

SUPPLEMENTAL ANALYSIS EXAMPLES

The 14 case summaries below illustrate the growing use of supplemental metrics to better explain noise exposure to the public and better inform the decision makers. NA has emerged as the most widely used supplemental metric in airport noise analysis. Public response to the inclusion of supplemental metrics in airport noise studies has been all positive.

As reported in the Noise Regulation Report November 2006 Issue:

While DNL might give airport planners and the FAA a convenient, uniform way of depicting average noise exposure for an average annual day using the average fleet mix, average ground tracks, average flight tracks, average aircraft performance characteristics, and average atmospheric conditions, it does not convey to residents how frequently they are or will be disturbed by noise. "There is growing evidence that the number and intensity of the individual noise events that make up DNL are more important to public understanding of the effects of noise around airports," according to senior staff at Wyle Laboratories.

"Further evidence of the disconnect between DNL as a figure of merit and public acceptance is that airport officials and federal authorities are sometimes surprised by strong opposition to growth and expansion projects when they can project future DNL contours will be smaller than current contours because of a quieter future fleet mix. Frequency of operations is a component of noise exposure that defines the noise environment for many individuals (perhaps even better than average sound

energy), and the sooner we incorporate frequency of operations into the analysis of airport noise exposure, the better we will manage public opposition to the many needed airport expansion projects."

Wyle's approach is to look inside DNL by calculating the number of minutes the maximum sound level exceeds specified thresholds in the average annual day (Time Above, or TA) and the number of times within the selected time period that noise levels exceed a specific threshold (Number of events Above, or NA). With detailed grid point analysis given locations in a study area, TA and NA can be calculated over a range of thresholds, so that residents can graphically see how airport operational changes will affect them.

"Several airports have now included some level of NA and TA analysis in their recent noise studies, and in each instance, the public response has been very positive, and airport official's concerns that providing this additional noise exposure information may lead to greater demands for mitigation have proven to be unfounded," said Wyle special projects director Bill Albee.

Supplemental Information on The Noise Data for the Eastern WV Regional Airport/Shepherd Field - Martinsburg WV

Eastern WV Regional Airport/Shepherd Field is a joint use airport located in Martinsburg, WV. In 2001, the West Virginia Air National Guard Bureau (ANGB) proposed conversion of their C-130H aircraft to the C-5A aircraft. When the conversion is implemented, the 2000 baseline annual number of C-130H operations of 6,897 would be replaced by a total of 564 C-5A operations per year. The C-5A is substantially louder than the C-130H to the extent that even though the total annual number of C-5A operations will be 12 times less than the C-130H number of operations, the forecast DNL contours are substantially larger than the baseline contours, to the extent that the projected DNL 70 dB contour will approximate the baseline DNL 65 dB contour.

In response, the local Board of Supervisors proposed to preclude new development within the future DNL 70 dB contour. If imposed, this restriction would have stopped

a previously approved new subdivision valued at \$15 million. The affected developer sought additional supplemental analysis to present to the Board of Supervisors to assure that they were making their decision based on the best available information.

To supplement the DNL analysis of the projected change in the noise environment between the baseline and the proposed action, a seven grid point analysis was performed using the Number-of-events Above (NA) metric. Figure 1 below shows the seven grid points, with points 1, 3, 4, 6, and 7 on the projected DNL 70 contour line; point 2 on the runway centerline extended halfway between points 1 and 5; and point 5 where the DNL 75 dB contour intersects the runway centerline extended. Figure 2 shows the relation of the selected grid points to the baseline DNL contours (note that points 3, 4, 6 and 7 fall on the baseline DNL 65 dB contour).

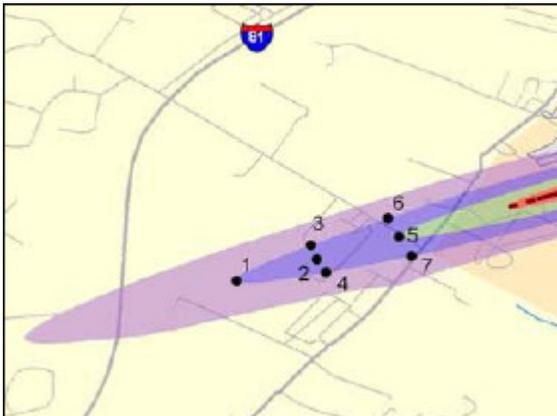


Figure 1



Figure 2

Table 1 below lists the coordinates and DNL values of the seven locations for both the baseline and proposed action conditions, and shows that the DNL is projected to increase from 5 to 7 dB at each grid point from the baseline to the proposed action.

Table 1. DNL at the Seven Supplemental Analysis Grid Points

Supplemental Analysis Point	Longitude (W)	Latitude (N)	BASELINE FY00 DNL (dB)	PROPOSED ACTION DNL (dB)
#1	78.01880	39.39248	65	70
#2	78.01252	39.39420	66	72
#3	78.01302	39.39531	65	70
#4	78.01180	39.39315	64	70
#5	78.00610	39.39595	68	75
#6	78.00698	39.39741	64	70
#7	78.00513	39.39443	64	70

Table 2 below compares the baseline and proposed action modeled number of aircraft events at or above the indicated Sound Exposure Level (SEL) for the average annual day and the percentage contribution of that number of events at that SEL to the DNL for that location.

Table 2. Number-of-Events Above SEL and Contribution to the DNL

Supplemental Analysis Point	SEL (dB)	Baseline FY00		Proposed Action	
		# aircraft events above	Contribution to DNL	# aircraft events above	Contribution to DNL
#1	110	0	3%	1	84%
	105	2	42%	3	94%
	100	4	52%	5	98%
	95	27	87%	8	99%
	90	42	100%	10	100%
#2	85	43	100%	11	100%
	110	1	16%	1	85%
	105	3	48%	4	97%
	100	4	52%	5	98%
	95	42	100%	10	100%
#3	90	42	100%	10	100%
	85	43	100%	11	100%
	110	0	3%	1	83%
	105	2	42%	3	95%
	100	4	52%	5	98%
#4	95	31	89%	9	99%
	90	42	100%	10	100%
	85	43	100%	11	100%
	110	2	37%	3	96%
	105	3	45%	4	98%
#5	100	9	57%	5	99%
	95	42	94%	10	100%
	90	43	94%	11	100%
	85	43	94%	11	100%
	#6	110	0	3%	1
105		2	43%	3	95%
100		4	53%	5	98%
95		31	88%	9	99%
90		42	100%	10	100%
#7	85	43	100%	11	100%
	110	0	2%	1	84%
	105	2	44%	3	96%
	100	4	54%	5	98%
	95	31	88%	9	99%

When comparing the proposed action to the baseline data presented in Table 2, it is apparent that while there are a few more events at or above SEL 100 dB threshold, there are considerably less events in the 85-100 dB range. 98 percent of the DNL will be generated by these few events at or above 100 dB for the proposed action, while only 54-52 percent of the baseline case DNL is caused by the events at or above 100 dB. While the future DNL noise contours will be substantially larger, it will be driven by an average of only 5 events per day at or above SEL 100 dB at each of the sites analyzed. Using SEL 95 as a threshold, a reduction on average of between 19 and 32 events per day

will result from implementation of the proposed action.

Most people regard all events at SEL 95 dB or higher to be intrusive, and many might perceive the trade off of 19 -32 fewer events per day at this level for an increase of 5 per day at SEL 100 dB or greater to be an improvement in their noise environment. At least that is the conclusion reached by the Martinsville Board of Supervisors, who revised their overlay zoning proposal, based on this supplemental analysis, to allow the previously approved subdivision in the future DNL 70 dB contour to proceed, and to only preclude new development within the projected DNL 75 dB contour.

Noise Study for the City of Eagan, MN

The new north-south runway at Minneapolis-St. Paul International Airport (MSP), Runway 17/35, opened in October, 2005. Runway 17/35 is predicted to eventually handle 37% of all departures and 16.5% of all arrivals at MSP. All departing operations on Runway 17/35 are to the south, and all arrival operations are to the north. Since the City of Eagan is the jurisdiction directly south of MSP it is directly under the new runway flight corridor. Now that the new corridor is in use, the west side of Eagan is experiencing a noticeable increase in environmental noise.

Several months before the new runway opened, the City of Eagan commissioned a study of existing and future noise levels. The goal was to analyze the future noise impact of Runway 17/35 on the City of Eagan, using the Integrated Noise Model (INM) input data from the MSP Part 150 noise study. Fifty noise modeling "grid points" were identified by City officials. A detailed analysis of noise exposure at these locations was conducted using the Day-Night Average Sound Level (DNL) metric, supplemented by metrics that focus on the noise impact of individual aircraft overflight events. To help the City of Eagan and the community better understand the expected future noise environment, in advance of the runway opening, the number and duration of aircraft

operations that exceed a range of selected sound level thresholds at the fifty grid points was modeled.

The INM input data used in the recent MSP Part 150 Study to produce their 2007 DNL average annual day noise contours was used for this study. Both the existing and future noise environments were thoroughly analyzed and quantified, including a comprehensive database of noise levels measured at specific locations before the opening of Runway 17/35. This information, along with the predicted aircraft noise levels modeled at these and a number of additional locations, enabled the City of Eagan to provide citizens with detailed noise exposure information in advance of the runway opening.

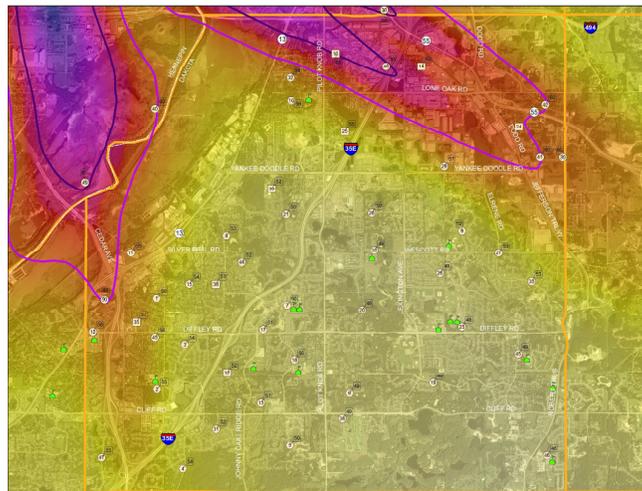
Never before has a community compiled a detailed database that not only provides the projected average DNL at many specific points throughout the community, but also a breakdown of that average noise exposure into the Number-of-Events Above and the Time Above components across the full range of thresholds that comprise the average aviation noise exposure. The study enabled a citizen to look at the data for the grid point nearest to their home and find out how many times they can expect to hear airplanes each day and how loud those

operations are predicted to be on the average annual day. The report was careful to point out that actual daily exposure may vary considerably from the average annual day so that citizens understand that on some days they will hear more than the average number of events and on other days they will hear less.

