MINNEAPOLIS, EAGAN, AND RICHFIELD VS. THE METROPOLITAN AIRPORTS COMMISSION

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Introduction

The Minneapolis–St. Paul Airport (MSP) is situated adjacent to older residential areas of the city of Minneapolis and bordered on other sides by newer suburbs including Eagan and Richfield. MSP opened a new runway in October 2005. Local communities surrounding the airport agreed not to fight the new runway with the promise that the airport would provide sound insulation to homes within the 60–65 day-night average sound level (DNL) zone. After making this promise to the communities, the airport reinterpreted its commitment and several lawsuits ensued from those affected. This paper describes one of two major lawsuits brought by the affected cities against the Metropolitan Airports Commission (MAC), the commission that runs the commercial airports in the Minneapolis–St. Paul area including MSP. There also was another lawsuit brought by citizens of Minneapolis that dealt with the efficacy of the environmental impact analysis.

"The outcome of the litigation was a negotiated settlement of $128 million for sound insulation in the 60–65 DNL zone."

This law case pits the city of Minneapolis and two suburbs, Eagan and Richfield, against the Metropolitan Airports Commission. There are two main technical issues to this case. First, MSP noise adversely and significantly affects the "quietude" in residential areas that are in the DNL zone of 60–65 dB. Second, a 5-dB noise insulation package for homes in this DNL zone will ameliorate the situation.

To provide the technical foundation for this law suit, Schomer and Associates, Inc. and Freytag and Associates, LLC were asked to develop the technical background and arguments requisite for the city of Minneapolis to prevail. Four general tasks were established for the consultants—(1) define "quietude,"(2) show that, absent MSP noise, the residential areas in the 60–65 DNL zone generally enjoyed quietude, (3) quantify the impacts of MSP noise on annoyance, speech interference, and sleep disturbance throughout this zone, and (4) quantify the benefits of a 5 dB noise insulation package. Both consultants worked on all parts of this study, 1–4, with Paul Schomer taking the lead for tasks 2 and 3 and Jack Freytag taking the lead for task 4.

Major points to be established: (1)Define "quietude"; (2) Show "quietude" exists absent MSP noise; (3) Quantify the impacts; (4) Show that a 5dB package of noise mitigation in homes would ameliorate disruption of "quietude."

Major points

(1) Define "quietude"

We first established a definition of "quietude," the term used by the Minnesota State Legislature in developing a law protecting the natural noise environment in land areas of Minnesota. Initially, the law was used primarily in parks and wilderness settings but for this case the law was used in residential areas. Thus, we had to establish a definition of quietude for the court. The definition established was the following—(1) The DNL is in the range of 50–55 dB, (2) Rarely are there noises at night with the potential to awaken someone, (3) One can use the indoor and outdoor areas of their home without any noise annoyance issues, and (4) One can have the windows open or closed as they wish without environmental noise problems.

(2) Show "quietude" exists, absent MSP noise

Having established the definition of quietude it was then necessary to show that, absent MSP aircraft noise, quietude exists in the residential communities surrounding the airport that were the subject of this lawsuit. To do this we had to do two things. First, we had to separately measure the day time and night time residential noise environment in these communities without including airport noise. Second, MSP has an environmental noise monitoring system in the DNL 60 – 64 dB zone that reports total noise—airport noise and what they term non-airport (or community) noise. It was necessary for us to explain to the court why this airport noise monitoring system generally overstates the true community noise contribution (i.e., without airport noise) frequently and substantially.

(a) The measurement sampling strategy.

Obviously it is impractical to measure throughout the large, residential, DNL 60–65 dB areas continuously for long periods of time. A sampling technique was required. Thus it was necessary to show that the random sampling procedure employed would serve to demonstrate the community noise without the airport noise included. To do this, we chose to perform random time- and spatial-sampling within the study area—the residential area defined to be in the 60–65 DNL zone and not already noise-insulated. We selected twenty five

Table 1. Measurement Types, File Designation, Address, and Approximate Number of Events for the Daytime, 30-Minute Sites

