features

The Impact of Airport Noise on Residential Real Estate

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abstract

As populations and airports expand, airport noise is an increasingly important issue for real estate analysts. In researching real estate damage issues, the topic of airport noise and its impact on property market values are particularly well-documented and well-researched areas. This article puts airport noise into the framework of the Detrimental Conditions (DC) Matrix, outlines the measurement of "noise," sets forth some of the health effects of airport noise, and addresses the impact that airport noise has on property market values.

As populations and airports expand, airport noise is an increasingly important issue for real estate analysts. In researching real estate damage issues, the topic of airport noise and its impact on property market values are particularly well-documented and well-researched areas. This article puts airport noise into the framework of the Detrimental Conditions (DC) Matrix, outlines the measurement of "noise," sets forth some of the health effects of airport noise, and addresses the impact that airport noise has on property market values. There are dozens of published studies on the topic, all of which virtually come to the conclusion that homes under or nearby the flight corridors of national or international airports experience some diminution in property market values.

An Overview of Detrimental Conditions

Diminution in value is the difference between the before and after market values of properties that have been damaged or taken. Hundreds of Detrimental Conditions (DCs) may impact real estate values, including environmental contamination, construction defects, geotechnical issues, eminent domain, economic declines, proximity issues, natural disasters, and many others. While identifying, categorizing, and analyzing these numerous DCs may seem overwhelming, the task becomes manageable when the fundamental stages and market value effects are considered in a logical sequence. The fundamental tools for a DC analysis, the DC Matrix, the DC Model, The Bell Chart, and the Three DC Approaches to Value, are set forth within the book *Real Estate Damages.*[1] On this basis, airport noise is generally categorized as a Class V Item of Disclosure, which is defined as being an externality or neighborhood condition, and is generally permanent in nature.

Detrimental Conditions Stages and Issues Related to Airport Noise

Utilizing the DC Matrix, it is apparent that several issues are relevant in studying airport noise. Based upon this discussion, the DC Matrix as related specifically to airports could be summarized as shown in Table 1.

1. Randall Bell, *Real Estate Damages: An Analysis of Detrimental Conditions,* (Chicago: Appraisal Institute, 1999).

Table 1 The DC Matrix—Airport Noise and Residential Properties

	Stages		
Issues	**Assessment**	**Repair**	**Ongoing**
Cost	Assessment by noise engineers and related costs	Noise mitigation such as double pane windows, insulation, etc.	Ongoing noise mitigation, i.e., water fountains, background music, etc.
Use	Not generally applicable	Not generally applicable	Possible
Risk	Not generally applicable	Not generally applicable	Market resistance, if any, as demonstrated by market data

Measuring Airport Noise

The perceptions and impacts of airport noise must be defined in order for them to be studied. Accordingly, a number of noise measurement methods are used by noise engineers. The impact of airport noise and those related perceptions are typically delineated by "noise contour lines" that vary from airport to airport, depending upon the size of the airport, prevalent wind directions, topography, and so forth. By measuring noise contours, a standard can be derived whereby the impact of noise from different airports can be compared.

Noise is unwanted sound. By that definition, the sound emanating from jet aircraft is considered noise to most people.[2] The real estate professional needs to assess the market's perceptions towards airport noise, knowing that those perceptions are then translated into sales prices when the properties are sold and other indications of market values. While most agree that excessive noise is bothersome, it is a subjective issue. For example, what is more annoying—a single firecracker or five motorcycles driving by at one-minute intervals? Is one motorcycle at 73 dB (see Table 2 for noise measurement terms and definitions) for 5 seconds more or less annoying than a jet at 68 dB for 27 seconds? Moreover, is the noise more annoying during the day or at night? If at night, how much more annoying is it?

In an effort to answer these questions, there has been a proliferation of noise measurement terms, techniques, and acronyms. To add to the confusion, there are ongoing debates over the merits of each approach. In an effort to provide at least some clarification of these issues, the following table outlines the primary noise measurement terms, their meanings, and comments that are summarized from various published sources. It is important to note that each of the noise measurement systems is scientifically designed to measure the level of noise, not the measure of annoyance.

To illustrate this issue, noise measurement methods measure noise in somewhat the same way the volume of water in a river can be measured. For example, the total gallons flowing past a certain point per day, the speed of the river, the volume between two points at a specific period in time, the peak levels, and so forth. However, these measurement techniques are not intended to measure flood-related damage, which in turn cause annoyance. The techniques themselves are only designed to measure noise.