The residents of the City of Eagan directly under the new runway flight pattern were alerted to expect an abrupt change from no aircraft overflights, in the range of tens to hundreds per day depending on how close to the airport they reside. While no amount of data can totally prepare every citizen for such an abrupt change in the noise environment, the citizens of Eagan were far better informed in advance of this runway opening than were citizens impacted by previous runway openings at any U.S. airport. When the City of Eagan officials made this information available to the public in a series of workshops, they found that citizens consistently went to the information station that showed the NA grid point results. Ms. Dianne Miller, Assistant to the City Administrator, conducted the workshops and reported:

“Clearly, we heard repeatedly at our nine neighborhood open houses that DNL is not helpful in determining what impact residents can expect. Rather, we were continually told, “I don’t want to know to know the average amount of noise, I simply want to know how many planes will be over my house each day.” In large part, it was because of comments such as this that the City undertook the noise study.

To present the results of the noise study, the City used three presentation boards—number of events above (NA), time above (TA), and a color coded DNL map. While I personally liked the color variations of the DNL map (shown below), interestingly, of the approximate 100 residents in attendance, not a single person went to the DNL map first. Rather, I would venture to say that 90% of the attendees were first drawn to the NA board. By overlaying the grid point analysis onto a City street map, residents could find their home on the map, and then look to the nearest grid point to see the number of planes per day predicted over a given decibel level (e.g. number of events per day over 65 decibels). City staff and Commissioners were very clear in explaining to residents that the NA grid was an estimate, based on a model that uses the term “Average annual day”. In short, I told residents that they could not sit at their window and expect to only count the number of events predicted by the study. In large part, residents understood that the study is based on models, and we clearly will be in a “wait and see” mode. I found that people appreciated the efforts of the City in embarking on the study, and they appreciated walking away with a number that was meaningful to them. Similarly, TA seemed to ease people a bit when they saw the actual amount of time per day they could expect events over a given threshold (e.g. twelve minutes per day with events over 65 decibels).”



Noise Study for St. Petersburg/ Clearwater International Airport

In response to community concerns about aircraft noise impacts, the St. Petersburg-Clearwater International Airport (PIE) is conducting a multi-phased Noise Study that would serve to support ongoing work of the PIE Noise Abatement Task Force. The scope of the Study includes identification of any significant changes in noise exposure that may result from any recommended modifications to arrival and departure flight procedures from the separate airspace study. The Task Force expressed a critical concern in understanding the overall noise environment, so a primary goal of the Study is to identify and fully disclose the current and future aircraft-generated noise levels in the vicinity of the airport.

To fully achieve this goal, the Study includes presentation of results using supplemental noise metrics along with the traditional Day/Night Average Sound Level (DNL) metric annual average day noise contours. In addition to updating the DNL noise exposure contours for PIE, the following project tasks were performed in Phase I and will be used in the Phase II analysis of feasible noise abatement measures, which will be completed in 2007:

- Expand the noise modeling study area to include all affected neighborhoods in Pinellas County;
- Conduct detailed noise analysis at grid points throughout the study area;
- Improve the description of the noise environment using single-event metrics to "break down" the average DNL metric into its component parts; and
- Improve communication of noise results through maps showing noise exposure beyond the standard 65 dB DNL contour.

Improve communication of noise results through maps showing noise exposure beyond the standard 65 dB DNL contour.

A detailed analysis of noise exposure was conducted throughout the entire study area using DNL and two supplemental metrics -- Time Above (TA) and Number-of-events Above (NA). These metrics were used to break DNL down into its component parts and provide a more detailed analysis of noise exposure. The study area and grid points were selected by the PIE Noise Abatement office based on the following criteria: multiple noise complaints, locations near existing DNL contours, and locations near flight tracks. The grid point analysis included locations throughout the entire study area, most of which is located outside of the 65 dB and 60 dB DNL contours. The thirty-six specific grid points were selected throughout the study area for detailed analysis.

In addition to DNL, the TA and NA at each grid point was computed for sound level thresholds from 55 - 90 dB in 5 dB increments. These thresholds were selected to begin at a relatively low sound level and increase until the TA and NA was equal to zero at most sites. In addition to tables in the project reports showing TA and NA results at each grid point, contours were plotted on an aerial photo with gradual color shading to show TA and NA noise exposure throughout the entire study area as shown in Figures 1 and 2 below. These metrics were used to show the benefits of a noise abatement alternative for night air carrier arrivals from the north. The noise shift at key grid points and threshold levels are shown in Figure 3.

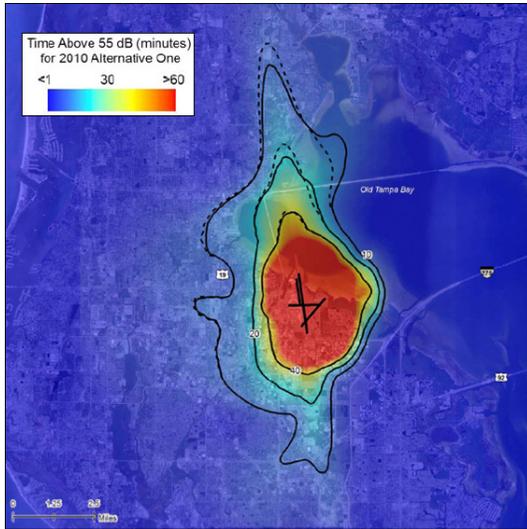


Figure 1. TA Contours

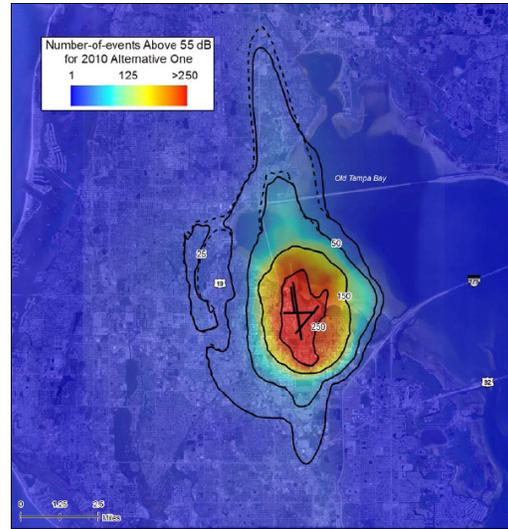


Figure 2. NA Contours

Point	City	Location	Total Number of Events with an L_{max} Between:					
			55 and 70 dB		70 and 80 dB		80 dB and Greater	
			No-Action	Alt. 1	No-Action	Alt. 1	No-Action	Alt. 1
5	Oldsmar	600 Shore Dr.	8	13	2	2	0	0
6		324 E. Shore Dr.	6	10	4	4	0	0
37		Oldsmar Power Plant	5	10	4	5	0	0
8	Safety Harbor	12 Fern Ct.	34	33	7	4	< 1	< 1
9		730 West Gate Dr.	37	36	7	4	< 1	< 1
15		1435 4th Street North (PIE Outer Marker)	33	32	7	4	< 1	< 1
16		Philippe Park (Bayshore Drive)	10	14	3	3	0	0
10	Clearwater	3240 San Mateo	41	41	12	8	< 1	< 1

Figure 3. Comparison of Number-of-Events at Several Ranges of L_{max}

When the noise modeling results were presented to the Task Force, they specifically commented that the TA and NA metric results clarified their understanding of the DNL metric and that they were appreciative of the lengths to which the airport had gone to candidly present a full disclosure of the airport's noise impacts on the community and facilitate their understanding. By doing so, Airport officials significantly increased their credibility in the eyes of the community.

New Runway EIS at Washington Dulles International Airport

The Federal Aviation Administration completed an Environmental Impact Statement (EIS) in 2004 to identify the potential environmental effects associated with the construction and operation of two new runways at Washington Dulles International Airport (IAD). FAA Orders 1050.1E and 5050.4A establish the Threshold of Significance for noise impacts to be a DNL increase of 1.5 dB or greater at

any noise-sensitive areas within the DNL 65 dB contour. Further analysis is prescribed if an increase in the DNL of 1.5 dB will occur at any noise-sensitive area within the DNL 65 dB contour.

The EIS noise analysis determined that off-airport aviation-related noise impacts are not anticipated with any of the alternatives. While the DNL 65 dB contour encompasses

several hundred areas off airport property, no residences and no noise-sensitive receptors would exceed the DNL 1.5 dB Threshold of Significance within the DNL 65 dB contour under any of the alternatives considered. Though not required by FAA Order 1050.1E, for the purposes of fully disclosing potential effects of the Build Alternatives, additional DNL contours were generated to identify noise-sensitive areas that would be exposed to increases of 3.0 dB or greater between the DNL 60 and 65 dB contours, and 5.0 dB or greater between the DNL 45 and 60 dB contours. This analysis revealed that increases of DNL 3 dB or greater between the DNL 60 and 65 dB contours and increases of 5 DNL or greater between the DNL 45 and 60 dB contours would occur for the build alternatives. While these projected increases would not exceed FAA's Threshold of Significance for noise impacts, both FAA and the Metropolitan Washington Airports Authority acknowledged that people may be adversely affected by these increases in aircraft noise levels associated with several build alternatives. To address these concerns, supplemental metric noise analysis was performed.

The Federal Interagency Committee on Noise issued a report in 1992 that identified sleep disturbance and speech interference as two areas where it is appropriate to consider analysis using supplemental metrics. Such analysis was undertaken in this EIS to determine whether or not these phenomena might occur and, if so, how frequently such interference/disturbance could potentially occur on an average daily/nightly basis. The supplemental metrics employed were other half of the points with implementation of either build alternative. Considering both build alternatives, the projected changes in TA 70 dB ranged from a maximum increase of 2.0 minutes to a maximum decrease of 2.4 minutes. The average change at all 45 points for the build alternatives was 0.3 minutes and 0.4 minutes respectively, compared to the No-Action.

Alternative. The EIS concluded that the TA 70 dB analysis helped confirm there is no

Maximum Sound Level (L_{max}), Time Above (TA), and Number-of-events Above (NA) in order to provide information about the number, level, and duration of the aircraft noise events that comprise the average daily noise exposure expressed by the DNL metric. The frequency of occurrence was described by plotting NA contours showing the number of events projected to occur on the average annual day at or above L_{max} 70 dB. Contours were plotted for 15, 30, 60 and 120 events per day for each alternative. The EIS stated that there are no established criteria for noise exposure measured by the L_{max} , TA, or NA metrics. The EIS further explained that the supplemental metrics were used to help communicate noise exposure in terms that help the public better understand the DNL metric, specifically pointing out that DNL is the only metric used to determine if a proposed action will have a significant noise impact.

