Noise Aviation Pollution In Airports: The Case Of Boston Logan International Airport

By

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ABSTRACT

During the 20th century, the world's air transportation system has changed dramatically with the gradual emergence of commercial aircraft. One of the immediate impacts of civil aviation on the environment is noise pollution. The continued growth of the aviation industry and expansion of airport capacity depends on how well noise compatibility planning is handled.

Noise metrics and the effect that noise has on the communities that surround an airport are the key topics that must be understood in order to evaluate and critic how the expansion of the airports can be aligned with the demands of the local communities for a quieter environment. A short literature review is presented on these two topics including the most recent research that has been conducted.

Furthermore a case study on Boston Logan International airport is presented to provide an example of how airport expansion can have a positive effect for the communities that t live in the area adjacent to the airport, in terms of cumulative noise exposition levels. The results of the studies are evaluated and some recommendations for future research are proposed.

Thesis Supervisor: Professor David H. Marks
Title: Professor of Engineering Systems and Civil and Environmental Engineering

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Antonis Boutatis

Cambridge, Massachusetts

May, 2001

"Σαν βγεις στο πηγαιμο για την Ιθακη
να ευχεσαι να ειναι μακρυς ο δρομος......."
ΚΑΒΑΦΗΣ

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1 Introduction

During the 20th century, the world's transportation system has changed dramatically with the gradual emergence of commercial aircraft. Each year thousands of aircraft carry several millions of passengers all over the world. The size of the world's fleet has increased constantly over the past few decades and is expected to do so in the future.

Civil aviation is one of the fastest growing transportation sectors of the world's economy. A brief look at the sector indicates some impressive developments. In 1994, the sector operated a total fleet of about 15,000 aircrafts, which served more than 10,000 airports. The sector directly employed 3.3 million people of which more that 1.4 million were in the United States. During the same year, more that 1.2 billion people and about 23 million tons of freight were transported. The aviation sector has constantly grown at the annual rates varying between 5% and 6.5%. The rates have been higher than the growing rates of Gross National Product (GNP), which indicates that the traffic volume is going to double every 12 years. If there are no significant constraints to such growth, the sector's measurable impact will rise to about $US 1800 billion by the year 2010 *(Air Transport Action Group 1996; International Civil Aviation Organization, 1994).*

1.1 Noise Pollution on airports

One of the important issues of the impacts of civil aviation on the environment is noise pollution. There are two sources of noise from any aircraft engine, machinery and primary jet noise. Noise is often considered one of the most serious environmental problems of aviation. Particularly noise generated at the airports has emerged to be an annoyance to people living nearby. The fast growth in the number of aircraft movements has meant the number of jets in the airline fleets, coupled with the inability of the local community to properly control the land use around the airports has emphasized the urgent need for systematically coping with the problem. Aircraft were first regulated in 1959 by the setting of the limits to sound generated aviation noise. The acceptable noise level was established at 112PNdB (perceived noise level in decibels). The International Civil Aviation Organization established international certification standard for commercial jet aircraft in 1971 (*Transport Action Group, 1996a And Air Transport Action Group, 1996b).*

Landing and takeoff procedures have been continuously improved to abate the noise around airports and have been separately designed for specific locations. Generally, any noise abatement procedure consists of a time and space component. The time component usually includes a restriction for noisy aircraft use at an airport during certain periods of a day. In some cases these restrictions may be extended to all aircraft. For example, at many West European airports the aircraft operations have been completely banned during the night hours (10:00p.m. to 06:00 a.m.). The space component is represented by 3-D aircraft path to/from the airport (*Connor, 1996).* The other measure for reducing noise nuisance is a stricter control of land use around an airport. The generic idea has been to prevent residential and other unsuitable use of land around airports (*Walder, 1991*).