Noise Mitigation

There are only three ways to mitigate noise: (1) quiet the source, (2) put more distance between the source of the noise and the receptor, and (3) build or create a barrier to the noise. It is often infeasible for homeowners to have control over quieting the source of jet noise, and it is equally impractical to move their house further from the airport. The third choice is often the only option for homeowners who are impacted by airport noise. For example, attics and walls may be insulated and double pane windows may be installed. On an ongoing basis, background music, fountains, or running water may "drown out" some of the noise. Of course, outside activities such as barbecues, sports, swimming, and so forth do not generally benefit from these measures. It is estimated that airport noise heard within the interior of a property with lightweight construction is reduced from 15 to 30 dBAs. According to a 1972 study, the most recent obtainable, mobile homes reduce jet landing noise levels by 14 dBA to 23 dB(A).[3]

The primary problem with double pane windows is that they must be kept closed to effectively reduce airport noise. With the costs of air conditioning, this can be a significant factor to a household budget where the climate is mild and where natural breezes would otherwise cool. Citing these concerns, it is

2. Lester Reingold, "Research not Regulation," *Air Transport World* (May, 1995): 79.
3. Robert S. Stone, Kenneth R. Regier, and Ellwyn Brickson, "The Human Effects of Exposures to Aircraft Noise in a Residential Environment," Division of Environmental Health, Orange County Health Department (May 19, 1972): 37.

Table 2 Airport Noise Comparison Chart

Term	Meaning	Comments
dB	Decibels	The most fundamental of noise measurements, however, this scale fails to account for noise frequency.
dB(A)	Decibels with "A Weighting"	The most common measurement of noise, with the "A weighting" which accounts for the fact that humans do not hear low frequencies and high frequencies as well as they hear middle frequencies, and corrects for this accordingly.[1] (There are also "B" and "C" ratings that are not discussed here.) The "A weighting" has become so common that it is often considered synonymous with dB. It is a geometric (not logarithmic) scale measured in tenths. The term "decibels" is derived from "decimals," meaning "a tenth," and from the developer, Alexander Graham Bell.

What People Will Accept Without Undue Complaint[2]

Location	Day dBA	Night dBA
Rural residential	35–40	25–35
Suburban residential	40–50	30–40
Urban residential	45–55	35–45
Commercial	55–65	45–55
Industrial	60–70	50–60

Estimated Community Response to Noise[3]

Noise Level in dB(A) Above Acceptable Level	Estimated Community Response
0	No observed reaction
5	Sporadic complaints
10	Widespread complaints
15	Treats of action
20	Vigorous action

Human Effects Criteria for Noise Control[4]

Objectives	Noise Levels at Which Harmful Effects Begin to Occur, dB(A)
Prevention of hearing loss	75–85
Prevention of extra-auditory physiological effects	65–75
Prevention of speech interference	50–60
Prevention of interruption of sleep	45–50
Satisfying subjective preferences	45–50

PNL	Perceived Noise Level	An active band analysis that measures noise in one octave intervals. Measures sound in each octave and compensates for discrete tones that are annoying but not necessarily loud, such as a scratch across a blackboard.
EPNL	Effective	Similar to PNL but measures noises in one-third octaves. This is a noise measurement method Perceived where the decibels of the noise of an aircraft includes the loudness and the frequency Noise Levelspectrum of the noise for takeoffs and landings. This measurement utilizes EPBdB over time.
EPNdB	Effective Perceived Noise Level in Decibels	Noise generated by a single event. Few people can detect a sound below 5 EPNdB. An increase of 10 EPBdB is usually perceived as a doubling of loudness.[5] This system requires rigorous mathematical calculations and accounts for the qualities of jet noise that are particularly annoying.
SEL	Sound Exposure Level	A measurement of noise that accounts for both sound intensity and duration.[6] The net noise energy is calculated from the area of a triangle formed by the graphically illustrated increase, peak event, and decrease of a noise event and converted into a one-second measurement.
SENEL	Single Event Noise Exposure Level	Synonymous with SEL.

1. FAA WebPages–April, 1999. "Aircraft Noise: How We Measure It and Assess Its Impact," <http://www.faa.gov/region/aea/noise/tindxbrkdwn.htm>.
2. Table III, "What People Will Accept Without Undue Complaint," Table IV, "Estimated Community Response to Noise," Orange County Health Department Report (1972).
3. Ibid.
4. Ibid.
5. FAA WebPages–April, 1999. "Aircraft Noise: How We Measure It and Assess Its Impact," <http://www.faa.gov/region/aea/noise/tindxbrkdwn.htm>.
6. Ibid.

