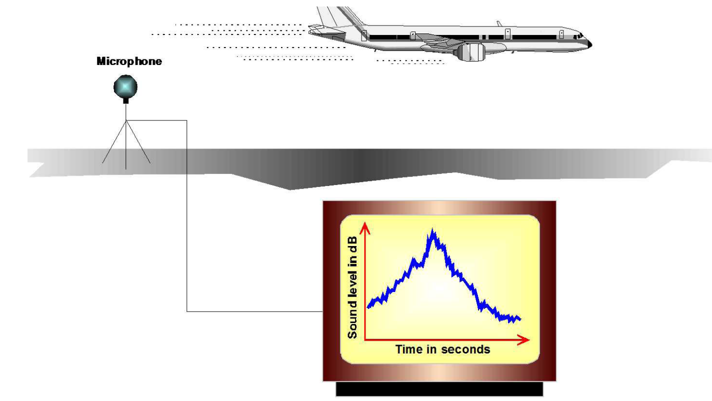

Figure 1. *Nominal time history of an individual aircraft overflight as observed on the ground in the vicinity of an airport.*

Aircraft noise experienced in airport communities varies simultaneously and greatly in the amplitude, frequency, and time domains. As illustrated in **Figure 1**, within about half a minute, an individual overflight heard in an airport neighborhood characteristically emerges from the neighborhood ambient-noise environment into noticeability as an aircraft approaches an observer on the ground; increases in sound level more or less steadily, often by 30 dB or more, as the aircraft approaches; changes continuously in character and frequency content due to the directivity of its narrow- and wideband engine and aerodynamic noise sources; and finally, decreases in sound level as the overflight recedes from the observer until it merges back into ambient-noise levels. In neighborhoods near the ends of runways, overflights may recur at about two-minute intervals, more or less continually, throughout many hours of the day and night.

Day-Night Average Sound Level

What aspect of such aircraft noise events constitutes the "best" measure of them: their frequency-weighted maximum level, individual duration, total number, energy average, temporal distribution, dynamic range, variance, tonal content, signal-to-noise ratio, rise and decay times, Doppler shift, or some other yet more subtle characteristic? The Airport Safety and Noise Act (ASNA) of 1979 (Public Law 96-193) required the Secretary of Transportation to identify a single, universally applicable aircraft noise measure-

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ment system. ASNA also required the Secretary of Transportation to "establish a single system for measuring noise that… has a highly reliable relationship between projected noise exposure and surveyed reactions of individuals to noise." Although Congressional mandates can direct executive agencies, they cannot create objective facts or statistical relationships. Just as King Canute (https://en.wikipedia.org/wiki/ King_Canute_and_the_waves) proved unable to command the tide to recede, a reliable predictive relationship for transportation noise-induced annoyance prevalence rates that is based on noise exposure alone exceeds both Congress's power to command and the FAA's ability to devise.

Six years after Congress passed ASNA, the FAA formally endorsed the Environmental Protection Agency's (EPA's) cumulative 24-hour, time-weighted average measure of A-weighted sound levels in Part 150 of the Federal Aviation Regulations. The measure is known as the Day-Night Average Sound Level (DNL) and is represented symbolically in mathematical expressions as L_{dn}.

Before ASNA, the FAA was unenthusiastic and noncommittal about the usefulness of equivalent energy measures of aircraft noise, in no small part because DNL had not been developed by the FAA. The FAA's position subsequently evolved to near-exclusive reliance on DNL for quantifying aircraft noise exposure and for predicting its consequences. (The FAA acknowledges the potential utility of other measures of aircraft noise for specialized purposes but offers no interpretive criteria or policy decision points for noise metrics other than DNL for purposes of assessing the significance of aircraft noise impacts.)