The L_{max} analysis identified the loudest maximum instantaneous sound level modeled for each noise-sensitive receptor point modeled in the EIS. This analysis indicated there will be a slight increase relative to the No-Action Alternative in the predicted L_{max} at most receptor sites under either of the build alternatives, with a maximum increase of 8.1 dB at one point under one of the build alternatives.

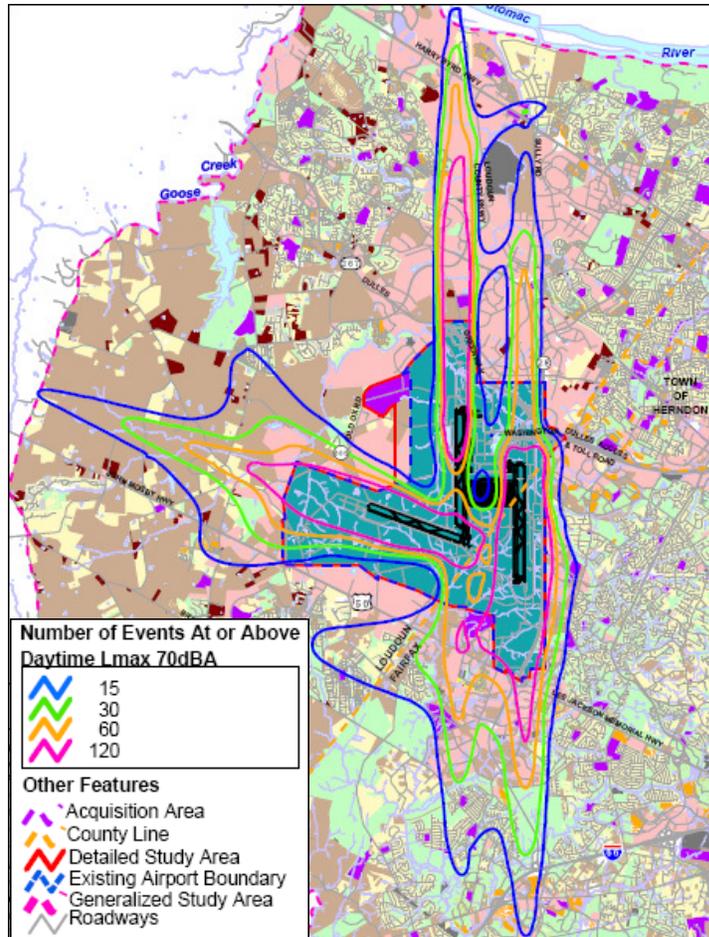
The TA metric was used to compare changes in the time above the selected threshold value of 70 dB at each of the 45 noise-sensitive receptor points. This analysis showed that relative to the No-Action Alternative the TA 70 dB would decrease at about half of the points and increase at the significant increase in noise exposure among any of the modeled build alternatives relative to the No-Action Alternative.

The NA metric was used to compare daytime changes in the number of events at or above the selected threshold value of L_{max} 70 dB at each of the 45 noise-sensitive receptor points. The analysis showed the NA70 would remain the same relative to the No-Action Alternative at 18 of the points if

either build alternative is implemented, and that the increase and decrease at the remaining points would split evenly. It further showed that several sites would experience increases or decreases of up to 60 events per day at or above L_{max} 70 dB.

The NA metric was also used to compare nighttime changes in the number of events at or above the selected threshold value of SEL 90 dB at the noise-sensitive receptor points.

The EIS points out that the SEL metric relates best to sleep disturbance research results, and that an SEL of 90 dBA correlates to an indoor maximum percent awakening of 10 percent or less. The EIS states that night operations will not be affected by the build alternatives and the analysis confirmed that neither of the build alternatives would result in an increase in potential incidents for sleep disturbance when compared to the No-Action Alternative.



Example of Daytime NA L_{max} Contour

Response to the supplemental noise analysis results provided at the public workshops was all positive, even from individuals who expressed opposition to the new runways. Many specifically stated that the supplemental analysis enabled them to understand the DNL metric and to clearly

understand the changes in noise exposure that will result from the new runways. Unlike virtually every other new runway project proposed at major airports in recent years, no legal challenges were made to slow or stop the project.

Nighttime Noise Criteria and Land-Use Guidelines for the City of High Point, NC

The goal of the current Federal Aviation Administration (FAA) noise compatibility guidelines is to provide guidance that encourages appropriate land uses around all U.S. airports. The FAA guidelines specify that DNL is the noise metric of choice in defining land-use compatibility. Based on this guidance, most of the Federal Aviation Regulation Part 150 Noise Compatibility Studies, Environmental Assessments and Environmental Impact Statements that have been conducted at U.S. airports are based upon the DNL 65 dB contour to identify the boundary between compatible or noncompatible noise exposure levels for noise-sensitive land uses. In essence, most of these studies have deferred to the DNL 65 dB threshold as a rigid standard or a de-facto “line in the sand”; and the general consensus has been that noise-sensitive land use without restriction should be allowed for areas that are exposed to noise levels below DNL 65 dB.

The Piedmont Triad International Airport (PTIA) is scheduled to become a new, full-service air cargo hub for FedEx in the near future. The City of High Point (City) is concerned that with the increase in nighttime operations that defining land-use compatibility by the projected DNL 65 dB contour will not be sufficient to protect the community from the increase in nighttime noise exposure. The new cargo operations forecast indicates that there will be a substantial increase in the number of nighttime operations, and that the operations are expected to occur within a short time period during the night. Since DNL is a 24-hour average noise metric (with a 10-dB weighting factor added to each operation between 10 PM and 7 AM), the City is concerned that when nighttime noise levels peak, the potential for increased sleep disturbance might not be accurately portrayed by the DNL noise metric alone. The City conducted a study to carefully and fully consider these issues by analyzing the projected noise impacts with the appropriate

supplemental noise metrics, and to adopt noise overlay zones that will provide sufficient protection, balanced with development goals, in the affected areas. The study focused on the following questions:

- Is DNL the appropriate metric for all land-use guidelines?
- What additional metrics are more appropriate for the specific circumstances?
- What are the criteria for delineating land-use zones?
- What are the appropriate control measures for each of these zones?

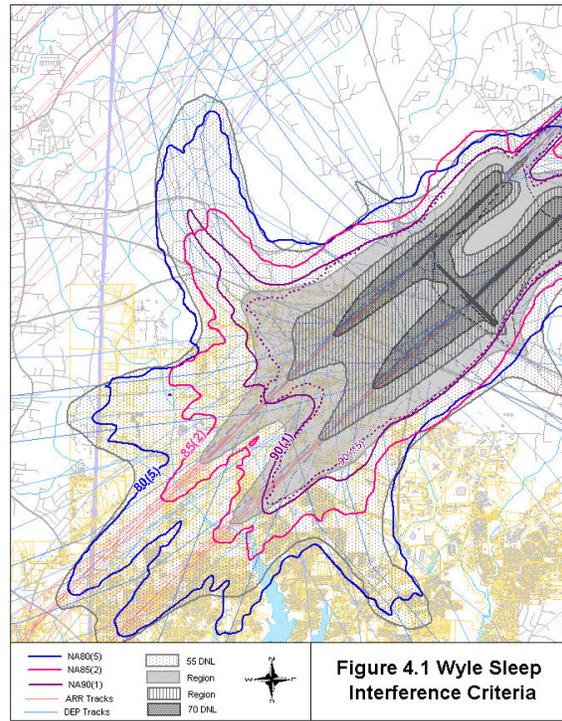
The City did not accept FAA’s DNL 65 dB guideline as sufficient to fully portray the nighttime noise environment in every situation, even with the 10 dB weighting factor for nighttime operations. They chose instead to quantify their nighttime noise exposure using the NA noise metric in order to quantify noise levels from the high frequency of individual aircraft over-flights projected to occur within a 3 hour time window each night. The NA metric was selected because the number, intensity and duration of individual noise events that occur during a sleep period are directly related to sleep disturbance research results. By combining the noise level and number of events, noise contours were produced based on the threshold single event noise levels and number of events associated with various levels of sleep disturbance identified in the sleep disturbance research literature.

As a result, three geographic areas were identified where different zoning guidelines could be applied to provide future protection against sleep disturbance. These zones were based on NA contours derived from varying degrees of sleep disturbance. The three noise overlay zones proposed for adoption were:

- Overlay Zone 3 - based on the NA 80dB, 5 events per night contour, within which disclosure of the nighttime noise

exposure level was recommended when a new residence is constructed or an existing residence is sold.

- Overlay Zone 2 - based on the NA 85 dB, 2 events per night contour, within which grant of avigation easements, a requirement for sufficient sound insulation to attain a noise level reduction of at least 25 dB in residential structures and noise disclosure were recommended.
- Overlay Zone 1 - based on the NA 90dB, 1 event contour within which prohibition of new residential development and of noise disclosure was recommended.
- A special Overlay Zone 1A within Zone 1 was also recommended to allow further residential development with certain restrictions in a current residential area that is not suited for any other type of development.



Zones 1, 1A and 2 were adopted shortly after the study was completed and Zone 3 was deferred for later consideration pending the completion of a Part 150 Study by PITA.

Oakland Airport Decision

The City of Oakland, CA prepared the required Environmental Impact Report (EIR) to analyze the consequences of their proposed Airport Development Plan for the Metropolitan Oakland International Airport. It's adequacy in defining nighttime noise impacts solely with the DNL noise metric was challenged in court by a citizens group and in it's decision, the California appeals court system set a precedent (at least in California) that DNL 65 dB is not a sufficient criteria to use in Environmental Impact Reports for this purpose and that single event noise levels must also be considered.

The appeal reviewed the decision of the Board of Port Commissioners for the Port of Oakland (the Port Commissioners) for the City of Oakland to certify the environmental impact report (EIR) analyzing the environmental consequences of the proposed

ADP. The ADP is a multi-faceted, long-range expansion proposal for the Airport that will provide increased capacity for both air cargo and passenger operations.

The trial court held that the EIR prepared for the ADP violated the California Environmental Quality Act (CEQA) by failing to analyze a reasonable range of alternatives, and by failing to evaluate the cumulative impacts of the ADP in combination with other reasonably foreseeable projects; ordering the Port Commissioners to set aside approval and certification of the EIR until a supplement to the EIR was prepared and circulated that complied with the requirements of CEQA. The court concluded that the EIR specifically failed to analyze adequately the noise impacts from planned additional nighttime flights.