Table 2 Airport Noise Comparison Chart *(continued)*

Term	Meaning	Comments
CNR	Composite Noise Rating System	A graphically produced measure which is used to measure aircraft noise annoyance on the house based on the number of flights, the time of day, and the perceived loudness of noise.[7] Any rating less than 100 CNR is designated as CNR Zone 1, from 100 to 115 is Zone 2, and any CNR greater than 115 is Zone 3.[8] On that basis, a rough approximation of CNR Zones and dBA can be made of Zone 1 being less than 67 dB(A), Zone 2 ranging from 67 dBA to 82 dBA, and Zone 3 being greater than 82 dB(A).[9] This is a scientifically valid approach but on a practical basis has been largely replaced by the DNL measure (see below) in more current noise studies.
NEF	Noise Exposure Forecast	Provides a measure of the total aircraft-generated noise energy received at locations near an airport during a typical 24-hour period, with an added penalty for nighttime (after 10 PM) noise.[10] The NEF method has been adopted by the Department of Housing and Urban Development, which will not guarantee mortgages on properties within NEF 40+ and generally considers properties with NEF 30+ unacceptable.[11] At below NEF 30, few people complain. At 30 to 40 NEF, individuals may complain and there may be group action. At 40+ NEF, there are numerous and repeated complaints and group action is probable.[12] NEF = Ldn 65; NEF 40 = Ldn 75.[13] This is a scientifically valid approach but on a practical basis has been largely replaced by the DNL measure in more current noise studies.
CNEL	Community Noise Exposure Level	A metric measurement method that is used in some areas of California. It has an additional night penalty over and above the DNL method. Specifically, it has a 5 dB(A) penalty for evening noise in addition to the 10 dB(A) penalty of night noise. Thus, CNEL noise contours tend to be larger than DNL contours.[14]
ASDS	Aircraft Sound Description System	A "time above" system that measures the time that noise exceeds a certain level, for example, the time during a 24 hour period in which the noise exceeds 85 dB(A). This is a scientifically valid approach but on a practical basis has been largely replaced by the DNL measure in more current noise studies.
DNL or Ldn	Day Night Average Sound Level	A sound measurement scale that accounts for nighttime noise levels where sounds between 10:00 PM and 7:00 AM incur a 10 dB(A) penalty over a 24 hour period, and accounts for various weather patterns that may affect noise levels. This means that one nighttime event is considered equal to 10 daytime events at the same level. (As an approximate conversion, NEF 40 = Ldn 75).[15] Generally speaking, this measurement scale converts the dB(A) of various noise events into SEL, which measures the noise level of each individual event in a one-second period. These individual events are then computed over the 24 hour period to reflect a DNL. One should be cautious before using DNL measurement in measuring disruption or annoyance; however, according to one study, Ldn has been correlated to the following:[16]

Disruption	DNL or Ldn Level
Low	60–65 Ldn
Moderate	60–70 Ldn
Substantial	70–75 Ldn
Severe	75–80 Ldn

The FAA identifies a DNL level of 65 generally as the threshold noise level of aviation noise. The EPA identifies 55 DNL as a threshold level. These disparities, however, do not mean or suggest that no one is annoyed below these levels, although this error in judgement is commonly made. According to one study, approximately 12% of people experiencing noise below 65 DNL are "highly annoyed" at this level. 55 to 65 DNL is described as "moderate exposure" to noise.

7. Peter Mieszkowski and Arthur M. Saper, "An Estimate of Airport Noise on Property Values," *Journal of Urban Economics* (1978): 25.
8. Robert S. Stone, Kenneth R. Regier, and Ellwyn Brickson, "The Human Effects of Exposures to Aircraft Noise in a Residential Environment" Division of Environmental Health, Orange County Health Department (May 19, 1972): 25–26.
9. Ibid., 32.
10. FAA WebPages–April, 1999. "Aircraft Noise: How We Measure It and Assess Its Impact," <http://www.faa.gov/region/aea/noise/tindxbrkdwn.htm>.
11. FAA WebPages–April, 1999. "Aircraft Noise: How We Measure It and Assess Its Impact," <http://www.faa.gov/region/aea/noise/tindxbrkdwn.htm>.
12. Ibid.
13. Ibid.
14. Booz-Allen & Hamilton Inc., "The Effect of Airport Noise on Housing Values: A Summary Report," Office of Environmental and Energy Federal Aviation Administration (September 15, 1994): 19.
15. FAA WebPages–April, 1999. "Aircraft Noise: How We Measure It and Assess Its Impact," <http://www.faa.gov/region/aea/noise/tindxbrkdwn.htm>.
16. Marvin Frankel, "Aircraft Noise and Residential Property Values: Results of a Survey Study," *The Appraisal Journal* (January, 1991): 106.

Table 2 Airport Noise Comparison Chart *(continued)*

Term	Meaning	Comments
DNL or Ldn	Day Night Average Sound Level	DNL is not intended or considered to be a good indication of "single event" noise. A 65 DNL is equivalent to 87.5 dBA with 500 events, 94.4 dBA with 100 events, and 97.4 dBA with 50 events. A single event at 97.4 dBA, while considered somewhat "acceptable" under the 65 DNL threshold would actually be equivalent to the noise from a power mower or a newspaper press.[17] In other words, because of the "averaging" effect of DNL noise measurements, a person could be abruptly aroused from sleep every night, but the remaining 24 hours of quiet would result in a DNL measurement that would be very low, yet erroneously suggesting that there was no annoyance. The DNL is a scientifically valid measurement of noise; however, some have inferred that its measurements reflect something that it is simply not designed to do. For these and other reasons, the interpretations of the DNL method are controversial and considered by many to be a "fictitious" averaging of sound. Accordingly, it has been widely criticized for understating the practical effects of noise and the related annoyance.[18]
Leq	Level of Equivalent Sound	Measures the number of events or energy summation, the exposure level, and the time-average of sound over a specified period of time.[19] This method of measuring the volume of noise collected has been compared similarly to the way rainwater is collected in a coffee can over a period of time.
NNI	Noise and Number Index	Like NEF (see below), NNI combines measures of loudness and number of events into a single cumulative index. 30 NNI equals 73 planes a day at 82 PNdB–about as loud as a vacuum cleaner at 10 feet. It differs from NEF in the way that it measures loudness as the maximum perceived noise level for each event. Like NEF, it is a cumulative energy measure and therefore may mask the hedonic effects of loudness and number of events.[20] The measure is further criticized as understating annoyance.[21] This is a system utilized primarily in Great Britain.