- Although DNL is commonly denigrated in public challenges to environmental impact disclosure exercises and other public debates, the measure is consistent with current scientific consensus standards (e.g., International Organization for Standardization [ISO], 2016). The noise measure itself is widely misunderstood and misinterpreted and is often distrusted by the public for various reasons. Mestre et al. (2011) point out that a cumulative 24-hour time-weighted annual average exposure level is an abstract concept, far removed from common experience. A quantity of noise exposure expressed in units of DNL cannot be directly experienced by casual observation in the same sense that the maximum sound level of a single noise event can be heard.
- Even though DNL values reflect all of the noise energy occurring during a 24-hour period, its very name, Day-Night Average Sound Level, is commonly misconstrued as implying that the measure is somehow insensitive to high-level noise events.
- The logarithmic arithmetic necessary to manipulate DNL values, and the normalization of the decibel notation to $10\log_{10}$ (86,400 seconds/day) are nonintuitive and poorly understood by nontechnical audiences.
- Understanding of prospective aircraft noise modeling and annual average day noise exposure contours, the context in which the public often encounters DNL-based information, is poor. Prospective contours are inevitably speculative to some degree because there are no facts about the future. The public nonetheless often confuses prospective noise contours with actual aircraft noise measurements or with retrospective noise contours. Noise contours themselves are sometimes misinterpreted as step functions and would be more usefully depicted with shading rather than sharp boundaries.

DNL is used in environmental impact disclosure documents as a required metric of noise exposure. However, the public does not fully appreciate the difference between DNL itself and the interpretive criteria that the FAA applies to DNL values for policy reasons. The resultant focus on the metric in lieu of a descriptive discussion of noise impacts is confusing and potentially misleading. DNL also often suffers from a "shoot-the-messenger" reaction to unpopular policies that are stated in decibels. This leads to a common criticism of DNL as a metric rather than a criticism of the manner in which noise exposure levels are interpreted for regulatory purposes.

Noise Effect of Greatest Concern for Regulatory Purposes

The rationale for FAA noise regulatory policy is described by the Federal Interagency Committee on Noise (FICON,1992). FICON states that "…the percent of the exposed population expected to be highly annoyed (%HA) [is] the most useful metric for characterizing or assessing noise impact on people," and that "…the updated 'Schultz curve' remains the best available source of empirical dosage-effect information to predict community response to transportation noise." The "Schultz curve" is an early dosage-response relationship (Schultz, 1978) linking transportation noise exposure to the prevalence of a consequential degree of transportation noise-induced annoyance in communities. The original analysis by Schultz has been revisited several times in subsequent decades and is now obsolete.

Rationale for Basing Aircraft Noise Regulation on Cumulative Noise Exposure

The tacit belief underlying use of DNL to predict community response to aircraft noise is known as the "equal energy" hypothesis. The hypothesis holds that annoyance with aircraft noise exposure is equally influenced by the number, duration, and acoustic energy of aircraft noise exposure. In other words, the equal energy hypothesis asserts that it is not simply the sound level of an aircraft overflight, the duration of individual overflights, or the number of overflights that controls its annoyance but the multiplicative product of all three.

Because DNL values reflect the simple product of all of the primary factors (sound level, duration, and number) that can reasonably affect the annoyance of aircraft noise exposure, it is equally sensitive to all of them. Thus, if the number of aircraft operations changes by a factor of two (that is, by 3 dB), or if the duration of aircraft overflights changes by a factor of two, or if the acoustic energy of individual aircraft overflights changes by 3 dB, so does DNL. In practice, this means that DNL is highly correlated with all sensible measures of aircraft noise.

The equal energy hypothesis stems from beliefs dating to the 1950s, (1) that the findings of laboratory studies of the acoustic determinants of annoyance can be freely generalized to community settings; and (2) annoyance with residential exposure to aircraft noise can be adequately accounted for in exclusively acoustic terms.

With the advantage of hindsight, these assumptions about the causes of community annoyance with transportation noise exposure appear naïve, but to the World War II generation of acousticians who first made them, they seemed quite plausible and worthy of careful investigation.