Accordingly, a supplement to the EIR was prepared that assessed single event noise associated with nighttime (10:00 p.m. to 7:00 a.m.) aircraft operations. The Supplemental EIR (SEIR) states that specifically, this analysis was prepared as required by the Revised Judgment to:

- Evaluate potential nighttime noise effects by comparing nighttime aircraft activity under normal operating conditions both with and without the ADP in 2010;
- Estimate the increase in the average number of nighttime flights at two or more locations in the cities of Alameda, Berkeley, and San Leandro that could result from the ADP in 2010; and
- Calculate the probability of awakening due to single event noise from a representative sampling of aircraft operations as a result of implementing the ADP. The analysis uses the sleep disturbance dose-response relationship recommended by the 1997 Federal Interagency Committee on Aviation Noise (FICAN) for interior sound exposure levels and percent awakening.

Paraphrasing the SEIR:

In addition to providing the supplemental information required by the Revised Judgment, the SEIR analyzed whether the ADP would result in a substantial increase in sleep disturbance compared to conditions existing in 2000 and to conditions that would exist in 2010 without the ADP. In performing this analysis, the SEIR recognized that sleep can be affected by both the loudness of a single event and by the frequency of single events during the course of the night. Because no one numeric threshold accurately accounts for both the loudness of an individual event and the frequency of individual events in terms of the calculation of sleep disturbance, the SEIR qualitatively considered the numeric data regarding both factors.

The SEIR also recognized that individuals' experiences differ, and that a range of effects can occur. Quality of life effects can and do occur below the level that is deemed substantial for purposes of impact evaluation under CEQA. Thus, the SEIR presents as much information regarding the nighttime environment and potential effects on sleep as is feasible, so that, whether or not an impact is deemed significant, readers and decision-makers can gain a better understanding of the nighttime environment and the ADP's potential effects on sleep.

The SEIR presented existing nighttime arrivals and departures in 2000, and the increase in nighttime arrivals and departures with and without the ADP in 2010. Because arrivals and departures affect different geographic areas, arrivals and departures are presented separately. Also, South Field operations affect different geographic areas than North Field operations; therefore, the information in the SEIR is also broken down by South Field and North Field. In addition, each type of aircraft has its own noise effects, and people may perceive nighttime noise differently during different periods of the night. Accordingly, the information regarding nighttime operations is further broken down by whether the aircraft is a passenger, cargo, or general aviation aircraft; the type of aircraft (e.g., B-727, B-737, A-300, twin-engine turboprop, etc.); and the period of night in which the arrival or departure is expected to occur. The SEIR attempted to enable the reader to ascertain what could occur near a particular residential location. Based upon forecasts, the Port predicted that, compared to conditions existing in 2000, the ADP would generate 28 additional arrivals and 28 additional departures on South Field, and 13 additional arrivals and 15 additional departures on North Field, during the nighttime hours from 10 p.m. to 7 a.m.

To evaluate the noise levels of representative types of aircraft, the SEIR provided noise contours, or "footprints," for

various types of aircraft departing and arriving from South and North Fields in order to demonstrate the sound level associated with each type of aircraft in particular geographic areas, and found that, in general, aircraft noise footprints are getting smaller due to the replacement of older, louder aircraft with newer, quieter aircraft.

To provide further information regarding nighttime aircraft noise from the Airport, the SEIR quantified the number of aircraft events that are predicted to result in exterior single event noise at or above 90, 85, and 80 decibels (dB) sound exposure level (SEL) in a particular residential area on an average night. The SEIR provided single event noise contour maps depicting those geographic areas that would be exposed to single event noise at or above 90, 85, and 80 dB SEL, and the specified number of events.

The analysis showed that the majority of nighttime flights will not result in exterior noise levels at or above the lowest noise level reported (80 dB SEL). Out of 246 nighttime arrivals and departures projected for the ADP in 2010, only about 65 nighttime aircraft arrivals and departures would result in single event noise at or above 80 dB SEL at a residential location. When compared to 2000 existing conditions and to the No Project in 2010, it showed there will be no substantial ADP-related increase in the number of events at or above 85 or 90 dB SEL. In fact, in several locations, a decrease is predicted in the number of nightly aircraft events at or above these noise levels with the ADP in 2010, as compared to the other alternatives. Compared to existing conditions and future conditions in 2010, an increase in the number of events at or above the less intrusive noise level of 80 dB SEL is expected to occur at some locations near the Airport; however, this increase is not expected to substantially increase sleep disturbance.

As required by the Revised Judgment, this SEIR correlated nighttime single event noise levels with the potential for sleep disturbance. Using the methodology published by the FICAN, the SEIR identified the maximum percentage of a population that could be awakened by a single aircraft event at or above specific noise levels. Since the FICAN methodology is based on *interior* noise levels, this SEIR converted exterior noise levels from aircraft events to interior noise levels by taking into account the noise level reduction expected at particular residences based on building construction, whether sound insulation has been provided, and whether windows are opened or closed.

After considering the maximum percent awakening from individual aircraft events and the expected changes in the number of events at each noise level in each geographic area potentially affected by Oakland operations, the SEIR concluded that the ADP would not result in a substantial increase in sleep disturbance.

The SEL metric is the single event noise descriptor used in the SEIR analysis. SEL accounts for both the loudness of an event and its duration, and has been accepted by FICAN and other researchers as being appropriate for the assessment of the potential for sleep disturbance. The SEL value is *higher* than the maximum noise level (L_{max}) from a single event. The loudest noise level heard from an aircraft arrival or departure is about 10 dB *lower* than the SEL value.

The SEIR further stated: “The studies conducted at other airports have also revealed that the Number Above methodology provides meaningful information to the public regarding the expected frequency of noise events at or above specific noise levels and the geographic areas exposed to specific noise levels,” and that: “This approach is consistent with the approach used routinely in the evaluation of noise effects.”

The SEIR used a subjective sliding-scale approach to assess whether the increase in sleep disturbance would be deemed substantial. An increase (or decrease) in the number of aircraft events at or above 90 dB SEL was weighted more heavily than an increase (or decrease) in the number of aircraft events at or above 80 dB SEL,

because events at or above 90 dB SEL have a comparatively higher probability of disturbing sleep. Even though events less than 90 dB SEL have a lower probability of sleep disturbance, they were considered, reported, and analyzed in the SEIR to provide full disclosure to the public and decision-makers.

San Diego Airport Site Selection Program

California law required the San Diego County Regional Airport Authority (SDCRAA) to adopt a comprehensive plan on the development of the SCRAA's international airport, including a review of alternate sites. Aircraft noise analyses were performed for all potential airport sites, including Marine Corps Base (MCB) Camp Pendleton ("Pendleton"), Marine Corps Air Station (MCAS) Miramar ("Miramar"), Naval Air Station (NAS) North Island ("North Island"), two remote locations (named "Campo" and "Desert") and San Diego International Airport (SAN).

For each airport site scenario involving the military airfields, it was proposed that civilian air traffic would be integrated with current military air traffic. The Campo or Desert sites would be new airports with primarily civilian air traffic. For all alternate sites, SAN would be replaced, except for North Island in which SAN would continue to operate in its current configuration and layout. The six-site analysis resulted in the SDCRAA choosing the MCAS Miramar site for the voters, via a local ballot proposition, to decide whether the SDCRAA will pursue the site for a commercial airport.

In addition to developing the Community Noise Equivalent Level (CNEL) contours, the following supplemental analyses were performed:

- Gradual color shaded CNEL contour maps
- CNEL contributor analysis
- Sound Exposure Level (SEL) contours

- Instantaneous Maximum Sound Level (L_{max}) contours
- Noise simulation videos
- Flight frequency maps
- Time Above an L_{max} Threshold (TA) contours
- Number of Events At or Above an L_{max} Threshold (NA- L_{max}) contours
- Noise simulation videos

Typical noise maps contain DNL or CNEL contour lines at 5 dB intervals with minimal or non-existent information between the contour lines. The gradual color shaded CNEL maps provided visualization of the continuous change in aircraft noise exposure from CNELs from 60 dB to 85 dB. The CNEL contributor analysis resulted in a list of the top 4 contributors to the CNEL at 18 receptor sites in the vicinity of MCAS Miramar for existing and proposed scenarios.

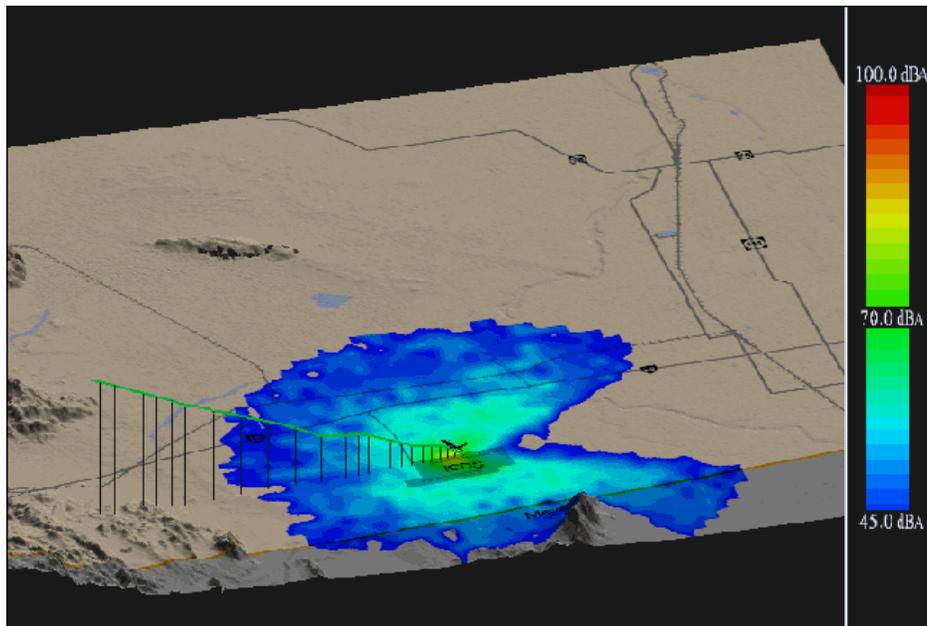
SEL contours, L_{max} contours and three-dimensional (3D) noise simulation videos provided decision-makers a fair site-independent comparison of the relative noisiness of applicable aircraft on a single-event basis. SEL and L_{max} contours were developed for several civilian and military aircraft types.