Site Type	File Name Assigned	City	Address	Aprx. Aircraft Event Count
Night; 9-hour	2002	Minneapolis	4849 13th Avenue S	Not Counted
Night; 9-hour	2003	Minneapolis	4525 Pillsbury Avenue S	Not Counted
Night; 9-hour	2004	Minneapolis	300 Elmwood Place	Not Counted
Night; 9-hour	2103	Minneapolis	4525 Pillsbury Avenue S	Not Counted
Night; 9-hour	2104	Minneapolis	300 Elmwood Place	Not Counted
Day; 30-min	3211	Richfield	6800 Bloomington Avenue @ 69th Street E	12
Day; 30-min	3112	Richfield	11th Avenue S @ 65th Street E	11
Day; 30-min	3214	Minneapolis	3030 53rd Street E	25
Day; 30-min	3115	Minneapolis	1700 49th Street E	9
Day; 30-min	3116	Minneapolis	4849 13th Avenue S	5
Day; 30-min	3117	Minneapolis	5300 Park Avenue	17
Day; 30-min	3118	Minneapolis	5201 Hampshire Dr	17
Day; 30-min	3119	Minneapolis	4901/4905 Oakland Avenue S	18
Day; 30-min	3120	Minneapolis	4725 27th Ave S	13
Day; 30-min	3121	Minneapolis	4644 Longfellow Avenue	23
Day; 30-min	4151	Minneapolis	300 Elmwood Place	14
Day; 30-min	4152	Minneapolis	Water Tower; intersection Prospect and Highview	15
Day; 30-min	4153	Minneapolis	School opposite 5825 Blaisdell	14
Day; 30-min	4154	Minneapolis	4905 Emerson Avenue	11
Day; 30-min	4155	Minneapolis	4525 Pillsbury Avenue S	10
Day; 30-min	4156	Minneapolis	opposite 401 Minnehaha Parkway	12
Day; 30-min	4157	Eagan	SW corner tennis court opposite 1428 Skyline	22
Day; 30-min	4158	Eagan	near parking lot at Bur Oaks Park	11
			SUM DAYTIME EVENTS	259
			NUMBER OF DAYTIME LOCATIONS	18
			AVERAGE	14.4
			ST DEV	5.18

Data for measurements 3111, 3113, and 3114 were incorrectly gathered. Data sets 3211 and 3214 are correctly gathered replications at these two sites. There was insufficient time available to replicate the measurements at site 3113.

sites at random within this zone (see Table 1), and collected 30-minute samples at each site. The time of day was distributed randomly throughout the daytime hours that were defined to be roughly 9:00 a.m. through 6:00 p.m. We excluded sites close to interstate highways or very major roads since it is clear that "quietude" does not exist close to these noise sources. Otherwise, this was a quasi-random spatial pattern with a random temporal pattern within the daytime hours stated. Figure 1 shows the location of the 18 daytime noise monitoring sites.

The sample measurements were performed using an observer. Basically, the data consisted of consecutive one-second, A-weighted, continuous, equivalent, sound levels (Leq) measurements during an entire 30-minute period. Thus, a complete data set consisted of 1,800 consecutive one-second Leq measurements. The presence of audible aircraft noise on a data log was marked, and with this log, the aircraft-noise-corrupted data were deleted before analysis from each data set. The Leq for the thirty-minute period was estimated from the remaining aircraft noise–free data. Our time- and spatial-sample also was a sample of the total time within the 30-minute measurement period for which aircraft noise was inaudible.

Questions were raised as to the efficacy of such a sampling strategy. MSP commented that a significant non-aircraft community noise event might be deleted during an audible aircraft event, and thereby understate the non-aircraft community noise environment. While this is true, it is equally likely that a very quiet community noise period may be deleted during an audible aircraft event; this would result in an overstated non-aircraft community noise environment. As long as the sampling period is random and independent of aircraft noise events, this sampling is valid. Thus, the sampling of the community noise environment is the same as if it were being done without aircraft noise by randomly cycling a sound level meter on and off. (It should be noted that this random sampling is superior to metered sampling because the metered sampling period will modulate with periodic noise events such as metered traffic skewing results.)

As a demonstration of how the random sampling works, Figure 2a shows 1,800 seconds of traffic noise recorded elsewhere for a different judicial matter. The energy-average Leq