After decades of subsequent research, neither of the above assumptions has proven to be tenable. In closely controlled laboratory measurements (of the sort described by Zwicker and Fastl [1999], for example), reliable differences can be observed in the ability of frequency-weighted measures of aircraft noise levels to predict individual annoyance judgments. In uncontrolled (real world) settings, however, community annoyance is not controlled by acoustic factors alone. Difficulties in measuring and predicting aircraft noise levels lead to further uncertainty in estimating noise-exposure levels.

Why Regulate Aircraft Noise?

All regulation seeks to balance conflicting societal interests. In the case of aircraft noise, the conflicting interests include satisfying nationwide demand for air transportation services, maintaining the habitability of residential neighborhoods near airports and the integrity of local government tax bases, and protecting both public investment in airport infrastructure and private residential property values.

The public conception of the purpose of aircraft noise regulatory policy in the vicinity of airports is to protect some percentage of residential populations from exposure to highly annoying aircraft noise. This is not the FAA's primary purpose, however. The agency sees protection of public investment in airports as the primary purpose for noise regulation. For example, the FAA's "land use compatibility" guidelines are intended to restrict land uses around airports to those that do not threaten continued operation and unfettered expansion of airports.

The FAA lacks authority to mandate off-airport uses for land that airports do not own. It is therefore careful to characterize its preferences for airport-vicinity land uses as advisory (cf. the well-known footnote to Table 1 of Appendix A of FAR Part 150) rather than mandatory, in large part to avoid reassuming any of the noise liability of which the Supreme Court relieved the agency in 1962. In effect, the FAA interprets its charter as protecting airports from communities.

The foundational questions that aircraft noise regulatory policy must answer are "How much noise is too much?" and "How can you tell?" The FAA's answers to these questions are that noise impacts due to aircraft noise exposure at L_{dn} <65 dB do not rise to a level of "significance," and that FICON's 1992 report somehow or other supports the FAA's policy determination that noise impacts associated with aircraft noise exposure at L_{dn} ≤65 dB are insignificant.

As with other issues in aircraft noise controversies, the customary answers to these questions are, in H. L. Mencken's (1949) words, appealingly "neat, plausible, and wrong." Although the FAA and other national regulatory bodies worldwide assert that their regulatory decisions are "fact and science based," the assertion does not withstand scrutiny. To understand why aircraft noise regulatory policy is not technically credible, it is helpful to understand the scientific progress that has been made in understanding community response to transportation noise since the 1950s.

Some Landmarks in Aircraft Noise Assessment and Regulation

The initial systematic efforts to predict community response[1] to aircraft noise exposure included those of Rosenblith et al. (1953) and Stevens et al. (1955). The early Community Noise Rating (CNR) approach to characterizing adverse community reaction to aircraft noise interpreted the findings of a score of case studies of community reaction to aircraft noise in terms of "sporadic" through "widespread" complaints, "threats of community action," and "vigorous community action" (Fidell, 2003). CNR values in airport neighborhoods were scaled in decibel-like (10 log[ratio]) units.

Community response to noise was classified solely with respect to complaint behavior. The original CNR classification of community response distinguished three categories of severity of noise impact. (As described below, it was not until two decades later that the technical rationale for regulation switched from managing complaints, an overt behavior, to limiting annoyance, a covert mental attitude.) After development of the effective perceived noise level (EPNL) metric in the late 1950s as a direct consequence of the controversy surrounding the start of jet operations at New York airports, CNR values were converted into Noise Exposure Forecast (NEF) values

$$\mathrm{NEF} = \mathrm{EPNL} + 10\log_{10}(\text{number of daytime flight operations} + 16.7 * (\text{number of night operations}) - 88\ \mathrm{dB}$$

The constant 16.7 represents a 10-dB nighttime penalty on the number of operations per hour (not the cumulative number of operations) when the ratio of 16 daytime hours to 9 nighttime hours is taken into account. Both constants in the above equation are assumptions of convenience based on engineering judgment such as that of Galloway and Pietrasanta (1963). The constants were intended (1) to weight nighttime flights 10 times more heavily than daytime flights and (2) to avoid confusion between CNR and NEF values. The approximate relationship between NEF and CNR values was NEF = CNR – 72 dB.