Noise simulation videos are 3D animations (i.e., movies) of typical departure and arrival operations of accurately showing the propagation of aircraft sound levels along the ground over time. The Noise Model Simulation (NMSim) was used to generate videos of the noise simulation videos for the Campo and Desert sites. NMSim is aircraft

type-specific in terms of spectral signature and sound magnitude, and includes the effect of topography and terrain on sound propagation with state-of-the-art algorithms. NMSim also includes the effects of changes in engine power, airspeed and altitude. Its resultant videos uniquely depict how instantaneous sound output and exposure changes throughout each individual event, thus increasing the credibility of the entire site analysis and demonstrating the aforementioned effects.

Flight frequency maps, using gradual color shading and density, enabled visualization of the numbers of departure and arrival events along each modeled flight corridor for the Campo and Desert sites.

For TA and NA contours, an L_{max} threshold of 60 dB, associated with speech interference, was chosen, and the period of interest was a full 24-hour day of annual average daily flight operations. NA 60 dB contours were plotted for the existing and proposed MCAS Miramar site aircraft flight operations And TA 60 dB contours were plotted for the proposed MCAS Miramar civilian traffic only. In tandem, the NA and TA contours effectively related the potential frequency and duration of speech interference for the average annual day operations for areas in the vicinity of the airport site.



GTAA: Land-Use Planning Guidelines for New Non-Urban Airports

The Greater Toronto Airports Authority (GTAA) performed a study to develop land-use planning guidelines specifically for new airports in non-urban locations in Canada. The goal was to define a noise level threshold for an Airport Operating Area (AOA) boundary, within which no noise-sensitive land uses could be developed. The noise threshold also achieved an appropriate

balance between the competing requirements of development interests and community noise protection. Noise-sensitive uses include schools, day-care centers, nursing homes, residences, hospitals, and other similar uses where airport noise may significantly disrupt human activities (such as conversation, teaching, and sleep).

The study produced a comprehensive overview of current aircraft noise and land-use compatibility guidance from the responsible Canadian Federal and Provincial agencies, and included an overview of the scientific and historical basis for aircraft noise land-use guidelines.

The study focused primarily on research results of noise effects on annoyance, speech interference, and sleep disturbance. Additional noise factors examined included: habituation to noise; the differences between a non-urban and an urban environment; community attitudes toward the noise source; prior experience with the noise source; the purpose of the flight operations; and unique opportunities available during airport planning.

The existing Canadian land-use guidelines are defined in terms of the Canadian Noise Exposure Forecast (NEF) metric. The NEF is an energy-average noise metric similar to DNL. However, speech interference and sleep disturbance research results are presented in terms of single-event noise levels and the frequency of events. Therefore, the Number-of-events Above (NA) supplemental metric was used to define noise level criteria for speech interference and sleep disturbance. Separate criteria were defined for:

- Residential speech interference
- Classroom speech interference
- Residential sleep disturbance

To relate the study results to the existing Canadian guidelines and correlate the NA criteria with NEF levels, the Integrated Noise Model was used to model typical small, medium and large airport cases. Each airport case consisted of typical operations, which were normalized by condensing them to a single runway with a straight out departure track and straight-in arrival track with all departures and arrivals modeled in a single direction. This approach was used to isolate any variables related to airport size, number of operations and differences in fleet mix. The large airport case results are illustrated in the graphic below.

The study conclusions and recommendations were derived mainly from objective research of sleep disturbance and speech interference, rather than subjective surveys of annoyance. The speech interference and sleep disturbance research results showed the effects of single event noise, whereas the annoyance studies relied on energy-average metrics such as DNL and NEF.

The selected speech interference criteria for schools and residences were based on one event per hour at two different SEL thresholds (linked to word intelligibility in classrooms and sentence intelligibility inside a residence). The criteria were then adjusted to a full 15-hour daytime period (7:00 am – 10:00 pm). As shown in the figure, the contour showing the speech interference criterion for schools is the NA90(15) and the contour showing the speech interference criterion for residences is the NA85(15), computed from the daytime operations. The two speech interference criteria correlated with NEF levels of 25 to 33. The sleep disturbance criterion selected was 1 event at or above 90 dB SEL during night hours (10:00 pm - 7:00 am) and is delineated by the NA90(1) contour, computed from the nighttime operations. The sleep disturbance criterion correlated with NEF levels of 27 to 30.

In order to define a land-use guideline, the single event metric results were correlated with energy-average metrics to produce a single NEF criterion above which no noise-sensitive development should occur around a new non-urban airport. A single criterion was deemed more practical than varying criteria addressing each of the effects of noise separately. The selected single criterion was NEF 25, which was shown to approximate each of the speech interference and sleep disturbance criteria. Ultimately, Transport Canada adopted the recommended NEF 25 criterion nation-wide applicable to all new airports in non-urban settings.

Vancouver International Airport Vicinity Residential Land Use Planning Practices

Because airports both attract growth and must try to limit the development of land uses nearby that are considered incompatible with noise from aviation activity, planning for land uses around airports has been and continues to be one of the more challenging aspects of transportation policy-making. The purpose of this study was for the City of Richmond, BC to develop appropriate guidelines to use in evaluating various proposals for use and re-use of land in areas exposed to overflight noise from the Vancouver International Airport. It was recognized that there currently exists significant incompatible land use in the City of Richmond, so the primary goal was to prevent the development of new incompatible land uses, rather than to remediate the existing problem uses.

Adverse impacts from noise are analyzed using a wide body of scientific research, with particular attention to annoyance, speech interference and sleep disturbance (the three most well documented adverse impacts for residences exposed to airport noise). The analysis in this study combined a re-evaluation of the Transport Canada NEF-based guidance (associated primarily with annoyance) with a careful consideration of the need to protect residents from speech interference and sleep disturbance, which are better represented by the number of intrusive events during the daytime or nighttime, respectively.

Annoyance is the primary response factor upon which most nations have based their airport land use criteria. The most widely accepted threshold level to define noise-sensitive land uses as “not compatible” in Canada is $NEF_{(CDN)} 30$ (comparable to DNL 65 dB in the U.S.). This was the existing recommended criterion for annoyance from noise for new residential and live-work dwellings in the City of Richmond at the time of the study.

To analyze the daytime NA, aircraft activity at Vancouver International Airport was assessed for the period between 7 AM and

10 PM. Setting the noise threshold at $L_{max} 75$ dB and looking for the area exposed to 15 noise events per day at or above this threshold produces the metric $L_{max} NA75(15)$. This represents the area where homes are exposed to 15 events per day or an average of one event per hour at $L_{max} 75$ dB or higher. The $L_{max} NA75(15)$ noise contour defines the area within which new residential construction should not be permitted in order to maintain adequate sentence intelligibility with the windows open.

Combining both the sentence and word intelligibility requirements, and considering the fact that most Richmond residents keep their windows open, these guidelines recommend preventing new construction of residential and live-work units within the $L_{max} NA75(15)$ area. This will protect speech intelligibility inside the home and begin to manage the number of very loud aircraft overflights that interfere with the use of outdoor living areas. Given the high current and projected operation levels, and keeping in mind that social speech intelligibility disruption occurs at $L_{max} 60$ dB, there will be a substantial number of overflights that exceed this level. However, outdoor speech interference is given a lower priority for the purposes of providing flexibility in land use planning.

At an outdoor SEL of 95 dB, approximately 10 percent of the population may be awakened by an overflight. At an outdoor SEL of 90 dB, 2 to 3 percent of the population may be awakened by a nighttime noise event depending on whether the windows are closed or open. The NA metric, which was used with L_{max} values for speech interference, can also be used with SEL values. SEL NA contours were produced for the nighttime hours from 10 PM to 7 AM to show one event per night at the selected threshold levels.

To provide adequate protection from aircraft overflight noise at night, it was recommended that new residential and live-

work homes be restricted to the area outside the SEL NA90(1) contour. For work-live areas where there is a lesser expectation of quiet, and where air conditioning is expected so that windows may remain closed year-round, SEL NA95(1) was used.

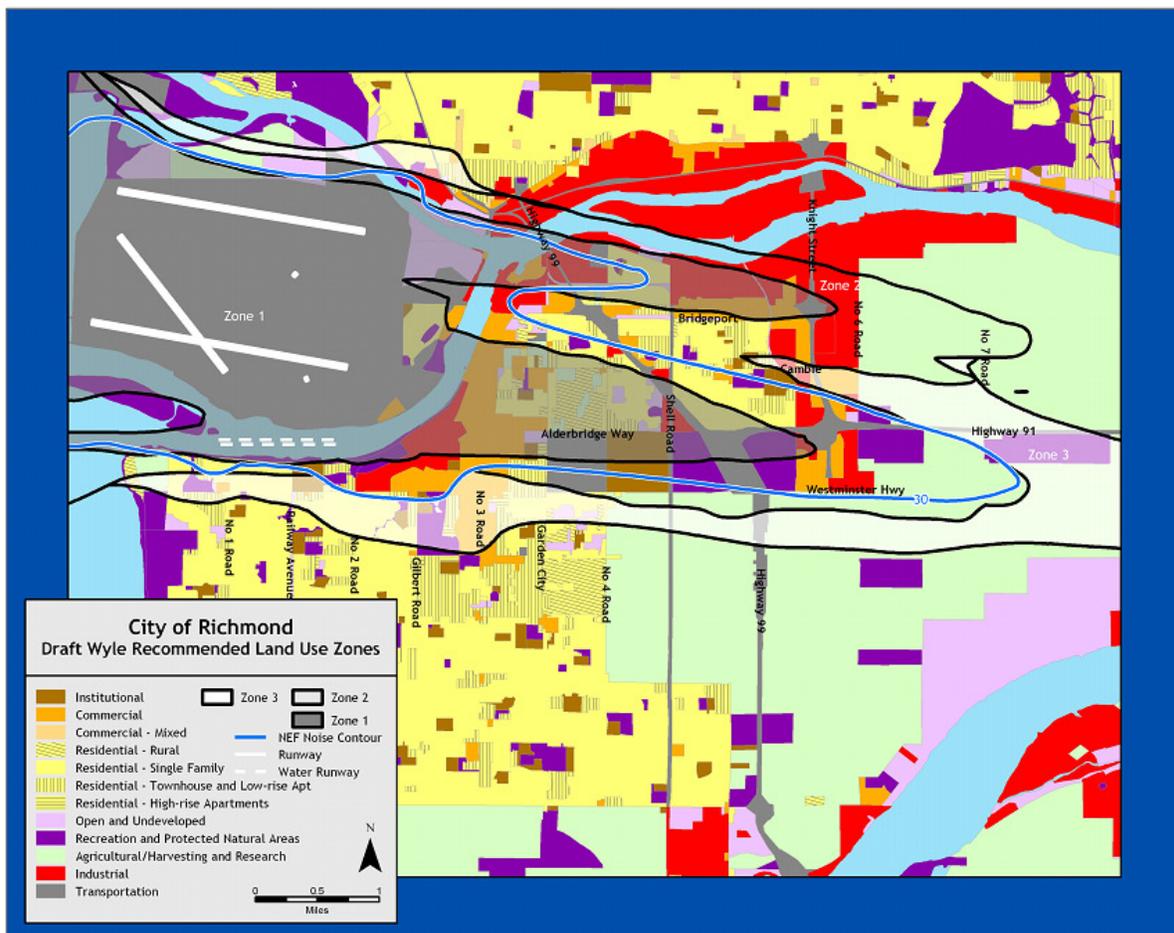
The recommendations were framed in terms of three new land use zones that reflect NEF contours for 2011 together with the single-event noise analyses noted above. The proposed planning zones were:

Zone 1 – No new residential development of any type permitted. This line combines the NEF 35, the “Fifteen events during the day with a sound level at or above 80 dB,” and I the “One event at night with sound energy greater than 95 dB” contours, merged into one boundary.