The last but perhaps the most important measures for reducing aircraft noise nuisance is improved aircraft engine design and a rapid replacement of the noisy aircraft by quieter ones. Introduction of high by-pass combustion technology to aircraft engines has reduced the primary noise from engines from about 88 dB (A) to 65 dB (A) over the last thirty years (*Air Transport Action Group, 1996b).* Besides reducing absolute and relative levels of noise, the introduction of aircraft with quieter engines has reduced the spatial spreading of noise around the airports. This has been achieved by squeezing the noise "foot print", that is generated during landing and take-off. Reduction in contours has reduced the number of people directly exposed to intrusive aircraft noise in the vicinity of airports. Further efforts to reduce the level of aviation noise are expected to take place under the stable growth of the aviation sector and the evolution of the available Technology.

2 Noise metrics

2.1 Introduction

The topic of noise metrics has traditionally involved a rather confusing proliferation of units and indices. In response to the requirements of the Aviation Safety and Noise Abatement Act of 1979 (P.L 96-193), the FAA established a single system of metrics for measuring and evaluating noise for land use planning and environmental impact assessment. The FAA also has another system of metrics, which it employs for certification of commercial aircraft. The following paragraphs attempt to describe both systems of metric and identify other noise metrics frequently and necessarily employed in noise certification which can provide detailed analysis of noise effects such as speech interference, hearing impact and sleep disturbance. *(Massport "Logan Airport noise information report"- 1991).*

Sound measures or acoustical metrics, all consist of three basic building blocks:

1) sound pressure level, expressed in decibels,
2) frequency or pitch of the sound,
3) time.

The sound pressure levels at various frequencies, for a given point in time, are usually combined into a frequency spectrum, which is somewhat analogous to the fingerprint of the sound. This spectrum, which varies with time, represents the real starting point for the metric story. From this point of origin, the following classes of metrics have evolved: .*(G.J.J. Ruijgrok "Elements of Aviation Acoustics" Delft press 1993)*

(1) Single Event Maximum Sound Levels
(2) Single Event Energy Dose
(3) Cumulative Energy Average Metrics

(4) Cumulative Time Metrics

An understanding of these four classes essential for an individual undertaking a comprehensive assessment of noise effects *(FAA " Aviation noise effects" Washington , Dc U.S. Department of Commerce-Mar 1985).*

2.2 Decibel scale (db)

Sound Pressure, the physical quantity that we percept as noise, is experienced in the human ear on a range from barely audible to extremely loud. Because the ripples of sound typically experienced vary in height from 1 to 100000 units, noise is expressed logarithmically in a compassed scale of 20 to 120. The units in this scale are known as decibels (db), (*Massport "Logan Airport noise information report"- 1991).*

Two important rules about the noise levels:

- 10 decibel increase in sound pressure level perceive by the people twice as loud noise
- Changes in noise levels of less than about 3 decibels (db) are not readily detectable in our day to day environment.

2.2.1 Decibel-dB(A)

A unit on a logarithmic scale is used to indicate the intensity of sound in comparison to the lowest audible sound (developed by Alexander Graham Bell). In the case of Amsterdam Schiphol, noise intensity is measured using an 'A' filter (calibrated to the frequency range of the human ear).

2.3 Aviation Noise measures

FAA has established a series of Noise Measures in order to present how the noise affects people. Three of the most common measures used by the aviation community to describe an individual noise event, such as one aircraft takeoff or landing, the noise perceived at one particular spot during an event, or the highest noise generated by an event, are (*Massport "Logan Airport noise information report"- 1991:*

- A-weighted Decibel (dbA)
- Sound Exposure Level (SEL)
- The effective Perceived Noise Level (EPNL)

Three of the most common measures of the total (cumulative) noise from a series of individual noise events, such as a number of Takeoffs and Landings over the course of a day, are:

- Equivalent sound level (Leq)
- Day night Average Sound Level (Ldn)
- Time Above a Threshold Level.

In other countries like Netherlands different units and metrics have been established to measure noise pollution. The last years an effort has been made to establish a common EU framework for the assessment and management of exposure to environmental noise. Particularly in Netherlands, one of the most conservative countries in environmental legislation, a huge effort is undergoing in order to adapt the legislation that use Kenstern Units (The Dutch metrics for cumulative noise) to Day and Night Level noise (LDN) concerning aviation noise pollution.