[1] *The term "community response" to noise has served since the late 1970s as an informal term for the percentage of a representative sample of noise-exposed residents who describe themselves as consequentially annoyed by transportation noise. This percentage has been measured directly in many field studies of community response to aircraft noise exposure since the first modern social survey of this kind was undertaken at London Heathrow Airport (McKennell, 1963).*

On the basis of little more than engineering judgment informed by field experience, much of it near military airbases, NEF values of 30 dB or less were thought to be suitable for aircraft noise exposure in areas of single-family detached dwellings. NEF values between 30 and 40 dB were thought to be tolerable in neighborhoods of higher density housing, and NEF values in excess of NEF = 40 dB were thought of as suitable only for industrial and recreational purposes. When NEF values were supplanted by DNL values after publication of EPA's *Levels Document* in 1974, a further "correction" of 35 dB was added to NEF values to distinguish them from DNL values.

All of the above corrections, adjustments, and constants were based on the personal opinions of acoustical consultants practicing in the 1950s through 1970s, not on large-scale systematic research. All long precede ASNA's direction to the FAA. FAA's land use compatibility guidelines were summarized in a 1980 report issued by a "Federal Interagency Committee on Urban Noise (FICUN)" that describes "land use compatibility" with airports, not reciprocally between airports and communities. None of the interpretations of compatibility made in the FICUN report were supported by any form of comprehensive, community- or theory-based, peer-reviewed, or otherwise objective study, and none have been meaningfully revised. What informally seemed to some to be an acceptable level of noise pollution near military airfields six decades ago is not necessarily still acceptable in modern civil society.

What's Wrong with FICON's 1992 Analyses?

The FAA cites a technical report (FICON, 1992) produced by a self-appointed Federal Interagency Committee on Noise as the technical basis for its policy preferences. The report asserts that the dosage-response relationship shown in **Figure 2** reliably predicts the percentage of a nominally average community that is highly annoyed by the cumulative noise exposure of a community on a hypothetical, annual average day. The FICON dosage-response relationship was devised to update a key linkage between aircraft noise exposure and community response that had been developed by Schultz (1978).

Schultz's 1978 "synthesis" study was the earliest large-scale examination of a fragmented international literature on the annoyance of transportation noise. Schultz showed that the findings of disparate studies could be interpreted to yield predictions of the prevalence of a consequential degree of

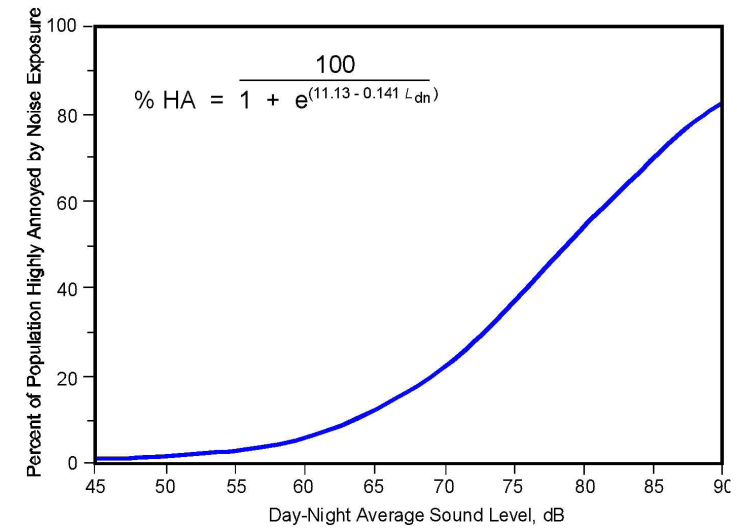

Figure 2. Dosage-response relationship developed by Federal Interagency Committee on Noise (FICON, 1992) and endorsed by the Federal Aviation Administration (FAA) for predicting the prevalence of high annoyance in communities from cumulative exposure to aircraft noise. %HA, percent of the exposed population expected to be highly annoyed; L_{dn}, Day-Night Average Sound Level.