Zone 2 – No new residential or live-work development permitted. Work-live development is permitted provided adequate protection from aircraft noise is ensured through appropriate sound insulation materials and methods. This line combines the NEF 30, the “Fifteen events during the day above 75 dB,” and the “One event at night above 90 dB” contours, merged into one boundary.

Zone 3 – All types of residential development are permitted but sound insulation materials and methods are required. This line combines the NEF 25 and the “Fifteen events during the day above 75 dB” contours, merged into one boundary.

There are no restrictions recommended outside Zone 3. The graphic below show the recommended planning zones compared to the NEF 30 contour.



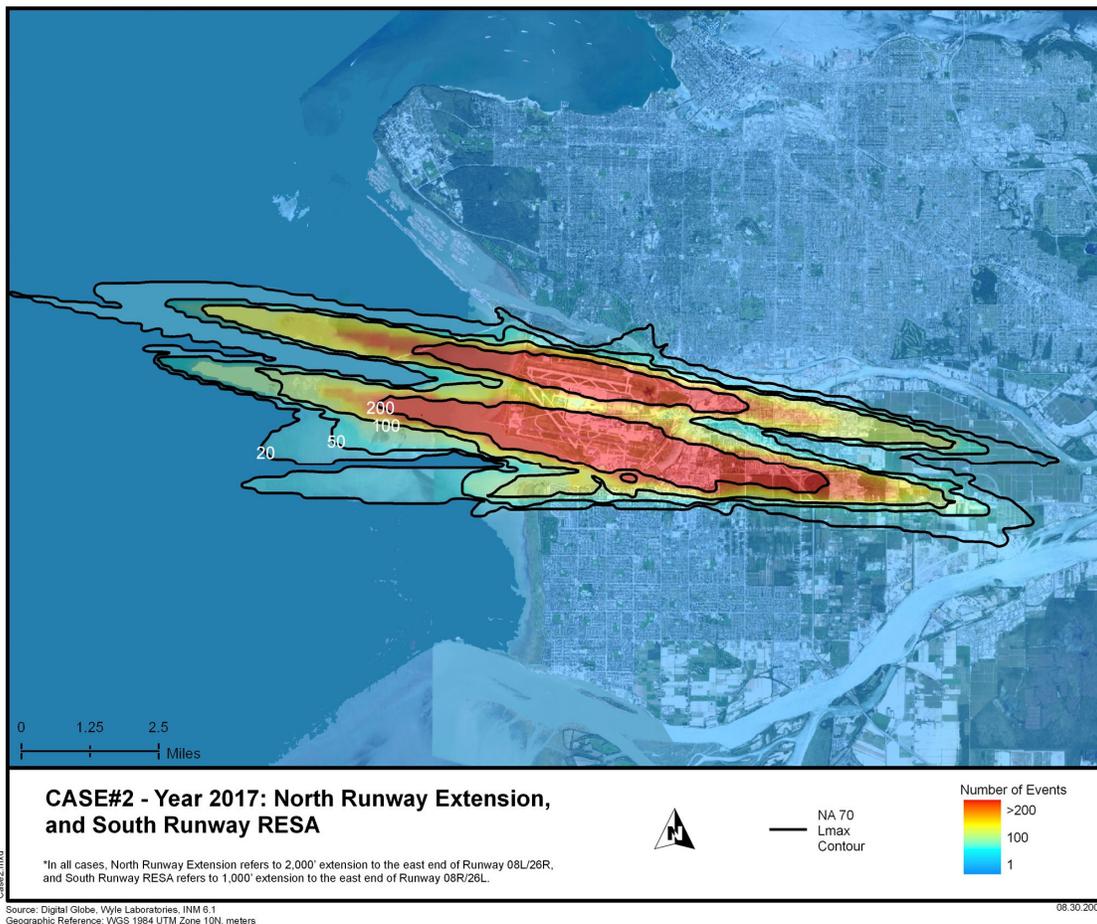
Alternative Analysis for the Vancouver International Airport Master Plan

Vancouver International Airport (YVR) in Vancouver, BC is in the process of updating its master plan, and is evaluating a number of alternatives. YVR officials concluded that comparing the noise exposure associated with the alternatives with Noise Exposure Forecast (NEF) contours might not yield the best comparison from a noise perspective. Therefore, supplemental noise analysis was conducted using the Number-of-events Above (NA) metric to supplement the NEF comparison of the alternatives.

A total of eight scenarios, representing various airport configuration and airport development alternatives, were modeled; and NA noise exposure contours were produced for each of those scenarios. Advanced GIS techniques were then employed to present the NA analysis and results in a graphic form that facilitates clear

and easy comparison of the feasibility of the development alternatives and communicates a better understand of their potential impacts (example below). The NA threshold level chosen for the analysis and alternative comparison was 70 dB. The resulting NA contours were plotted on an aerial photograph with contour lines showing 20, 50 100, and 200 events for each of the airport alternatives modeled, with gradual color shading to show the range of events from 0 to 200+ per day. A separate graphic was produced for each alternative.

The NA 70 dB levels at the noise sensitive areas around the airport can be easily compared and will be given full consideration along with other decision factors in the process of selecting the preferred expansion alternative for the YVR Master Plan Update.

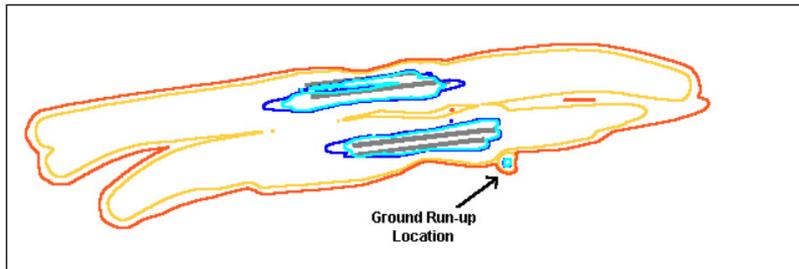


Nighttime Noise Analysis for Los Angeles International Airport

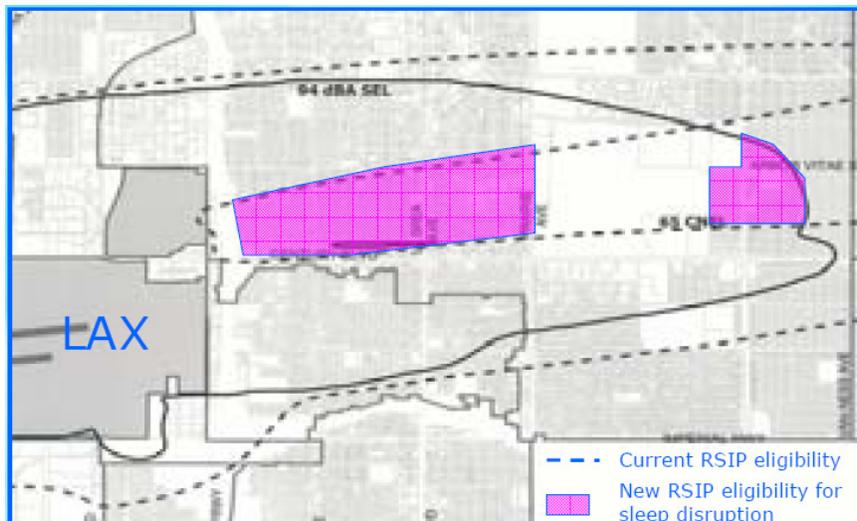
Los Angeles International Airport (LAX) receives a large number of noise complaints whenever large jet aircraft depart to the East during the nighttime hours. While the vast majority of night flights depart to the West, these East departures are of sufficient concern that LAX has undertaken a FAR Part 161 study to explore the possibility of precluding them altogether, except under certain wind conditions. Cognizant of the “Berkeley Jets” decision by California Superior Court on Oakland’s EIR for nighttime cargo development, LAX officials decided to include supplemental analysis in their Master Plan Update specifically to address sleep disturbance. The “Berkeley Jets” decision required a more comprehensive look at single event noise levels, particularly at the numbers and levels of flights during the night hours, and left to

the sponsor the responsibility to establish thresholds of significance to define impacts.

Based on thorough historical sleep disturbance studies performed world wide, adjusted for local conditions, LAX officials selected SEL 94 dB as a viable noise level above which a determined number of operations might cause sleep disturbance. The NA metric was selected to perform this analysis because the number, intensity and duration of individual noise events that occur during a sleep period are directly related to sleep disturbance research results. Since a single operation to the East at night generates a large number of noise complaints over a wide area, the SEL 94 dB contour was modeled to cover the entire area subject to 1 event at this level every 10 days.