2.4 Single Event Noise Metrics

2.4.1 Perceived noise level (PNL) and TPNL

When we have to deal with noise from airplane flyovers, frequently the Perceived noise level is used. Investigating the reactions of a large number of people has developed perceived noise level. Those experiments have shown that people are more sensitive to complex sounds containing high frequency components than they are to high frequency pure tones.

The perceived noise level of a sound signal having a pronounced spectral irregularity may be adjusted by a so called tone correction, which has been introduced to account for the increased noisiness of audible discrete frequency components such as found in airplane flyover noise.*(G.J.J. Ruijgrok "Elements of Aviation Acoustics" 1993)*

2.4.2 A-Level Noise

A measure of sound pressure level designed to reflect the acuity of the human ear, which does not respond equally to all frequencies. The ear is less efficient at low and high frequencies than at medium or speech-range frequencies. Therefore, to describe a sound containing a wide range of frequencies in a manner representative of the ear's response, it is necessary to reduce the effects of the low and high frequencies with respect to the medium frequencies. The resultant sound level is said to be A-weighted, and the units are dBA. The A-weighted sound level is also called the noise level. Sound level meters have an A-weighting network for measuring A-weighted sound level. *(FAA " Aviation noise effects" Washington , Dc U.S. Department of Commerce-Mar 1985).*

2.4.3 Sound Exposure Level (SEL)

SEL is a measure of the effect of duration and magnitude for a single event measured in A-weighted sound level above a specified threshold, which is at least 10 dB below the maximum value. Actually, it is the accumulation of the sound energy over the duration of an event, where duration is defined as the time when A-weighted sound level first exceeds a threshold level, usually equal to the background noise, to the time that the noise level drops back down below the Threshold. The SEL is normalized to one second and exceeds the Lmax noise on the order of 7to 12 Db. It is obvious that SEL noise take in consideration not only the loudness of Flyovers but also the duration of those events. The Sel noise can be described by the following equation:

$$SEL = 10 Log \int_{t1}^{t2} 10^{(SPL(t)/10} dt$$

In typical aircraft noise model calculations, SEL is used in computing aircraft acoustical contribution to the Equivalent Sound Level (Leq) and the Day-Night Sound Level (DNL). *(G.J.J. Ruijgrok "Elements of Aviation Acoustics". Delft press 1993)*

2.4.4 Effective Perceived Noise Level (EPNL)

Effective Perceived Noise Level (Expressed in dB or EPNdB) is a single number measure of complex aircraft flyover noise, which approximates human annoyance responses. It is derived from Perceived noise level in dbA and PNLT and includes correction terms for the duration of an aircraft flyover and the presence of audible pure tones or discrete frequencies (such as the whine of a jet aircraft) in the noise signal. The FAA use the EPNL as the noise certification metric for large transport and turbojet aircraft and helicopters.

The relation that expresses it is as follows

$$EPNL = 10Log\left[\frac{\Delta t}{T_{10}}\sum_{K=t1}^{t2} 10^{\frac{Ltpn(k)}{10}}\right]$$

Where Δt=0.5 s

t2 and t1 are the points of time closest to those instants when TPNL is 10 TPNdb less than its maximum value and K denotes the kth time segment within the duration interval *(G.J.J. Ruijgrok "Elements of Aviation Acoustics" Delft press 1993).*

2.5 Cumulative energy average metrics

2.5.1 LAeq (equivalent A-weighted sound level (EAL), expressed in dbA)

Equivalent sound level, Leq, is the energy average noise level (usually A-weighted) integrated over some specified time. Equivalent signifies that the total acoustical energy associated with the fluctuating sound (during the prescribed time period) is equal to the total acoustical energy associated with a steady sound level of Leq for the same period of time. The purpose of Leq is to provide a single number measure of noise averaged over a specified time period.

The average noise level over a specified period, expressed in dB(A). Generally the Laeq noise is an important and well known descriptor of the subjective loudness of an airplane flyover noise that measures and asses the effect of duration on loudness to the human ears responds. Mathematically it describes the total amount of sound energy delivered to the recipient during the event divided by the measurement time period and provides a single number descriptor of time varying sound which is given by:

$$L_{Aeq,T} = 10 Log\left[\frac{1}{T}\int_{O}^{T} 10^{\frac{L_A(t)}{10}} dt\right]$$

Where $L_A(t)$ is the instaneous A-weighted sound level.