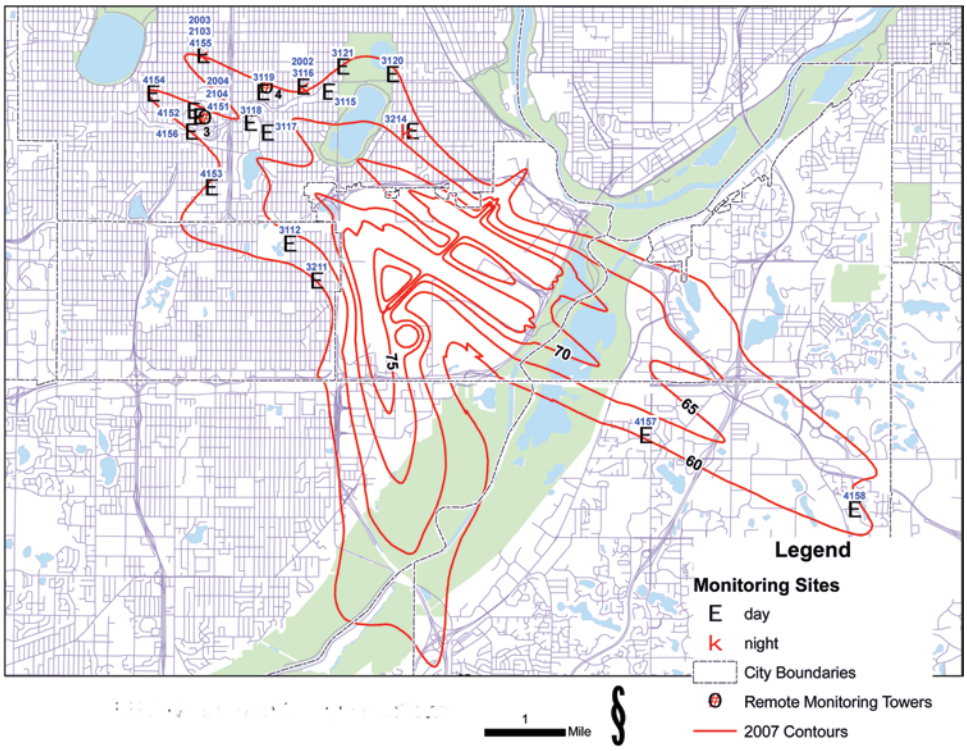

Fig. 1. Site map showing Minneapolis–St. Paul Airport (MSP) monitor sites (18 daytime sites and 4 nighttime sites listed in Table 1).

for these 1,800 seconds is 42.9 dB. Figure 2b shows 150 random seconds from these 1,800 seconds and the computed Leq is 42.0 dB. Figure 2c shows just 15 random seconds selected from the 1,800 seconds and the Leq is 42.2 dB. So with this simple example, the random samples are within 1 dB of the universe of samples. (This is generally the case—if statistics are more or less Gaussian, a sample of twenty-five independent events usually gives a good estimate of the true average.) What was needed was a time- and space-average for the residential communities in the zone of interest to indicate the levels of noise generally found in these communities during the day, and the eighteen 30-minute samples provided these data. The daytime measurement results are given in Table 2 and show that the typical community A-weighted Leq values, absent noise from MSP, are in a range from 44 to 54 dB with an average of 49 dB. Clearly these Leq values fall within the range defined for quietude.

For nighttime, whole-night continuous measurements at four sites were measured in an attempt to obtain two complete measurement nights per site. This approach for nighttime, using a small set of sites, was chosen for logistical reasons. Figure 1 shows the locations of four sites at which the monitoring was performed; however only three of these sites yielded useful results. Table 3 shows the nighttime monitoring results at the three useful sites. At the fourth site, the student interns operating the equipment did not understand the instructions well enough during the first night, and during the second night the power to the monitor was accidentally turned off, thus data from both nights at this fourth site were lost. Again, the results in Table 3 show that these example nighttime levels are well within the levels defined for quietude.

(b) Establish why airport-noise monitors systematically overstate the actual community noise, absent the airport.

Airport noise monitoring systems are installed by airports to measure the airport noise, and to ensure that the airport noise data are not corrupted by non-airport noise. That is, their event detection algorithms are designed to be fairly certain that noise included as airport noise is truly airport noise and does not include significant amounts of non-airport noise. Thus, they divide the universe of data into two bins—(1) noise that they are certain is airport noise, and (2) noise that they are not certain is airport noise. Universally, they term the second bin as "community noise—noise that they are not certain is airport noise." In reality, there should be three bins of data

- There should be the bin that is "almost certainly only airport noise."
- There should be a similar bin that is "almost certainly only community noise."
- There should be a bin of data for which it is unclear whether it is airport noise, community noise or both.

The first two of these three bins should be used to estimate the airport noise and the community noise, respectively. The third bin should be used only in computation of the total noise at the site, and not included in estimates of aircraft noise or community noise.

However, that is not how airport noise monitors are programmed. In the case of MSP, they require that airport noise be above a threshold long enough, but not too long. Specifically, they require that an aircraft noise event be above 65 decibels for at least eight seconds, and that it correlates with control tower records for an aircraft being in the area of the monitor in question at the time in question. It is easy to list a series of reasons why this sampling strategy, or any similar sampling, cannot just divide the data into two bins: aircraft and non-aircraft.

- There are aircraft events that never reach the 65 dB threshold such as smaller planes or planes more distant from the noise monitor.
- There are aircraft noise events that exceed the 65 dB threshold but not for eight consecutive seconds.
- There are valid events for which the noise below 65 dB is not included in the airport noise bin. They are included with the community noise.