annoyance attributable to a community's transportation noise exposure. Successors to Schultz's dosage-response function continue to provide the technical underpinnings of modern standards such as International Standard 1996-1 (2016).

Ground breaking as it was four decades ago, Schultz's 1978 dosage-response relationship was already obsolete by 1992. Both Schultz's and FICON's dosage-response relationships were flawed in important ways. Most obviously, they failed to distinguish among the annoyance of aircraft and other forms of transportation noise exposure. Decibel for decibel, communities are more tolerant of road and rail noise than of aircraft noise (Miedema and Vos, 1998). Including the annoyance of road and rail noise in a generic dosage-response relationship forces it to underpredict the annoyance of aircraft noise exposure.

Both the Schultz (1978) and FICON (1992) dosage-response relationships are demonstrably incorrect and do not yield reliable or credible predictions of the prevalence of aircraft noise-induced annoyance. They are both based on limited sets of dated field observations; exclude data from some surveys documenting high annoyance prevalence rates at modest noise-exposure levels; and considerably underestimate the annoyance of aircraft noise exposure in many communities.

The FICON dosage-response relationship accounts for only about a fifth of the variance in the relationship between aircraft noise exposure and the prevalence of high annoyance in communities, and virtually none of the variance in the range of greatest regulatory interest: 55 dB ≤ L_{dn} ≤ 65 dB (Fidell and Silvati, 2004). **Figure 2** is misleading because it does not display the data that FICON's relationship supposedly represents.

Figure 3 illustrates the enormous variability in annoyance prevalence rates of residential populations in different communities. Each of the 500+ open circles represents an empirical field measurement of the prevalence of aircraft noise-induced annoyance. **Figure 4** shows that the FICON fitting function falls far short of the centroid of this cloud of data points. As such, it fails to explain or otherwise account for the great majority of the variance in the relationship.

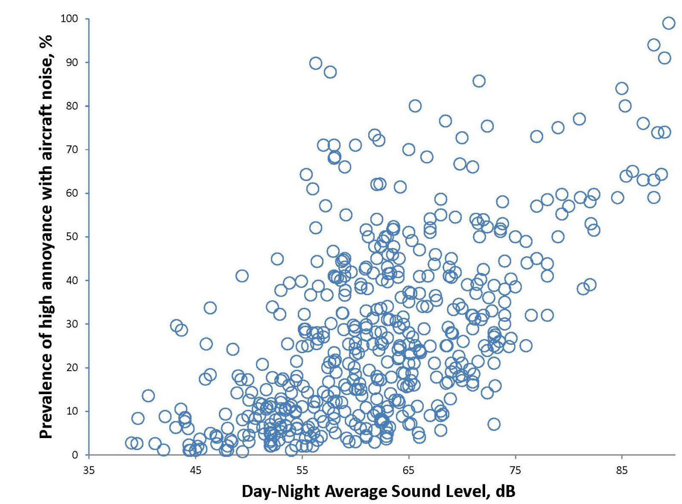

Figure 3. Illustration of the great variability in field measurements of aircraft noise-induced annoyance prevalence rates in approximately 550 communities.