(G.J.J. Ruijgrok "Elements of Aviation Acoustics" 1993)

2.5.2 Day-Night Sound Level (DNL), Expressed in dB.

Day-Night Sound Level (DNL) was developed as a single number measure of community noise exposure. It is often referred to as Ldn in the literature. DNL was introduced as a simple method for predicting the effects on a population of the average long-term exposure to environmental noise. It is an enhancement of the Equivalent Sound Level (Leq) because a correction for nighttime noise intrusions was added. A 10 dB correction is applied to nighttime (10 p.m. to 7 a.m.) sound levels to account for increased annoyance due to noise during the night hours. DNL uses the same energy equivalent concept as Leq. The specified time integration period is 24 hours. As in the case of Leq, there is no stipulation of a minimum noise-sampling threshold. The DNL can be derived directly from the A-weighted sound level or the sound exposure level. For assessing long-term noise exposure, the yearly average DNL (DNL y-average) is the specified metric in the FAA Federal Aviation Regulation, Part 150, noise compatibility planning process. The equation that describes noise mathematically is:

$$L_{dn} = 10\log\sum_{i}^{n}\frac{10^{SEL_i \bullet 10LOG(d_i+10n_i)/10}}{10} / 8.64 * 10^4$$

Where SELi=Sound Exposure Level dbA,

Di= Number of flights during the day

Ni=Number of flights during the night

(FAA- 1985, Massport "Logan Airport noise information report"- 1991)

2.5.3 Time above threshold level (TA), Day, Evening, Night

The Day-TA metric provide the duration in minutes for which aircraft related noise exceeded specified A-weighted sound levels during the period 7:00 a.m. to 7:00 p.m. The Evening TA metrics provide the duration in minutes for which aircraft related noise exceeded A-weighted sound levels during the period from 7:00 p.m. to 10:00 p.m. The Night TA metrics provide the duration in minutes for which aircraft related noise exceeded A-weighted sound levels during the period from 10:00 p.m. to 7:00 a.m. "Duration" is a concept that is often more accepted than exposure measured in db, however there is no direct relationship between TA and exposure. The number of minutes per day that the sound level is above a given threshold may decrease with a change in airport operations, while the noise exposure, as measured by Leq or Ldn, increases (or vice versa).

The FAA certificates aircraft for flight in the United States by means of standards that use Dba EPNL as their basis. These standards are the Federal Aviation Regulations Part 36 (FAR Part 36).

2.5.4 KU (Kosten Unit)

This unit is used to express annual levels of aircraft noise in the Netherlands. Noise levels (at ground level) are computed at about 12,000 posts along flight paths in the greater Schiphol area. These values are rated according to the time of day and then added up. The rating scale runs from 1 in the daytime to 10 at night (the nighttime penalty factor). Joining points with equal noise levels map out noise contours. The method of calculation and the unit are named after Professor Kosten, the man who developed them.

The noise load in konsten units (KU) combines average (i.e. on an energy basis) maximum A-weighted sound level with the number of passages heard within the period of one year. Noise load is used for the quantification of noise pollution in the vicinity of commercial airports and is computed from the following equation:

$$Ke = 20Log\left[\sum_{j=1}^{n} w(j)10^{\frac{L_{A\max}(j)}{15}}\right] - 157$$

Where N is the number of events per year, L_{Amax} (j) is the maximum A-weighted sound level occurring during the jth event, and w(j) is the time of day weighting factor for event j.