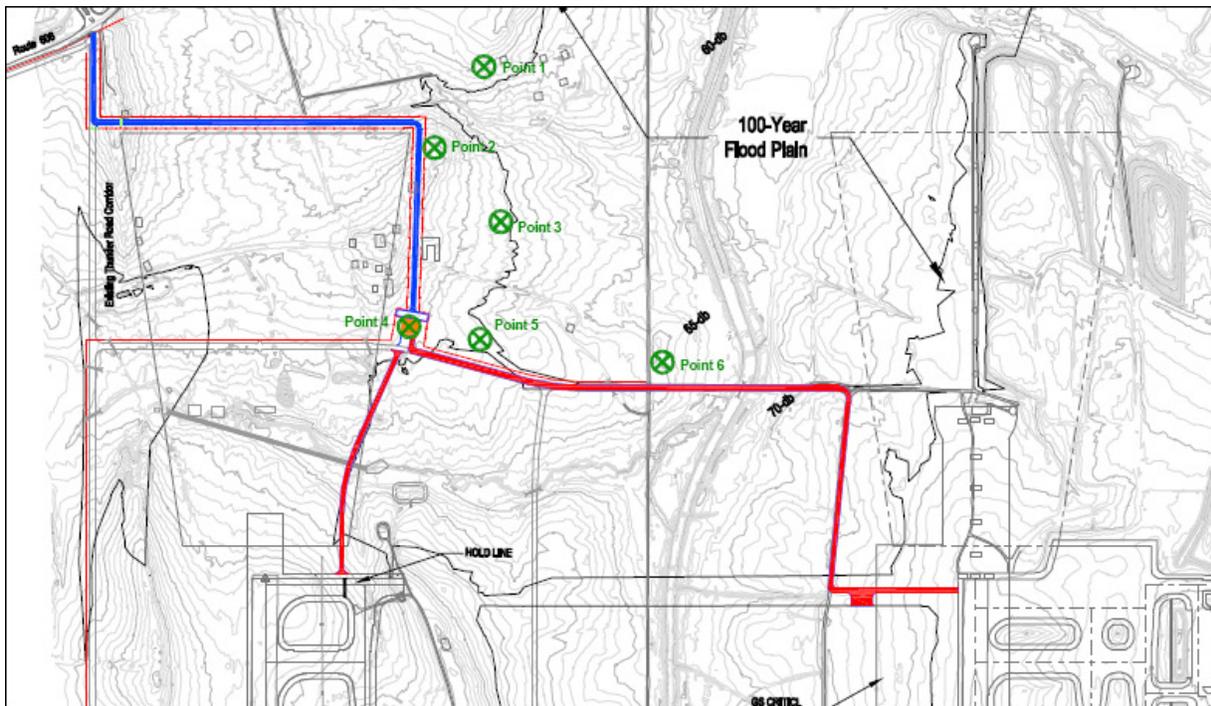
Potentially, the residential areas that are within this SEL 94 dB contour, but outside of the DNL 65 dB contour, will become eligible for sound insulation. The graphic below, from the LAX Master Plan documentation, shows this potential noise mitigation area. No final decision to include these areas in the LAX noise mitigation program has been made.



Noise Analysis for Public Safety Facility at Washington Dulles Airport

Washington Dulles International Airport performed a noise analysis to determine the best location for a new Airport Rescue and Fire Fighting Facility (ARFF). The ARFF will include housing for the staff with sleeping quarters that will be used throughout the daytime and nighttime. A noise analysis was conducted to determine the outdoor noise exposure at six potential sites, and to determine the noise level reduction (NLR) required to minimize the potential for sleep disturbance within the facility. The figure below presents the potential sites which are between the centerlines of the existing runway on the right and the future runway on the left.

Integrated Noise Model (INM) data for the preferred runway alternative from the new runway EIS forecast year 2025 was used to conduct a grid point analysis for the six potential locations. The INM was used to compute the Day-Night Average Sound Level (DNL) and the Time Above (TA). In addition, the Number-of-Events Above (NA) was computed. The TA and NA were calculated for a range of threshold levels from 60 dB and up in 5 dB increments to an upper threshold level at which the TA and NA were equal to zero. Because the ARFF sleeping quarters will be used throughout the day and night, all metrics were calculated over the full 24-hour day.



It has been well established in the scientific community that SEL predicts sleep disturbance much more reliably than the maximum sound level. While there is no widely accepted sleep disturbance criterion, the NA metric is well suited to define a sleep disturbance criterion that will minimize sleep disturbance. The NA90(1) defines locations at which one event above SEL 90 dB (outdoors) will occur during an

average night or other sleep period. The indoor SEL would be approximately 20 to 25 dB lower with doors and windows closed (depending on the NLR of the building). Only one proposed location (point 6) had a DNL of 65 dB. All other points had a DNL less than 65 dB. Under FAA land use compatibility guidelines, 65 dB DNL is compatible with residential development and therefore was assumed to be suitable for the

proposed ARFF. The TA and NA metrics provided more details about the noise exposure at each point. In an 8-hour sleeping period, the NA SEL 90 dB ranged among the grid points from 3.7 to 15 events (assuming an even distribution of events throughout the day). If the ARFF sleeping area is designed with a Noise Level Reduction (NLR) of 25 dB, the indoor exposure to those events would be SEL 65 dB. If designed to achieve an NLR of 30 to 35, the SEL of these events in the sleeping area would be 55 to 60 dB, which is

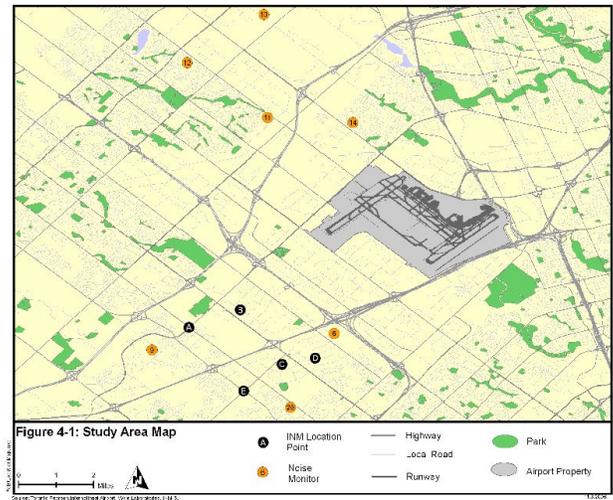
sufficient to preclude anything but minor sleep disturbance.

Of the six grid points analyzed, points 1 and 3 had the lowest DNL and the fewest number of events above the sleep disturbance criterion. Since factors other than noise may be considered, all locations except point 6 were deemed suitable locations for the ARFF. To assure minimum sleep disturbance from aircraft noise, a design NLR of 30 to 35 dB for the sleeping area was recommended regardless of the location ultimately selected.

Noise Analysis of Potential Day Care and School Sites, Greater Toronto Airports Authority

The Greater Toronto Airports Authority (GTAA) performed a study to assess the compatibility of potential day care centers and schools at specified locations between the Toronto-Pearson International Airport (YYZ) Noise Exposure Forecast (NEF) 30 and 35 contours. The scope of the study was to investigate current weekday noise exposure at specific locations representing potential school and day care sites and to review existing noise research in order to develop a reference body of knowledge to assist GTAA in answering four key policy questions:

- (1) Should day cares be treated differently from schools in terms of permitted or prohibited land uses within the 30-35 NEF contours?
- (2) As employment uses are permitted in the immediate vicinity of the airport, should day care centers be differentiated from private schools; and thus, permitted as accessory uses to employment uses?
- (3) What are the arguments for and against prohibiting day cares and schools (as a principal and/or accessory use) in the 30-35 NEF



contour as supported by the existing evidence (in terms of both indoor and outdoor environments)?

- (4) If there is an argument for permitting day cares and/or schools (as a principal and/or accessory use) within the 30-35 NEF contour, what mitigation measures and conditions should be imposed on their development (insulation, warnings, limitations on outdoor use, provision of alternative outdoor facilities, etc.)?

The study investigated weekday aircraft noise exposure for five specific locations within the Pearson Airport Operating Area (AOA).

The locations were specified by the GTAA as sites where day care centers might be located within office buildings or other employment areas to the southwest of YYZ. Airport operations and radar data for 2005 was filtered to include only weekday arrivals and departures between 7:30 am and 5:30 pm (corresponding with school hours). One of the unique features of this study was inclusion of only those operations that affect the study locations, which occurs in two flow configurations. To determine the potential worst-case noise exposure scenarios at these locations, peak traffic levels in the northeast and southwest directions were modeled and compared to the annual average traffic levels for these two flow configurations. The noise model results for the potential sites were presented using the equivalent sound level (L_{eq}), maximum A-weighted sound level (L_{max}), and the Number-of-Events Above (NA) metrics, since the NEF exposure levels were irrelevant to the analysis. Historic community-noise measurement data was also used to supplement the modeling results.

A literature search was conducted to determine if any studies show a causal relationship between aircraft noise exposure and developmental problems in day care- and/or school-aged children. Factors such as cognition, stress, and reading comprehension were considered. The most up-to-date and relevant research studies were reviewed and referenced, but were inconclusive with respect to proving a causal relationship. There are not enough studies available to confirm or deny a relationship, and the few existing studies do not prove a definitive relationship. Speech interference

was thus determined to be the most pertinent criteria upon which GTAA can base policy decisions.

In contrast with cognition, stress, and reading comprehension, the effects of noise on speech interference can be more easily quantified. There are widely accepted speech interference criteria, where a percentage of words or sentences become unintelligible. Speech interference criteria are most stringent for sensitive areas such as classrooms. The criteria used in this study were an indoor L_{eq} of 35 dB, an indoor L_{max} of 50 dB, and an indoor Number-of-Events Above threshold of NA50(10). NA50(10) corresponds to 10 events per day exceeding an indoor L_{max} of 50 dB. Assumptions were made as to how much outdoor-to-indoor noise level reduction is typically provided by a building, given both “windows closed” and “windows open” scenarios. Using these assumptions, the indoor noise exposure level at each of the five sites was modeled. The results are presented in the table below.

The study determined that, while an argument could be made to allow schools and day care centers based on L_{eq} values alone, the results of the NA analysis should be carefully considered. The noise analysis determined that more than 10 noise events would likely interrupt normal speech in a classroom at three of the five sites, assuming that the windows were closed during a 10-hour day care/school day. The NA50(10) threshold was exceeded at all five modeled locations with a “windows open” assumption. By performing this in-depth analysis of noise exposure using supplemental noise metrics rather NEF alone, GTAA was able to make more technically-defensible policy decisions regarding whether or not to allow schools and day care centers to be located between the YYZ NEF 30 to 35 noise contours.