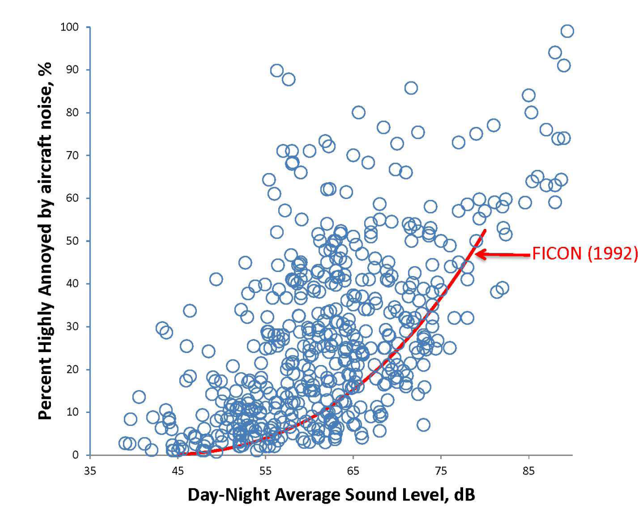

Figure 4. Summary of worldwide observations of the prevalence of all transportation noise-induced annoyance. The solid curve in the figure is a dosage-response relationship relied on in the United States to predict annoyance prevalence rates in all communities to all transportation noise sources.

Modern Understandings of Community Response to Aircraft Noise Exposure

Figure 5 illustrates the differences between FICON (1992) and the latest analysis of the prevalence of high annoyance due to aircraft noise exposure of Annex F of the ISO Final Draft of International Standard 1996-1. At the same aircraft noise-exposure levels, the modern (red) function reveals that considerably greater percentages of residential populations are highly annoyed by aircraft noise exposure than predicted by the obsolete (blue) function.

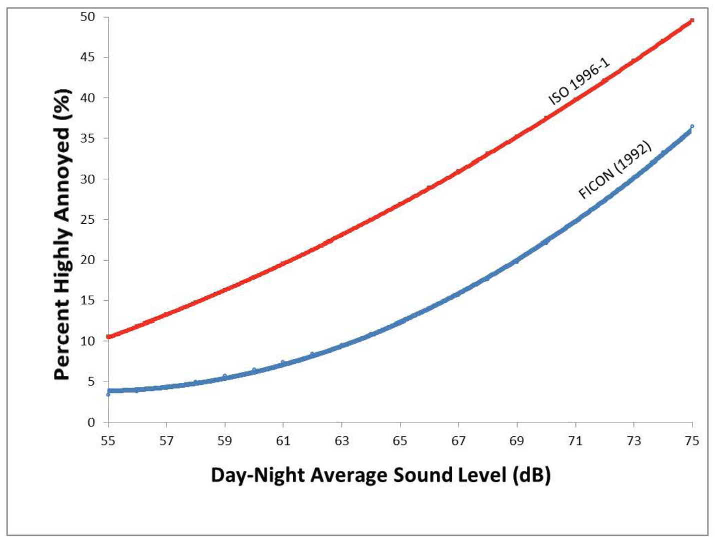

Figure 5. Comparison of FICON (1992) and International Organization for Standardization (ISO; 1996-1) predictions of aircraft noise-induced percentages of high annoyance for a community of average tolerance for aircraft noise.

For example, the FICON dosage-response relationship predicts that 12.3% of the residential population is highly annoyed at a noise-exposure level of L_{dn} = 65 dB. Current information indicates that, on average, about 28% of the population is highly annoyed by aircraft noise exposure of L_{dn} = 65 dB. The FICON curve clearly underestimates the prevalence of annoyance due to aircraft noise exposure by more than a factor of two in a hypothetically average community.

The enormous range of aircraft noise-induced annoyance prevalence rates in communities with similar noise exposure that is evident in **Figure 3** is not due to simple error of measurement but to multiple causation of annoyance. A univariate prediction of annoyance prevalence rates, such as the FICON curve, attributes all variation in annoyance to variation in noise exposure. Assuming that noise exposure is the sole cause of annoyance ignores the obvious differences between people and sound level meters. A dosage-response relationship derived from univariate regression fails to acknowledge, much less quantify, any of the variance in annoyance prevalence rates due to factors other than noise exposure per se.