The KU calculation method does not directly link noise impact and noise disturbance. Indirectly, the percentage of people subjected to serious noise disturbance levels is taken to be 10% lower than the noise level in KUs. So, if the noise level is 20 KU, 10% of the inhabitants are subjected to serious noise disturbance; at 35 KU, this figure amounts to 25%.*(G.J.J. Ruijgrok "Elements of Aviation Acoustics" 1993)*

Figure 2-1: Present Schiphol Design and the KU noise zone

The Dutch government is in this period to the procedure of transform the Ku noise zone to an Ldn (Day and night exposure level noise) noise zone but Until recently the results of this study has not been published. (*Schiphol Group 1999 annual report*). In the next table the main noise metrics are illustrated according to FAA

METRIC	DESCRIPTION
One-third Octave Sound Pressure Levels	The one-third octave band sound pressure levels are the starting point for all other metrics; useful in implementation of soundproofing
PNL	Sound Level from which EPNL was developed
PNLT	Sound level from which EPNL was develped
EPNL	A maximum sound level single event cumulative metric developed from the PNLT and PNL sound level. Used in FAR Part 36, Appendix C Certification, Advisory Circular 36-IB and Advisory Circular 36-2A.
NEF	An Airport cumulative metric no longer in use in the U.S. but often used in older studies; replaced by DNL (the FAA approved metric)
Alm	A sound level metric applied as follows: Airport Noise Analysis 1050.IC Analysis FAR Part 36 Appendix F Certification Specific eligibility for Soundproofing Implementation of Soundproofing Noise Monitoring Systems FAA Advisory Circular
TA	An airport cumulative metric derived from dB(A) and applied as follows: Airport Noise Analysis l050.ID Analysis Noise Monitoring Systems
Lx	An airport Cumulative metric derived from dB(A) and applied as follows: Airport Noise Analysis l050.ID Analysis Noise Monitoring Systems
SEL	A maximum sound level, single event cumulative metric derived from dB(A) and applied as follows: Airport Noise Analysis Noise Monitoring Systems
Leq	An airport cumulative metric derived from SEL; no application in aviation
DNL	An airport cumulative metric derived from SEL with the following applications: Airport Noise Contours Airport Noise Analysis FAR l050.ID Analysis General Eligibility for Soundproofing Noise Monitoring Systems
CNEL	An airport cumulative metric derived from SEL used only by the state of California; CNEL will be phased out in the next few years.

Table 2-1: Noise Aviation Metrics (Source: FAA 1985)

3 Noise effect to people

3.1 Introduction

The typical response of humans to aircraft noise is annoyance. Annoyance response is complex and, considered on an individual basis, displays wide inconsistency for any given noise level. What is annoyance to one person may not be to another. This basic difference in response makes the question of annoyance hard to define and be quantified in a acceptable way. An individual's tolerance to aircraft noise is also subjective. In the case of average annoyance reactions within a community, aggregate annoyance response/noise level relationships have been developed. There are research findings, which display aggregate community annoyance responses mainly as a function of Day and Night level noise. The continued growth of the aviation industry and expansion of airport capacity depends in a large on how well noise compatibility planning is handled (*FAA " Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

3.2 Criteria of annoyance

The factors that affect human response in noise, according to FAA (FAA-1985) can be divided in 3 main categories. The first category differs to measurable physical characteristics of sound, the second emotional variables of each person individually and the third to physical variables other the measurable physical characteristics of sound that influent the way that people react to noise. It is clear that the 2^{nd} category contributes the most to the high difficulties that researchers confronted when they asses noise effects on the people. The other 2 categories can easily be quantified and asses for noise pollution phenomenon.

3.3 Physical Characteristics of noise

3.3.1 Intensity

A ten decibel increase in intensity may be considered a doubling of the perceived loudness or noisiness of a sound; however, other psychoacoustics evidence suggests that a somewhat greater than 10 decibel increase in peak level of airplane flyover noise is required to produce a perceived doubling of loudness. This have to deal in some part with the fact that intensity in db is expressed in a logarithmic scale(*FAA "Aviation noise effects" Washington , Dc U.S. Department of Commerce-Mar 1985).*

3.3.2 Frequency.

Sounds with concentration of energy between 2,000 Hz and 8,000 Hz are perceived to be noisier than sounds of equal sound pressure level outside this range. As we mentioned in noise metrics human ear is more sensitive to the middle frequencies that's why we differ to a weighted filter noises. The source frequency spectrum at a given distance and at various emission angles is essential in finding the dominant source component and reduces noise at the source. Moreover, the Knowledge of distribution of a sound intensity with respect to frequency allows us to make efficient use of absorbent materials aiming to the noise reduction.*(FAA-1985, Elements of aviation Acoustics GIJ Ruijgrok-Delft University press/1993)*