17. FAA WebPages–April, 1999. "Aircraft Noise: How We Measure It and Assess Its Impact," <http://www.faa.gov/region/aea/noise/tindxbrkdwn.htm>.
18. FAA WebPages–April, 1999. "Aircraft Noise: How We Measure It and Assess Its Impact," <http://www.faa.gov/region/aea/noise/tindxbrkdwn.htm>.
19. Ibid.
20. Terrence J. Levesque, "Modeling the Effects of Airport Noise on Residential Housing Markets," *Journal of Transport Economics and Policy* (May, 1994): 200.
21. M. E. Paul, "Can Aircraft Nuisance Noise be Measured in Money?" Report of the Commission on the Third London Airport, H. M. S. O. (1971): 299.

reported that some home owners in Australia have gone to the extreme of installing microphones, micro-processors, and mechanical arms that shut the windows temporally as nearby jets take off and land at a nearby airport.

There are many instances where adequate noise mitigation was simply not possible and the highest and best use was indeed impacted. For example, large residential neighborhoods were demolished near Los Angeles International, Sea-Tac, and Phoenix Sky Harbor Airports. At the Las Vegas International Airport, a large subdivision, with noise levels under the 65 DNL levels established by the FAA were purchased and subsequently rented by the County. This reflects the concept that property owners may react more negatively than renters do. While generally there is no impact on the highest and best use of a residential property due to aircraft noise, these instances show that in more extreme situations, the noise issues cannot be mitigated and the highest and best use has changed from residential to some other use. Based upon factors like these, when considering airport noise, it may not be prudent to construct new residential improvements to replace older residential improvements that are at the end of their physical life. While this article focuses on noise issues, air quality, jet blasts, and health issues might also be additional issues that the analyst must consider.

Airport Noise and Health-Related Issues

While a real estate analyst primarily focuses on and measures the impact of airport noise on property market values, it should be noted that airport noise is associated with a variety of "costs," of which the impact on real estate is only one. In addition, airport operations may cause a variety of effects such as noise, visual impairment, pollution, traffic, emotional, and health-related effects. Of course, these other costs are outside the scope of the real estate analyst's direct realm of expertise. However, it would be naive to assume that real estate is the only issue. Some of these other issues are briefly addressed here.

Some speculate that noise is not a major health problem because people adapt to it; however, according to one published source, this is a myth.[4] Noise re-

4. Robert S. Stone, Kenneth R. Regier, and Ellwyn Brickson, "The Human Effects of Exposures to Aircraft Noise in a Residential Environment," Division of Environmental Health, Orange County Health Department (May 19, 1972): 2.

lated stress has a measurable impact on human health. A 1993 study of Los Angeles International Airport (LAX) indicated that cardiovascular disease increased 18%, and accidental deaths increased 60% for people over 75. Suicides doubled for people between 45 and 54. Approximately 60 more people died each year.[5] A British study of doctors working at Springfield Mental Hospital shows that admissions per 1,000 people who live near London's Heathrow Airport are significantly higher than those from a population in a near-by quieter area.

The Orange County Health Department in California published one of the most comprehensive health-related studies reviewed.[6] It utilizes the CNR Zones 1, 2, and 3 to reflect various impacts on health. It states that airport noise can specifically cause sleep disturbance, physiological stress reactions, temporary threshold shifts in hearing, interference with speech and communications, and psychological distress. Further, the study cites that health is not simply the absence of organic disease, but rather a total state of physical, mental, and emotional well being. The study further states "it is clear that excessive and needless noise constitutes a nuisance at best, a health hazard at worst."

The effects of noise on people can take many other forms as well[7]:

1. Noise can interfere with speech and other forms of communication.
2. Noise can produce physiological stress reactions with may turn out to have significant long-term health implications.
3. Noise can be a major source of annoyance by disturbing sleep, rest, and relaxation.
4. Noise can interfere with the performance of complicated tasks.
5. Noise can reduce the opportunity for privacy.
6. Noise can cause temporary hearing losses, which, if repeated, will result in chronic hearing loss.