Annoyance prevalence rates can be influenced, *inter alia*, by concerns about the effects of aircraft operation and airport expansion on neighborhood amenities and property values; attitudes of misfeasance and malfeasance; fear of crashes; and the demographic characteristics of overflown populations. Although many efforts have been made to predict annoyance judgments from individual characteristics, none has been useful for purposes of predicting community response to aircraft noise. After all, airplanes fly over everyone: introverts and extroverts, young and old, male and female, and sensitive and insensitive.

Furthermore, regression analyses that treat noise-induced annoyance as determined exclusively by noise exposure yield predictions of the prevalence of annoyance only for a hypothetical, nominally average community, not for any real community. The U.S. National Environmental Policy Act (NEPA), in contrast, requires that project proponents disclose the noise impacts of specific projects in particular communities, not in a generic and hypothetical average community. FICON's wholly descriptive approach to predicting annoyance due to aircraft noise exposure is blind to bona fide differences among communities with respect to the annoyance of aircraft noise.

Dosage-response relationships fashioned by regression techniques lead to Procrustean regulation that fails to accurately predict annoyance prevalence rates in nearly all communities. A one-size-fits-all, regression-based dosage-response relationship can greatly overestimate annoyance in actual communities of greater than average tolerance for noise exposure. It also underestimates annoyance in actual communities of lesser than average tolerance for noise exposure. Unless the purpose of aircraft noise regulatory policy is construed as protecting sound level meters from annoyance, however, it makes little pragmatic sense to treat people as two-legged sound level meters by ignoring nonacoustic influences on the annoyance of transportation noise.

Fidell et al. (2011) and Schomer et al. (2012) have shown that a first-principles approach to explaining differences in community response to transportation noise accounts for appreciably more variance in the association between noise exposure and annoyance prevalence rates than purely descriptive (univariate regression-based) analyses (Wilson et al., 2013). The additional variance is explained by a second independent variable, community tolerance level (CTL; represented symbolically in mathematical expressions as L_{ct}), that accounts for the aggregate effect of all nonacoustic influences on annoyance judgments.

CTL analysis follows from the observation that the rate of growth of community annoyance with transportation noise exposure closely resembles the rate of growth of loudness with sound level. A CTL value is an estimate of DNL value at which half of a community describes itself as highly annoyed by transportation noise exposure. The range of CTL values derived from social survey measurements of reactions to aircraft noise in 44 communities extends over three orders of magnitude (from roughly 55 dB $\leq L_{ct} \leq$ 85 dB), equivalent to a factor of about 1,000:1 in community-specific tolerance for aircraft noise exposure.

For reasons explained by Fidell et al. (2011), annoyance prevalence rates in CTL analyses are predicted as

$$\text{percent (highly annoyed)} = e^{-(A/m)} \qquad (1)$$

where A is a scalar nonacoustic decision criterion originally described by Fidell et al. (1988), and m is an estimated noise dose calculated as

$$m = (10^{(\mathrm{DNL}/10)})^{0.3} \qquad (2)$$

and CTL is calculated from A as

$$\mathrm{CTL} = 33.3\,(\log_{10} A) + 5.32 \qquad (3)$$

The value of A, an entirely nonacoustic parameter and hence of CTL, expresses the aggregate effect of all of the non-dose-related factors that influence annoyance prevalence rates in a community. The parameter A translates a dosage-response relationship of a fixed shape along the abscissa.

The distribution of A values across communities can be determined from databases of community-specific social survey findings. The empirical distribution of A values across communities is shown in **Figure 6** (from Fidell et al., 2014).