Location Point	Annual Average Scenario 654 Total Operations ²				Northeast Peak Traffic Scenario ¹ 722 Total Operations ²				Southwest Peak Traffic Scenario ¹ 730 Total Operations ²			
	Indoor L _{eq} (dB) Windows Closed*	Indoor L _{eq} (dB) Windows Open**	Indoor NA50 L _{max} Windows Closed*	Indoor NA50 L _{max} Windows Open**	Indoor L _{eq} (dB) Windows Closed*	Indoor L _{eq} (dB) Windows Open**	Indoor NA50 L _{max} Windows Closed*	Indoor NA50 L _{max} Windows Open**	Indoor L _{eq} (dB) Windows Closed*	Indoor L _{eq} (dB) Windows Open**	Indoor NA50 L _{max} Windows Closed*	Indoor NA50 L _{max} Windows Open**
A	30.0	40.0	19	101	33.1	43.1	56	157	30.6	40.6	17	108
B	27.6	37.6	6	75	25.4	35.4	0	89	30.3	40.3	14	106
C	29.1	39.1	18	120	30.2	40.2	36	149	28.2	38.2	8	140
D	29.4	39.4	9	107	28.1	38.1	3	85	29.4	39.4	9	145
E	26.8	36.8	5	94	28.0	38.0	5	127	26.7	36.7	3	91

Notes: ¹ Operations are based on one specific day, and reflect the specific runway use and fleet mix from that day
² Number of operations during school hours only (7:30 am to 5:30 pm)
* Assuming a room NLR of 25 dB
** Assuming a room NLR of 15 dB

Boston Logan Airport Noise Study Massachusetts Port Authority (Massport), Boston, MA, Federal Aviation Administration (FAA)

The history and background information that follows is sourced directly from the project website,

http://bostonoverflightnoisestudy.com/BONS/history/index_2.asp

History

In 1995, Massport initiated a study, called the Airside Improvements Planning Project, to consider ways to reduce airfield delays and congestion. This study built on earlier studies completed by the Federal Aviation Administration (FAA), which identified a number of options to improve airside congestion and delay at the airport. Massport then decided to pursue certain recommendations of these studies and on August 22, 1995, the U.S. Environmental Protection Agency (EPA) published the FAA's Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS). FAA and Massport then began preparation of a combined EIS/Environmental Impact Report (EIR) to meet federal and state requirements, respectively.

A Draft EIS/EIR was filed for review in February 1999 and on May 7, 1999, it was concluded that the Draft EIR should proceed to a Final EIR. In January 2000, the FAA decided to prepare a Supplemental Draft EIS (SDEIS). Two years later, on June 28, 2002,

FAA published a Notice of Availability (NOA) of the Final EIS. The Record of Decision (ROD) was signed in August of 2002.

The ROD approved the following actions:

- A reduction in minima on Runways 22L, 27, 33L, and 15R;
- Construction of a new 5,000 foot unidirectional, wind speed restricted Runway 14/32, to be used only to/from the southeast;
- An extension to Taxiway D;
- A realignment of Taxiway N; and
- A reworking of the taxiways in the southwest corner of the Airport.

The approval of the ROD was conditional pending implementation of a number of mitigation measures including a joint effort with the FAA, Massport, and the Logan Airport Community Advisory Committee (CAC) to develop a scope that would enhance existing and/or develop new noise abatement measures applicable to aircraft overflights.

This study, officially called the Boston Logan Airport Noise Study will be completed in three phases. Phase 1 will define and, to the extent feasible, implement potential noise abatement alternatives that

do not require a detailed environmental assessment. Phase 2 will address additional noise abatement alternatives that will require detailed analysis to meet FAA environmental requirements. Phase 3 will assess modifications to the Preferential Runway Assignment System and provide for appropriate environmental documentation that may be necessary for implementation of recommended actions of Phase 2. Phase 1 began in late 2004 and was completed in late 2006. Phase 2 began coincident with the completion of Phase 1 and is expected to take another two years.

Supplemental Noise Analysis

The Boston Study is the first FAA-sponsored study to rely on supplemental analysis as a major decision-making tool. Most of the flight track changes for the first phase are 15-20 miles from Logan and result in minor changes in Day-Night Average Sound Level (DNL) – well beyond DNL 65 dB – where decision-making on what alternatives to carry forward can only be reached through the use of supplemental analysis tools. The intention is to extract out the component parts of DNL into values that document the proposed changes and allow FAA, MASSPORT, and the CAC to use in their decision-making process.

In all, 18 measures were evaluated in Phase 1. Phase 2 is expected to evaluate 14 measures that are expected to have significant environmental impacts.

Note that the Phase 1 alternatives are the so-called “low-hanging fruit.” These are alternatives developed during the study that were expected to be Categorical-Excluded (Cat-Exed) under the National Environmental Policy Act (NEPA).

Consequently, where the environmental analysis showed that the DNL increases did not trip the “levels of significance” under FAA Orders 1050.1E and 5050.4B, the supplemental analysis results developed for the project were used as the main decision-making tools. Essentially, for those alternatives that did not have significant environmental impacts under NEPA, the community relied on the supplemental tools and metrics to make their decision on what measures that they considered beneficial to the surrounding communities.

Grid Point Analysis and Extended Study Area

As stated above, most of the 18 Phase 1 measures were comprised of air traffic changes anywhere from 10-20 from the airport, with all but one alternative having no effect on sound levels of DNL65 or above. To assist the project stakeholders in the process, 130 community locations were evaluated throughout an extended study area (approximately an area of 30nm by 30 nm). Multiple supplemental noise metrics computed to document before and after conditions. Examples included – Number-of-Events Above (NA) various Sound Level Thresholds (NA50-55, NA55-60,...NA80+) and Time Above (TA) Specified Sound Level Thresholds (TA50, TA55, TA60, TA65) over the course of an annual average day. An example of a typical analysis table is shown below. For those measures where nighttime flights were of concern, Nighttime NA values above 70 dB SEL were computed to allow some assessment of the potential for sleep disturbance. Similarly, NA values above 60 dB SEL per average day were presented – this threshold was chosen as a representative threshold to predict outdoor effects on speech.

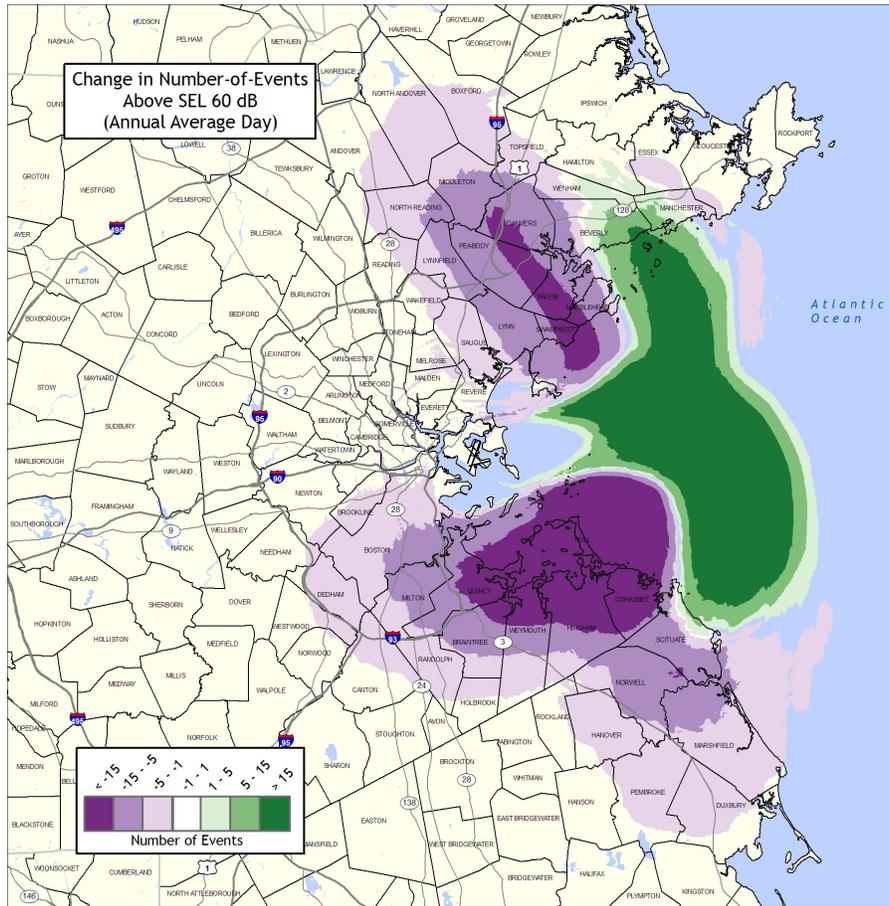
An Example of NA and TA Analysis – the component parts of DNL

Location	Condition	Average Annual Day (24 Hours) DNL	Number of Events Above (NA) Specified Sound Levels							Total NA 60+ SEL (ops)	Nighttime (10:00 pm - 7:00 am) NA 70 SEL (ops)	Time Above (TA) Specified Sound Levels			
			Average Annual Day (24 Hours)									Average Annual Day (24 hours)			
			NA 50-55 _{SEL} (ops)	NA 55-60 _{SEL} (ops)	NA 60-65 _{SEL} (ops)	NA 65-70 _{SEL} (ops)	NA 70-75 _{SEL} (ops)	NA 75-80 _{SEL} (ops)	NA 80+ _{SEL} (ops)			TA 50 (min)	TA 55 (min)	TA 60 (min)	TA 65 (min)
PT001	Existing Condition	53.7	8	3	1	1	<1	<1	0	6	<1	<1	<1	0	0
	Alternative 1	53.7	8	3	1	1	<1	<1	0	6	<1	<1	<1	0	0
	Change	0.0	<1	0	<1	<1	<1	0	0	<1	0	0	0	0	0
PT002	Existing Condition	47.2	21	10	6	2	<1	<1	0	19	<1	2	<1	<1	0
	Alternative 1	47.2	22	11	6	2	<1	<1	0	21	<1	2	<1	<1	0
	Change	0.0	1	1	<1	<1	0	0	0	2	0	0	0	0	0
PT003	Existing Condition	45.8	15	7	3	1	<1	<1	0	11	<1	1	<1	<1	0
	Alternative 1	45.8	16	7	3	1	<1	<1	0	12	<1	1	<1	<1	0
	Change	0.0	1	<1	<1	0	0	0	0	<1	0	0	0	0	0
PT004	Existing Condition	49.4	9	2	2	<1	<1	<1	0	6	<1	<1	<1	<1	0
	Alternative 1	49.4	9	2	2	<1	<1	<1	0	6	<1	<1	<1	<1	0
	Change	0.0	<1	0	0	0	0	0	0	0	0	<1	0	<1	0

NA Change Maps

One of the most effective tools developed for the Boston project was the NA change map. For each of the 14 measures evaluated,

a map was developed that allowed the project stakeholders to quickly see the changes in number of aircraft events above 60 dB SEL.



An Example of an NA Change Map

Shoreline Crossing Evaluation

An additional supplemental analysis tool that was used is a prediction of the change in aircraft altitude that was expected for several alternatives. The simple concept for these alternatives was to move the departing aircraft further out over the Atlantic Ocean before turning them back toward land, thereby providing some relief to the

community. The project extracted out both the actual altitude of aircraft from radar and the INM-modeled altitudes (6000-7000 ft, 7,000-8,000 ft, etc.) of aircraft as they cross various gates along the shoreline north and south of Logan. This tool proved to be a highly effective surrogate analysis tool that provided results that could not be shown with a noise metric.