3.3.3 Sound Pressure Level-Changes

Sounds that are increasing in level are judged to be somewhat louder than those decreasing in level (consider police and Emergency vehicle sirens) even if they differ exactly at the same level. For example if we have a 80 Adb noise that decreases to 70 Adb it will be perceived as less annoying than a noise that increase from 60 Adb to 70 Adb. *(FAA " Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

3.3.4 Increase rate of Sound Pressure Level

Impulsive sounds, sounds that reaching a high peak very abruptly, such as pile drivers or jackhammers are usually perceived to be nosier than sounds with the same pressure level but with lower rate of increase. This case applies very often in landing and takes offs of aircrafts when during their passage above a building in low altitude a sudden increase of noise occurs, causing a major disturbance to the residents (*FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

3.4 Emotional variables

According to the FAA 1985 Report, "knowledge of the existence of these individual variables helps to understand why it is not possible to state simply that a given noise level from a given noise source will elicit a particular community reaction or have a certain environmental impact". In order to do that, it would be necessary to know how much each variable contributes to human reaction to noise, which is almost impossible since those variables cannot be quantified in a constant and solid way. Research in psychoacoustics has revealed that an individual's attitudes, beliefs and values may greatly influence the degree to which a person considers a given sound annoying. The aggregate emotional response of an individual to noise has been found to depend on (*FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

3.4.1 "Necessity of the Noise

If people feel that their needs and concerns are being ignored, they are more likely to feel hostile towards the noise. This feeling of being alienated or of being ignored and abused is the root of many human annoyance reactions. If people feel that those creating the noise care about their welfare and are doing what they can to mitigate the noise, they are usually more tolerant of the noise and are willing and able to accommodate higher noise levels (*FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

3.4.2 Importance of the Activity, which is producing the Noise

If the noise is produced by an activity which people feel is vital, they are not as annoyed by it as they would be if the noise-producing activity were considered superfluous. (*FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

3.4.3 Activity During Noise Incident Noise

An individual's sleep, rest and relaxation have been found to be more easily disrupted by noise than his communication and entertainment activities (*FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

3.4.4 Attitudes about Environment

The existence of undesirable features in a person's residential environment will influence the way in which he reacts to a particular intrusion (*FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

3.4.5 Sensitivity to Noise

People vary in their ability to hear sound, their physiological predisposition to noise and their emotional experience of annoyance to a given noise (*FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

3.4.6 Belief about the Effect of Noise on Health

The extent to which people believe that exposure to aircraft noise will damage their health affects their response to aviation noise (*FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

3.4.7 Feeling Associated with the Noise

For instance, the extent to which an individual fears physical harm from the source of the noise will affect his attitude toward the noise" (*FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

3.5 *Physical Variables*

Researchers have also identified a number of physical factors that influence the way in which individuals react to a noise. Those factors although that they can easily be understand, cannot be also quantified, increasing by this way the difficulty which researchers confront when asses human response in aviation pollution. Section 3.5.1 to 3.5.6 classes these factors *(FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

3.5.1 Neighborhood location

Instances of annoyance, disturbance and complaint associated with a particular noise exposure will be greatest in rural areas, followed by suburban and urban residential areas, and then commercial and industrial areas in decreasing order. The type of neighborhood may actually be associated with one's expectations regarding noise there. People expect rural neighborhoods to be quieter than cities. Consequently, a given noise exposure may produce greater negative reaction in a rural area *(FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).* Obviously, the neighborhood location affects the way that people perceived noise, not only of there expectations but also from the fact that background noise in urban areas is higher than in rural areas that mask a larger amount of noise dose.

3.5.2 Daytime

A number of studies have suggested that noise intrusions are considered more annoying in the early evening and at night than during the day.(FAA-1985). That can be easily explained by the fact that people during the daytime are out of there home and working, and therefore do not experience the noise pollution. In order to take this into account for a, different hours and levels of annoyance, most of the relations (DNL, Leq, Ku) that are using to quantify in a cumulative way the noise pollution in airports, have penalty factors (i.e. DNL noise penalty factor for the night flights).