The report further states:

> Typically, an emotional reaction occurs when a homeowner, for example, purchases a residence near an airport or freeway without really being aware of the noise, perhaps because the decision to buy is made on a weekend when the noise level is at its lowest. However, after an investment is made, and the full extent of the noise is realized, a feeling of regret and depression occurs. One couple interviewed during a community noise survey of Seal Beach bought a home adjacent to the San Diego freeway where sound levels average 60 dBA at night and 73 dBA during the day. Then, after living there a few days, they put the property up for sale. That was over four years ago and they still can't sell the house. Their daughter of five years is reportedly developing hearing problems and has difficulty understanding the difference between similar words like *candy, sandy,* or *dandy.* This couple realizes their error but can do nothing to rectify it. There is little doubt that they have been seriously affected, psychologically, by this situation.[8]

The report goes on to describe numerous and various noise (specifically airport noise) related disorders, including (a) subjective, or mental health, effects, (b) sleep disturbance and deprivation, (c) interference with speech and communication, (d) physiological effects, and (e) hearing loss.

The Impact of Airport Noise on Market Values

When commercial jet operations commenced in 1959, the Federal Aviation Administrator had to get an unlisted home phone number because outraged citizens called him at night and harassed him about aircraft noise.[9] The subject still strikes an emotional cord with many people today, and the body of published literature consistently reflects a real and negative impact on property market values. Some have speculated that the convenience and economic revenues from an airport serve to offset any diminution in value; however, nothing in the body of published literature supports this notion. In fact, it is directly dispelled in an article published in the *Journal of Transport, Economics and Policy,* which utilizes hedonic regression to show that NNI 50 properties sustain a diminution in value ranging from approximately -7% to -12%.[10] While tremendous economic benefits and revenues clearly are associated with a large airport, those under or nearby the flight path tend to suffer a net negative impact.

5. W. C. Meecham, and N. A. Shaw, "Increase in Mortality Rates Due to Aircraft Noise," *Schriftenreihe des Vereins fur Wasser-, Boden-und Lufthygiene* (88, 1993): 428–441.
6. Robert S. Stone, Kenneth R. Regier, and Ellwyn Brickson, "The Human Effects of Exposures to Aircraft Noise in a Residential Environment," Division of Environmental Health, Orange County Health Department (May 19, 1972).
7. Ibid.
8. Ibid.
9. Lester Reingold, "Research not Regulation," *Air Transport World* (May, 1995): 79.
10. Alan Collins and Alec Evans, "Aircraft Noise and Residential Property Values: An Artificial Neural Network Approach," *Journal of Transport Economics and Policy* (May, 1994): 194.

The issues are widespread. Approximately six million Americans currently reside on 900,000 acres of land exposed to levels of aircraft noise that creates a significant annoyance for most residents (NEF 30+). Furthermore, 600,000 Americans reside in areas that are severely impacted by aircraft noise, that is, areas in excess of NEF 40.[11] Despite the magnitude of noise problems, no single or universal criterion defines a "noisy" airport.[12]

The fact that a property is situated near a noise source is not automatic evidence of a loss in market value. The analyst must therefore find and employ valid methods of accurately measuring market value loss. Measuring the impact of noise on property market values is generally a relatively simple concept of a paired-sales analysis; however, linear regressions and hedonic modeling are also frequently used. Unfortunately, as illustrated in the discussion of various noise measurement methods, no single standard exists, which adds to the complexity of a study. However, in context of these various methods, consistent themes and correlations emerge.

In studying the "most likely impact" of airport noise on real estate damages, it should be recognized that there are outlying extremes. Like many detrimental conditions, there is a segment of the market that appears to be almost immune to the effects, while at the opposite extreme there is often a segment that will not purchase a property at any cost that is impacted by a detrimental condition. For example, a portion of the population seems more or less imperturbable.[13, 14] If located close to an airport or under a flight path, these people are still not seriously disturbed.

Nevertheless, for most people, noise is a significant issue, and there is a segment of the population that will live under a major flight corridor if enticed through a discount on the price.[15] However, a slight majority of the market will not purchase a property that is close to a major airport *at any discount.*[16] Similarly, a significant portion of the market will neither purchase a property that is close to a motorway, nor one that is a few miles from a major airport.[17] Furthermore, those with special political agendas, such as pro- or anti-airport groups, often selectively cite study results such as these. A proper and unbiased study should consider the net effects of these issues on balance.

While some real estate analysts may initially believe that any potential buyer will purchase a damaged property if discounted enough, this is simply not true. To illustrate, consider a run down house in the middle of a heavy industrial area. Certainly a significant portion of the typical residential market will simply not purchase the property at any discount, as they simply will not live in such an area under any conditions and have no interest in buying, renting, or reselling such properties.

One of the most important studies published to date was conducted for the Federal Aviation Administration in 1994.[18] It studied three airports using a regression analysis: Baltimore/Washington International Airport (BWI), Los Angeles International Airport (LAX), and John F. Kennedy Airport (JFK) in New York. The results indicated a consistent negative impact on residential property market values.