Figure 3, derived from our MSP nighttime data, shows an aircraft noise event rising above the apparent 36 dB ambient to 69 dB. In terms of the airport, the area of the curve shaded in black is included in the airport noise bin. However,

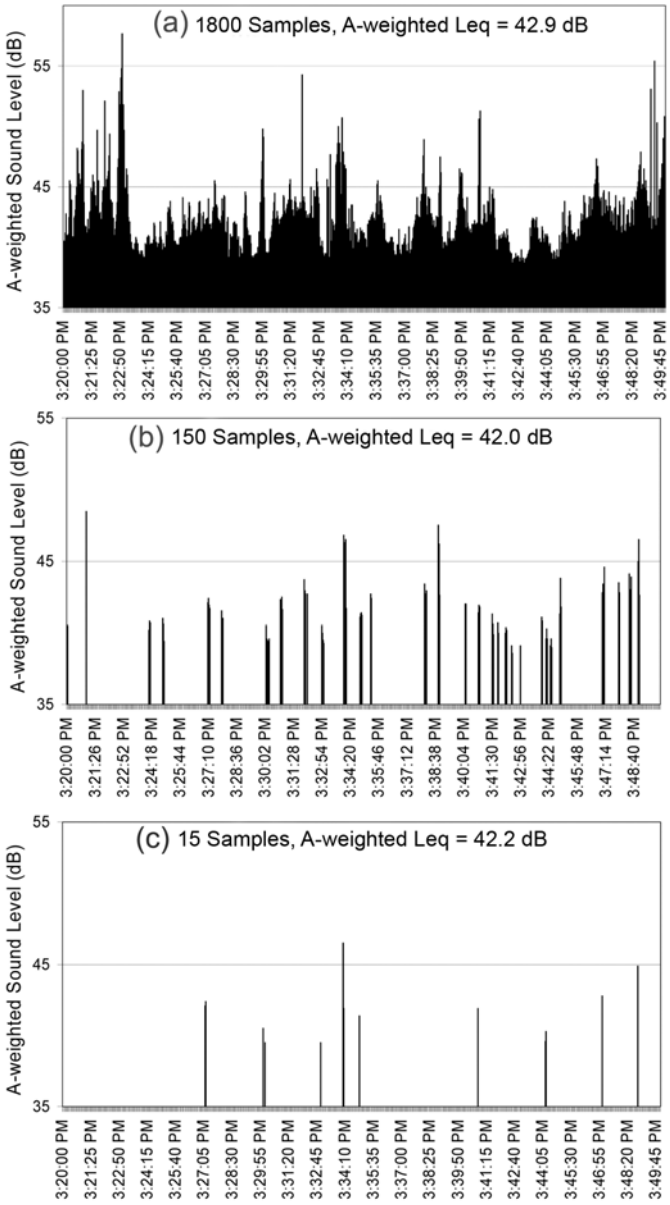

Fig. 2. Random sampling of sound—(a) the sound is sampled 1800 times. The "A-weighted, equivalent, continuous sound level (Leq)" is 42.9 dB. (b) the sound is sampled 150 times. The Leq is 42.0 dB. (c) the sound is sampled 15 times. The Leq is 42.2 dB.

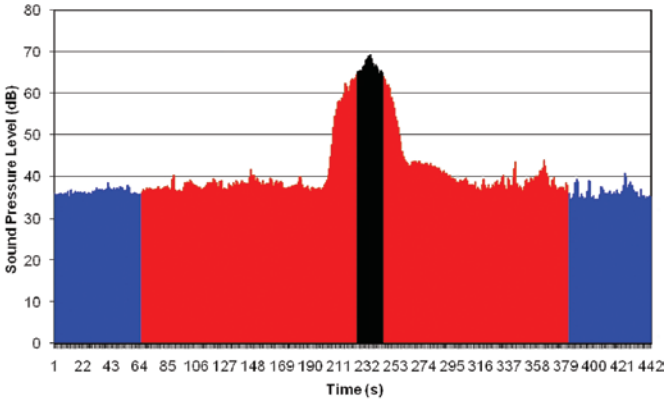

Fig. 3. Example of a nighttime aircraft fly-by noise from measured data. The black area is aircraft noise that the airport attributes to "airport noise." The red area is aircraft noise that the airport attributes to "community noise." The blue area is true "community noise."

the area shaded in red is placed in the "community" bin. The failure to include the red area with the black does not significantly diminish the reported airport noise. However, including the red area in the community noise bin, shaded in blue, substantially increases the apparent community noise. We termed these red areas as "tails." These tails to the airport noise events significantly distort and increase the community noise levels. Table 2 gives the total noise levels for the eighteen daytime monitoring sites, the "community" noise levels as computed by the airport method, the true community noise levels determined with an observer present, and the amount by which the airport computational method exaggerates the true community levels. One can note that the error generated by the airport's computational methods is on average 4 dB during daytime hours.

Another reason airport noise monitors fail to properly measure the community noise is that requiring correlation with control tower records means that any errors in record keeping propagate as airport noise being included as community noise. The airport's records show that about four percent of the aircraft are missed by the airport's noise analysis system. That is, the tower count of operations is about four percent higher than the noise analysis system count of operations.

Finally, not all airport noise monitoring systems are designed to measure lower noise levels, since aircraft noise near an airport is typically a relatively noisy event. So the electrical noise floor of the monitor can be a problem when trying to measure quiet community settings.

In summary, airport noise monitors do not measure community noise properly because they exclude from the airport bin and count in the community bin events that do not reach the threshold, events that reach the threshold but not for a long enough time, they fail to include the tails of valid events, they fail to include events uncorrelated with tower records, and they fail to account for self-noise of the monitoring system.