Figure 6 shows that the shape of the distribution of tolerance for aircraft noise exposure among communities is log normal. A few communities are highly tolerant of aircraft noise exposure, but most are relatively intolerant. Predictions of community response to aircraft noise exposure that fail to take the shape of this distribution into account, such as those that apply only to a hypothetical community of average tolerance for aircraft noise, are likely to be appreciably in error in most communities. Thus, regulatory policy that ignores empirically verifiable differences across communities in tolerance for noise exposure cannot have a uniform effect nationwide.

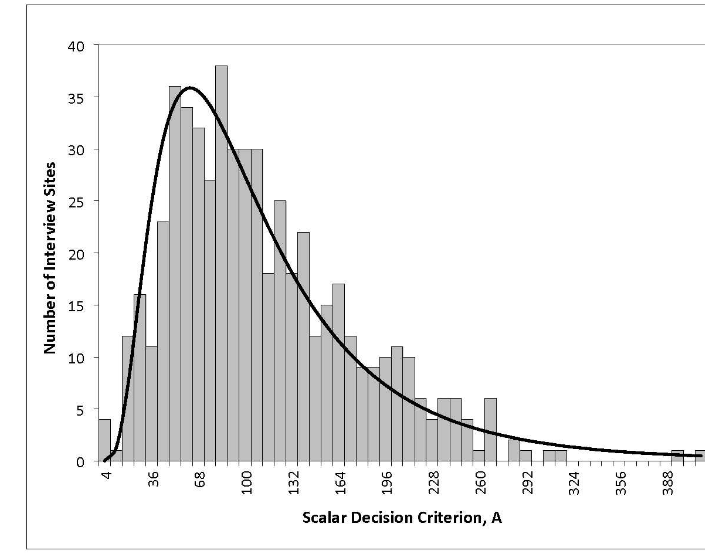

Figure 6. Histogram of scalar quantity (A) in 44 communities exposed to aircraft noise.

Summary

The FAA's definitions of the significance of noise exposure do not protect the supposed percentage of people in most US communities from exposure to highly annoying aircraft noise (Fidell et al., 2014). Legacy policies concerning the "significance" of noise impact and the compatibility of land uses (with airports) are based on informal engineering judgments made as early as the 1950s, and on the FAA's (now rescinded) charter to promote civil aviation rather than on any peer-reviewed or other technically justifiable analyses. FAA noise regulatory policy has not attempted to keep up with changes in the societal acceptability of pollution over the last six decades, with the improved technical understanding of noise effects, or even with the post-1996 changes in the agency's Congressional charter.

The FAA's constant numerical definition of significant noise impacts does not recognize empirically measureable differences in tolerance for noise exposure among communities, and thus does not provide a uniform effect on a national basis. In actual application, the FAA's definition of the significance of aircraft noise exposure affords unexpectedly little protection of noise-exposed populations in many communities from consequential degrees of annoyance due to transportation noise.

Systematic means are now available for analyzing population percentages in different communities associated with particular definitions of noise impacts. The efficacy and efficiency of regulatory policies expressed in acoustic units can now be gauged simply by specifying two parameters: (1) the percentage of the population of a nominally average community to be protected from high annoyance and (2) the percentage of people in all communities to be similarly protected (Fidell, 2014).

Acknowledgments
Portions of the text of this article paraphrase Fidell (2003, 2011, 2014), Mestre et al. (2011), ISO Final Draft of International Standard 1996-1, and a technical report prepared by the author for the Suburban O'Hare Commission. The author thanks Dr. William J. Galloway and Mr. Richard Horonjeff for discussions of conversions of Community Noise Response and Noise Exposure Forecast values into values of Day-Night Average Sound Level.

Biosketch

Sanford Fidell began his transportation noise research and consulting work in the Los Angeles office of Bolt, Beranek, and Newman (BBN) in 1968. In 33 years at BBN, he directed theoretical, laboratory, and field research in many areas of psychoacoustics and environmental acoustics. He has continued his research, consulting, and expert witness work on community response to noise and acoustic signal detection after forming Fidell Associates in 2001.

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