The BWI study had significant limitations, yet reflected homes near airports that would have a market value loss ranging from -$627 to -$14,595 per home. The LAX study was more straightforward. It included a study of both low priced and moderately priced neighborhoods. The study indicated that the adjusted market value of a low priced home was $1,268 less if impacted by airport noise, or -0.07 per dBA above a quiet threshold.[19] Moderately priced homes incurred a $60,873 loss if impacted, or 1.12% per dBA above a quiet threshold (which is not specified). Losses of the total home market value ranged from -0.8% for low priced homes and ranged from -15.7% to -19% for moderately priced homes.

The JFK study includes low, moderately, and high priced homes. It indicates a loss of -0.12% per dBA for low priced homes, -0.46% per dBA for moderately priced homes, and -1.35% per dBA for high priced homes.

The FAA study, while lacking a complete discussion of many issues, yields some significant informa-

11. FAA WebPages–April, 1999. "Aircraft Noise: How We Measure It and Assess Its Impact," <http://www.faa.gov/region/aea/noise/tindxbrkdwn.htm>.
12. Ibid.
13. M. E. Paul, "Can Aircraft Nuisance Noise be Measured in Money?" Report of the Commission on The Third London Airport, H. M. S. O. (1971): 298.
14. These market participants are termed the "survivor population."
15. This is called the "enticed population."
16. These market participants are termed the "exodus population."
17. M. E. Paul, "Can Aircraft Nuisance Noise be Measured in Money?" Report of the Commission on The Third London Airport, H. M. S. O. (1971): 316.
18. Booz-Allen & Hamilton Inc., "The Effect of Airport Noise on Housing Values: A Summary Report," Office of Environmental and Energy Federal Aviation Administration (September 15, 1994): 17.
19. A quiet threshold is generally considered to be that in an otherwise similar neighborhood but without airport noise.

tion. First, entry-level homes are impacted less as compared to moderately priced homes. In fact, the loss in market value low priced homes is generally minimal. This trend could be expected, as high priced homes are often in areas with more desirable neighborhood traits. Second, the study shows that the loss to moderately priced homes is as high as 19%, a significant figure as conventional loans often require a down payment of 20%. In other words, homebuyers who purchase a home with out knowledge of plans for an airport to be built nearby may stand to lose most or all of their equity if an airport is subsequently developed. Further, the reduction in value of a high priced home will be approximately 2.5 times that of a moderately priced home. This finding is also illustrated by a British study (see Table 3).

The FAA study correlates fairly well with a variety of other published studies. A study published in the *Journal of Environmental Economics and Management* indicates that an increase of NEF 5 over threshold noise levels would decrease the market value by 2.5%.[20] Another study in the same journal indicates a diminution in value of 0.67% per NEF. Yet another study in the same journal reflects a loss of 0.4% per NEF and refers to other studies with losses of 1% or more per NEF.[21]

Additional insights are added by a study published in the *Journal of Transport, Economics and Policy* which indicates that a one unit increase in NEF results in a diminution in value of 0.65% in property market value for detached housing.[22]

Comparing the market value of properties with no significant noise (less than 35 NNI) to those with airport noise, a study published in *Land Economics*, indicates what's demonstrated in Table 3.[23] Another study, also utilizing NNI noise contours, reflects these results (see Table 4).[24]

While utilizing a different noise measurement method of NNI, these studies reflect much of the same concepts as other studies. Namely, the higher the relative price of a property, the higher the diminution in value. According to the studies above, the highest loss is 22.5% to 29% for high-class housing, which reconciles somewhat with the 19% loss reflected in the FAA study for moderately priced housing. These results are also somewhat consistent with yet another published study that cites losses of 0.4% to 1.1% per NNI.[25]

A study published in *The Appraisal Journal* further correlates with many of these findings utilizing the Lnd method. It indicates a loss of market value ranging from 1.2% of low-impact properties to 21.5% for severely impacted properties. This study also reflects numerous instances in which communities or sectors were assigned to a noise category not consistent to their actual noise status.[26] These findings reconcile with the comments