To show that the community noise data reported by the noise-monitoring system was biased by these various factors, two forms of proof were used. First, we compared hourly community noise levels for those hours when no aircraft were reported as present in the vicinity of a given monitor with the same hours of the day, but for days when some aircraft were recorded as present. Secondly, we graphed and compared the hourly aircraft noise level with the hourly "community" noise levels. There is no reason for the true community noise to be correlated with the airport noise—the noise from children playing, vehicles in the street, etc. should not be correlated with the noise of aircraft arriving or departing MSP. Table 4 compares hours of the day for days where no aircraft were reported in the vicinity of that monitor and days where aircraft were reported to be in the vicinity. Clearly there is a large shift in the "community" level when aircraft are present versus when aircraft are not present. This is one clear indication that the reported community levels include significant amounts of airport noise. Figures 4 and 5 plot airport reported levels versus "community" levels. As shown on these figures there is a significant correlation between the two, again indicating that the "community" levels include significant quantities of airport noise. Thus, this analysis serves

Table 2. Daytime Measurement Results

Measurement Number	Total Noise	MSP Non -Airport Noise	Measured Non -Airport Noise	Difference in non -airport noise	L90	Measured Non-airport noise minus L90
3112	61.5	56.9	53.7	3.2	50.9	2.8
3116	62.3	49.9	43.6	6.3	39.1	4.5
3117	67.9	53.9	46.9	7.0	45.2	1.7
3118	66.1	54.7	50.8	3.9	45.9	4.9
3119	62.9	52.7	51.6	1.1	45.1	6.5
3120	61.8	51.2	47.0	4.2	44.5	2.5
3121	63.3	56.9	52.1	4.8	49.4	2.7
3211	56.4	54.6	51.5	3.1	48.5	3.0
3214	64.9	56.1	48.0	8.1	46	2.0
3215	63.6	53.7	52.7	1.0	49.6	3.1
4151	55.8	53.3	46.3	7.0	43.9	2.4
4152	57.4	53.7	53.5	0.2	42.4	11.1
4153	59.0	51.7	49.2	2.5	48.2	1.0
4154	56.9	52.0	52.0	0.0	44.8	7.2
4155	58.6	49.6	46.7	2.9	43.5	3.2
4156	66.1	52.3	46.9	5.4	41.8	5.1
4157	54.9	54.4	50.4	4.0	48.7	1.7
4158	56.7	51.8	46.0	5.8	42.8	3.2
Average	60.9	53.3	49.4	3.9	45.6	3.8
STDEV	4.0	2.1	3.0	2.4	3.1	2.5

This table shows our total measured noise, "MSP calculated" non-Airport noise, the actual measured non-Airport noise, and the difference between the two (dB). This table also shows the L90 and the difference between the measured MSP non-Airport noise and the L90.

to show that the monitored results that we developed with our sampling methodology were much more valid predictions of the community noise than the "community levels" measured by the airport's noise monitoring system.

(3) Quantify the impacts

The three impacts quantified were annoyance, speech interference, and sleep disturbance. Our noise criterion level for "quietude" was a DNL in the range of 50–55 dB. Our speech interference criterion was an indoor Leq less than 45 dB for indoor communication and a similar level for outdoor communication. Our sleep disturbance criterion was a single event level (SEL) greater than 50 dB. There was not great contention in the lawsuit on the speech interference criterion or the methodology and levels of sleep disturbance. For sleep disturbance, the methods of the new ANSI/ASA S12.9 Part 6 were used[1] by all parties to the lawsuit. (Details of the sleep disturbance methodology can be found in the July 2009 issue of *Acoustics Today*.)

The most contentious issue was the annoyance criteria. Airports and the Federal Aviation Administration (FAA) have relied on a 45 dB indoor criterion citing the Environmental Protection Agency (EPA) as their source. However, we felt that the Airport (and the FAA) were misinterpreting the EPA document.[2] Specifically they cited the 1974 EPA "Levels Document" which established "levels of environmental noise requisite to protect health and welfare with an adequate margin of safety." That document establishes indoor and outdoor noise criteria used by most federal agencies. It clearly states that the indoor criterion, 45 dB, is necessary and sufficient for protecting speech communication. The EPA presents indoor and outdoor numbers as a pair using the conjunction "and" in several places. Never do they use the conjunction "or." Examples citing this pair of criteria can be found on page 22 of the "Levels Document," on page D-34, and page D-36. It is the 55 dB outdoor criterion that protects from annoyance and the 45 dB indoor criterion that protects just indoor speech communication. But MSP sought to establish just the 45 dB indoor criterion as sufficient, ignoring annoyance and ignoring the outdoor level. They were not sustained by the court in this attempt.