Table 3 Percentage of Price Depreciation of House Value

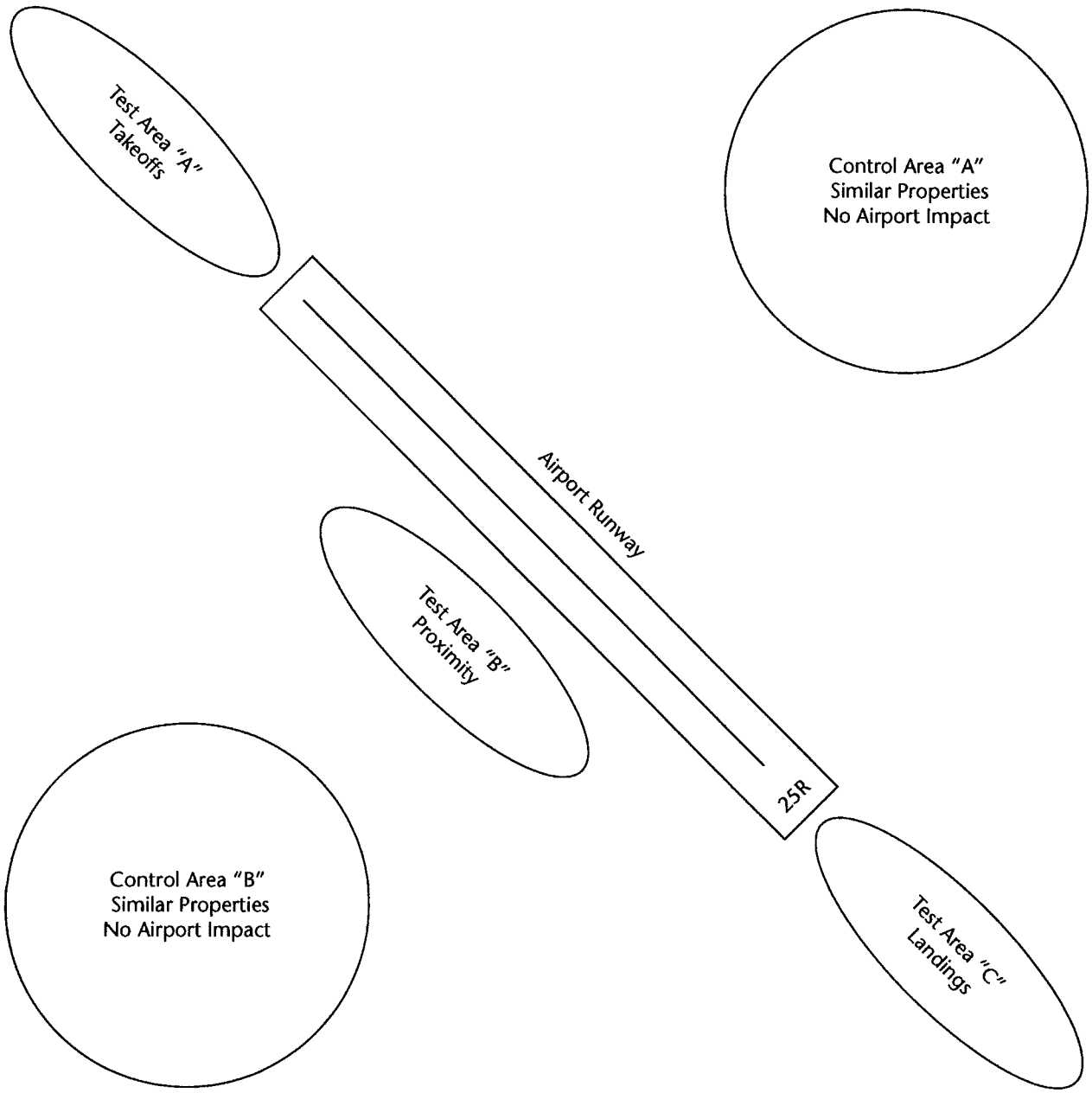
	Noise Zones		
Class of Property	**35–45 NNI**	**45–55 NNI**	**55+ NNI**
Low	0.0	2.9	5.0
Medium	2.6	6.3	10.5
High	3.3	13.3	22.5

Table 4 Percentage Depreciation of House Property Values Compared with Houses Outside the 35 NNI Contour

Class of Property	**35–45 NNI**	**45+ NNI**
Low	4.5	10.3
Medium	9.4	16.5
High	16.4	29.0

20. John P. Nelson, "Airport Noise, Location Rent, and the Market for Residential Amenities," *Journal of Environmental Economics and Management* (March 27, 1979): 329.
21. Peter W. Abelson, "Property Prices and the Value of Amenities," *Journal of Environmental Economics and Management* (January 5, 1979): 23.
22. Dean Uyeno, Stanley W. Hamilton, and Andrew J. G. Biggs, "Density of Residential Land Use and the Impact of Airport Noise," *Journal of Transport Economics and Policy* (January, 1993): 9.
23. Jonathan H. Mark, "A Preference Approach to Measuring the Impact of Environmental Externalities," *Land Economics*, (56:1): 85.
24. M. E. Paul, "Can Aircraft Nuisance Noise be Measured in Money?" Report of the Commission on The Third London Airport, H. M. S. O. (1971): 302.
25. Eran J. Feitelson, Robert E. Hurd, and Richard R. Mudge, "The Impact of Airport Noise on Willingness to Pay for Residences," *Pergamon* (April 5, 1996): 3.
26. Marvin Frankel, "Aircraft Noise and Residential Property Values: Results of a Survey Study," *The Appraisal Journal* (January, 1991): 108.