The conclusions on this point are clear. The EPA criteria are jointly outdoors and indoors. Moreover the primary criterion is 55 dB outdoors since the 45 dB indoor criterion protects only speech communication and in no way protects from sleep disturbance, and in no way establishes a level for indoor noise annoyance.

The next point was to show that the annoyance from airport noise in the 60–65 DNL zone is not low or insignificant. Here again it was necessary to show that the criteria presented by MSP were biased and misleading. The FAA uses a prediction curve (Fig. 6) for the percent "highly annoyed" versus

Table 3. Nighttime Measurement Results

Site	Date	Non-Airport/ Community LEQ(dB)	Total LEQ (dB)	Difference (dB)
4849 13th Ave. S	20 June 2006	39.4	50.0	10.6
4525 Pillsbury S	20 June 2006	43.4/37.9	50.0	6.6
4525 Pillsbury S	21 June 2006	39.3	48.5	9.2
300 Elmwood Pl.	20 June 2006	39.7	49.0	9.3
300 Elmwood Pl.	21 June 2006	35.8	48.1	16.3

Table 4. Difference in Community Levels (dB) at MSP Noise Monitor

Hour of the Day	"Community" Levels for Hours when Aircraft Reported to be Near Monitor (dB)	"Community" Levels for Hours when Aircraft *NOT* Reported to be Near Monitor dB)	Difference in Level (dB)
8:00	48.3	44.5	3.8
9:00	48.3	48.2	0.1
10:00	53.6	46.1	7.5
11:00	53.8	42.7	11.1
12:00	54.8	51.4	3.4
Average	51.8	46.6	5.2

Difference in Community Levels (dB) at MSP Noise Monitor between times when aircraft were reported to be near the monitor and when aircraft were not reported to be near the monitor.

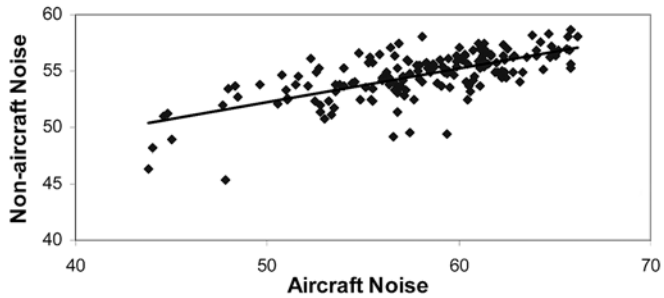

Fig. 4. "Non-airport" versus airport noise for daytime hours (7:00 a.m. to 10:00 p.m.).

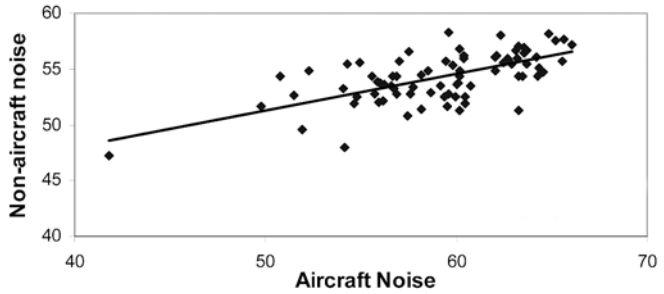

Fig. 5. "Non-airport" versus airport noise for nighttime hours (10:00 p.m. to 7:00 a.m.).

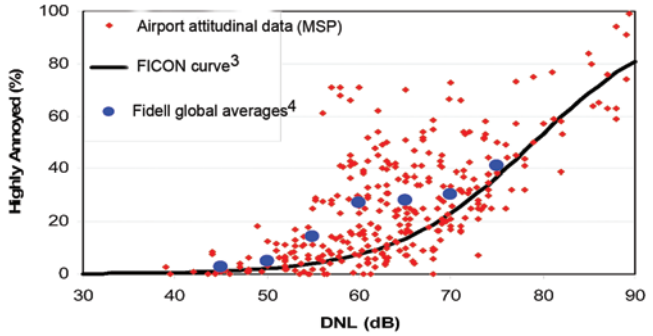

Fig. 6. Minneapolis–St. Paul airport noise attitudinal survey data (red dots) compared to Federal Interagency Committee on Noise report[3] and Fidell world-wide survey[4]

DNL that does not really fit their data set. Rather, this curve under-predicts in the range of interest, DNL 55–70. Moreover, they use an incomplete data set that does not include many surveys. For example, in the 5 dB range centered at 60 DNL (57.5–62.5 dB), they predict 8 percent highly annoyed whereas the true percentage is more than three times the FAA prediction[3] or about 25 percent highly annoyed. It was easy to show the errors in the airport's position since the bias to their curve is obvious; that is, it is obvious that their curve does not go through the middle of their data. Also, it was rather easy to show that their data were incomplete since one could use the published, reviewed data[4] by Sanford Fidell that include all data world-wide for aircraft noise surveys reported in English.