Exhibit 1 Airport Diminution in Value Study



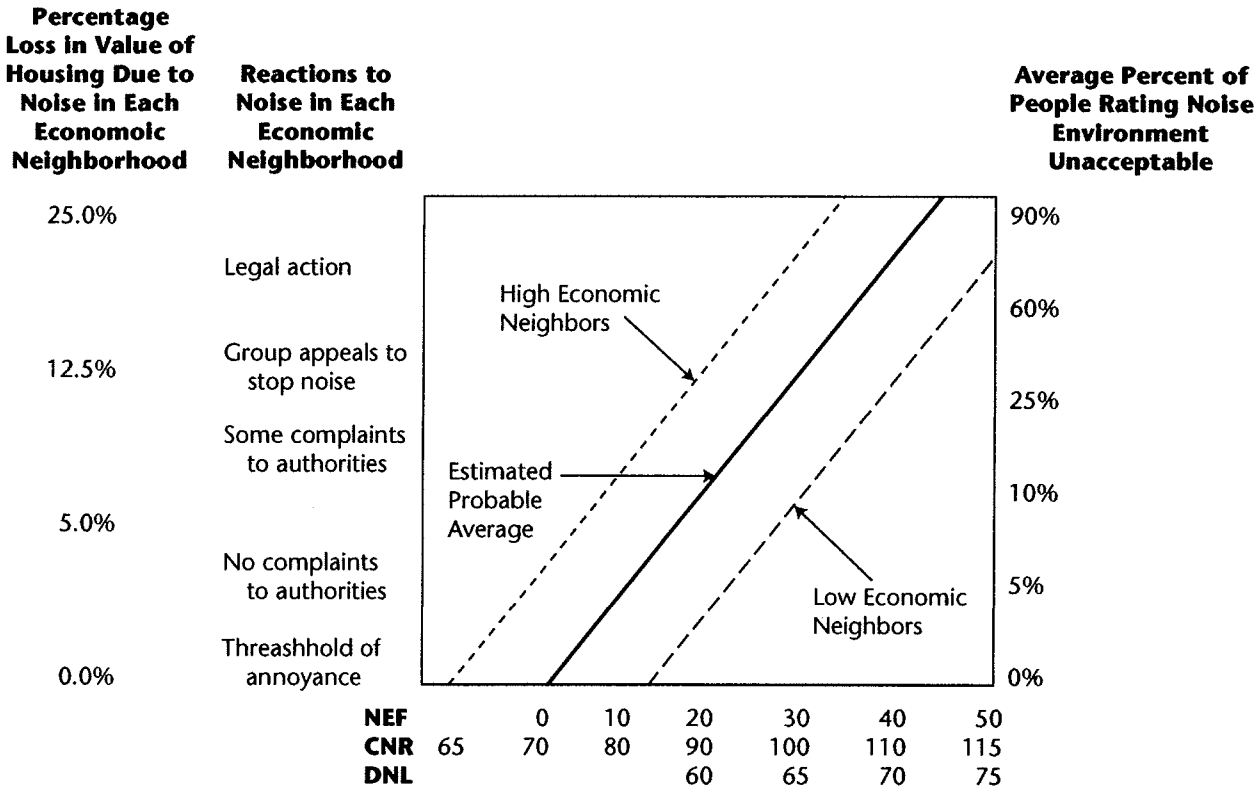
previously cited that certain "noise averaging" methods are considered controversial.

Conclusions

There are hundreds of DCs that may impact property market values. Airport noise is generally considered to be a Class V DC, meaning that it is an externality that is imposed onto property owners and generally on a permanent basis. As a Class V issue, airport noise has specific issues as outlined in the DC Matrix. These are assessment costs, repair (mitigation) costs, ongoing use costs, and ongoing market resistance. Noise is measured in a variety of ways and with various scales, which can be confusing to the non-noise engineer. The dB(A) is the basic unit of noise measurement. DNL is largely used; however, this is a "noise averaging" method that has been criticized because it does not address annoyance. Annoyance can therefore be understated by "averaging."

As populations expand, so will airports, which in turn will create more frequent valuation challenges for real estate analysts. The impact of noise from a na-

Exhibit 2 Relation Between Various Effects of Habitual Environmental Noise and a Composite Noise Rating, CNR and NEF



Source: Commission of London's Third Airport Papers and Proceedings VII, Part II, and Furthur Research Team Work 51. DNL and CNL reference added on sale of NEF30 = 65 DNL and NEF40 + 70 DNL.

tional or international airport on residential properties is universally negative on residential property market values under or near a heavy flight corridor. A significant portion of the population will not live in a home that is impacted by airport noise at any cost or discount. On the other hand, some of the population seems more or less impermeable to airport noise. On balance, the published studies cited here suggest that detached single-family homes under or nearby a final or down-wind flight corridor will suffer a measurable diminution in value. Various studies indicate that there is a correlation between noise levels, as measured by noise contours, and the diminution in value suffered. Further, according to the studies completed for the FAA, detached housing tends to be impacted more than semi-detached or terraced housing. The data suggests that more expensive homes tend to be impacted more than less expensive homes. Rural areas tend to be impacted more than suburban areas, which in turn tend to be impacted more than urban areas. Other research indicates that the number of flights is less important than the loudness and variability of the loudness of single events.[27] For this reason, single event dBL should be considered carefully.

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27. Terrence J. Levesque, "Modeling the Effects of Airport Noise on Residential Housing Markets," *Journal of Transport Economics and Policy* (May, 1994): 209.