The next point was to show that sleep disturbance would occur more or less throughout the zone of interest and not just in select areas. To do this we actually traced a large sample of nighttime flight tracks at MSP using data provided on their airport-noise office website. An example of northerly flow on the two main runways at MSP is shown for the hours from 10:30 p.m. to 6:30 a.m., and one can see that the flight tracks form a blanket over most of the area. The sound exposure levels (SEL values) along these tracks, as measured by the MSP noise monitors, were tabulated. Figure 7 shows the single event SEL values experienced within various noise contours. Here it can be seen that an SEL value of 85 dB is exceeded almost everywhere within the zones of interest, in this case with northerly flow on the runways. Similarly, Fig. 8 shows the same thing for southerly flow. As stated, the methods of the recent ANSI/ASA S12.9 Part 6 were used to compute the probability of being awakened at least once during the night.

(4) Show that a 5 dB package of noise mitigation in homes will ameliorate the situation

Table 5 quantifies the probability of awakening under existing conditions. We then assumed a 5 dB noise mitigation package and recomputed the likelihood of awakening. The change in the likelihood of awakening was used to quantify the noise benefits in the 60–65 DNL zone. In addition to the clear benefits of reduced sleep disturbance, a 5–dB reduction in the indoor noise environment clearly reduces noise annoyance.

Table 5. Population Awakened At Least Once by MSP Flyovers

Community	Homes	Population @ 1.5 per Home	People Awakened at least Once		
			Existing	Insulated	Reduction
Minneapolis	4,291	6,437	1,278	836	442
Richfield	845	1,268	252	165	87
Eagan	492	738	147	96	51
Total	5,628	8,443	1,677	1,097	580

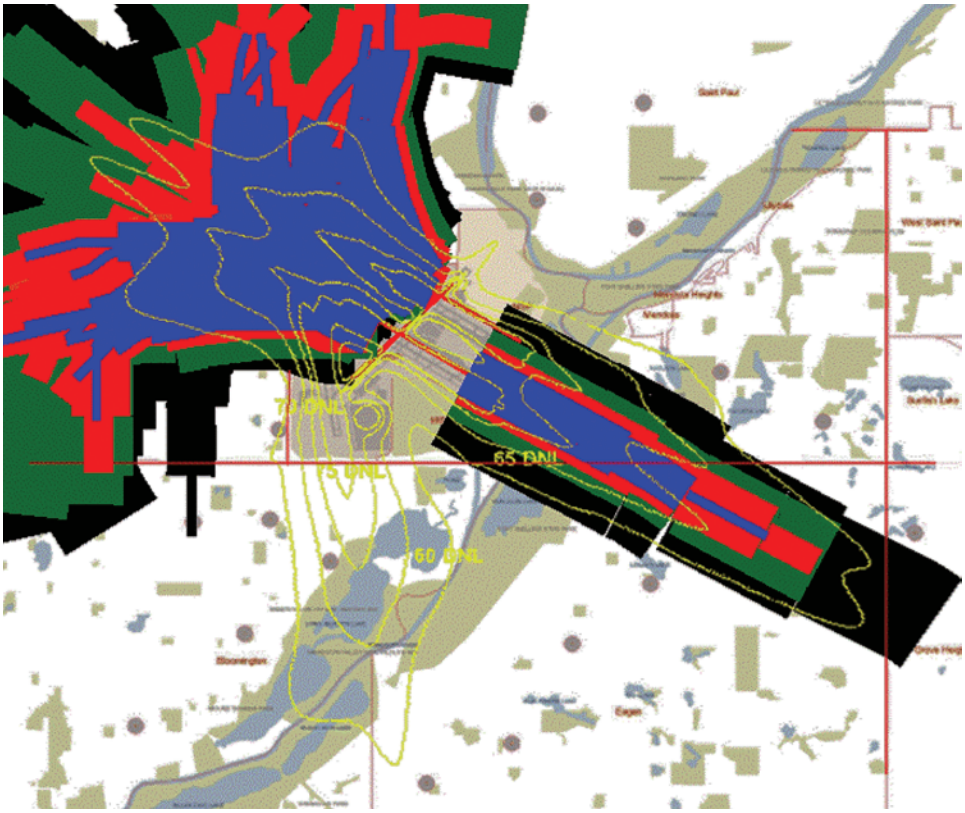

Fig. 7. Maximum A-level noise zones for six random nights with northerly takeoff flow (10:30 p.m. to 6:00 a.m.). Black, green, red, and blues indicates levels greater than 70, 75, 80, and 85 dB, respectively.

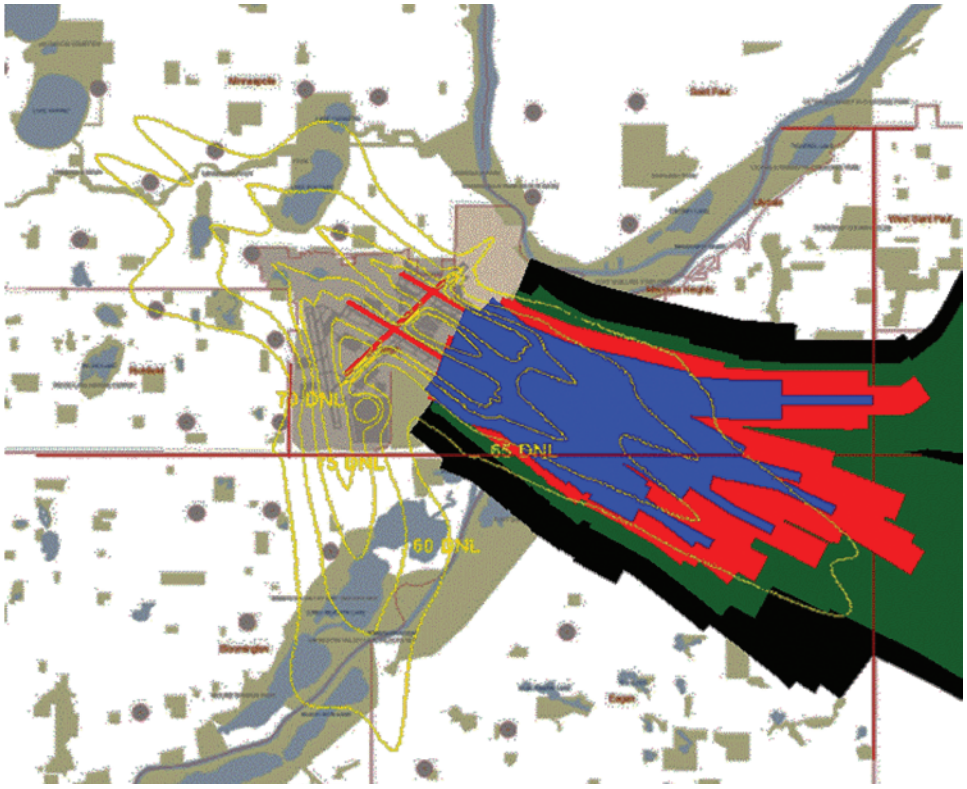

Fig. 8. Maximum A-level noise zones for three random nights with southerly takeoff flow (10:30 p.m. to 6:00 a.m.). Black, green, red, and blues indicates levels greater than 70, 75, 80, and 85 dB, respectively.

Results

The results after the trial and several months of negotiations urged by the court was a negotiated settlement of 128 million dollars to insulate homes in the DNL 60–65 dB zone as established by MSP in the City of Minneapolis and the suburbs of Eagan and Richfield. This is believed to be by far the largest noise settlement ever established. Several conclusions can be drawn from this study—(1) urban communities can be very quiet, absent a single noisy source such as an airport; (2) most airport noise monitors overstate the true community noise, sometimes by large amounts; (3) by itself, an indoor level of 45 dB is not a valid criterion; rather, outdoors less than 55 dB and indoors less than 45 dB are the proper pair of criteria; and (4) One can calculate the probability of being awakened at least once by a whole night's set of events. AT

References

1. ANSI S12.9 Part 6, American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound—Part 6: Methods for Estimation of Awakenings. (American National Standards Institute, New York).
2. EPA. *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*, US Environmental Protection Agency, Office of Noise Abatement and Control (ONAC), Report EPA550/9-74-004, Washington D.C.
3. Federal Interagency Committee on Noise (FICON) *Federal Agency Review of Selected Airport Noise Analysis*, August 1992. www.fican.org/pdf/nai-8-92.pdf. (Last viewed 11/19/2009).
4. Sanford Fidell and Laura Silvati, "Parsimonious alternative to regression analysis for characterizing prevalence rates of aircraft noise annoyance," Noise Control Eng. J. **52**(2), 56-68 (March-April 2004).

Jack Freytag began his acoustical consulting career in the early 1970's with Robin M. Towne & Associates in Seattle, Washington, where he worked on one of the first airport noise projects for Sea-Tac Airport. He then received a scholarship to the graduate engineering program at Stanford University at the National Aeronautics and Space Administration (NASA)–Stanford Joint Institute for Aeroacoustics where he conducted laboratory and theoretical studies at nearby NASA-Ames Research Center, Moffett Field. Upon graduation he joined The Bechtel Group where he worked for ten years, initially on industrial noise control projects but then in engineering management for large facilities worldwide (principally on a synthetic gasoline project in New Zealand). Other assignments included venture capital analyst, computer-aided design and drafting (CADD) manager and Executive Assistant to the President of Bechtel Petroleum. In 1985 he returned to acoustical consulting as a Director at Charles M. Salter Associates in San Francisco for twenty years and then for two years as a Director at Harris Miller Miller & Hanson in Newport Beach, California. He has managed more than forty sound insulation projects around airports. Recently Jack established his independent acoustical consulting practice, Freytag & Associates, LLC, in Newport Beach.

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