3.5.3 Season

Noise is considered more disturbing in the summer than in the winter. It is obvious that during the summer, windows are likely to be open and recreational activities take place out of doors. Unfortunately in the calculation of cumulative noise (i.e DNL) in which the residents of an area exposed to noise pollution we do not take in consideration the seasonal exposition level of noise. Karl. D Kyter, one of the main researchers on aviation noise pollution, has suggested that areas like California with a warm climate affects the people with a 5 db extra noise dose than in areas like N. York or London with a moderate climate. *(Karl D Kryter. "The Effects of noise on Man" New York, Academic Press inc 1985)*

3.5.4 Predictability of the Noise

Research has revealed that individuals exposed to unpredictable noise have a lower noise tolerance than those exposed to predictable noise *(FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).* This can be observed in every day life, when a sudden noise event can even cause a sense of fear.

3.5.5 Control over the Noise Source

A person who has no control over the noise source will be more annoyed than one who is able to exercise some control *(FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

3.5.6 Length of Time an Individual Is Exposed to a Noise

There is little evidence supporting the argument that annoyance resulting from noise will decrease with continued exposure; rather, under some circumstances, annoyance may increase *(FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

It is obvious that some of these variables not only cannot be quantified, but moreover they are closly related and it is even impossible to distinguish them. Lets take, for example, the variables of the predictability and the control over the noise. The person who will have some control over the noise source will be probably awarded for the fact that a noise event is going to occurred and consequently will experience less annoyance.

3.6 Review Of Recent Research

The different ways that individual perceives, noise makes it impossible to predict accurately how individuals respond to a given noise. In the case of a communities response to a noise there is a lot of research that has been conducted to relate community response to Ldn or other types of cumulative noise. This measure will represent the average annoyance response for the community *(FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

In any residential area, surrounding an airport, there will be a given percentage of the population highly annoyed, a given percentage mildly annoyed and others who will not be annoyed at all. The changing percentage of population within a given response category is the most accepted indicator of noise annoyance impact from all the agencies all over the world.*(FAA-1985)*

During the early part of 70s, many studies focused on the relationship between annoyance and noise exposure and by analyzing the results of numerous social surveys conducted at major airports in several countries, the curve shown in **Figure 3-1** were derived. Curves that relate the degree of annoyance and percent of population affected with noise exposure are expressed in DNL. Surveys and studies that have been conducted in different countries, investigated the relationship between the DNL and the percentage of those questioned who suffered feelings of fear, disruption of conversation, sleep or work activities.

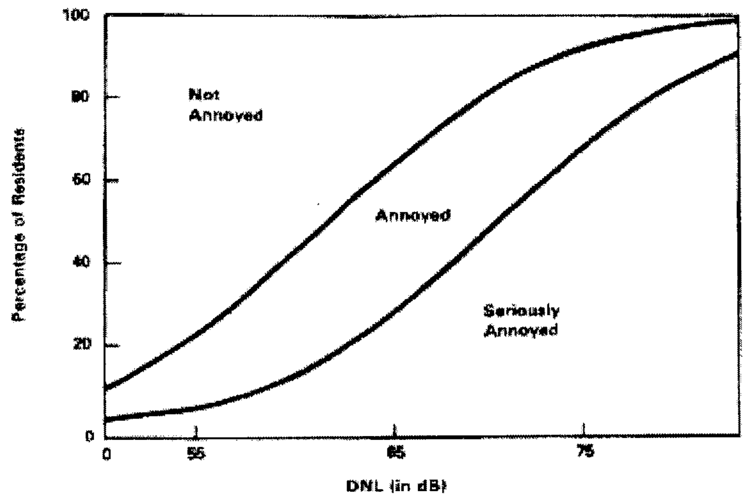

Figure 3-1Annoyance caused By aircraft noise in Residential Communities near major airports.
Source: Richards, E. J, and J. B. Ollerhead. Noise Burden Factor - New Way of Rating Airport Noise. Sound and Vibration,V. 7, No, 12, December 1973

In 1960 the "Wilson Committee" was appointed by the British Government to investigate the nature, sources and effects of the problem of noise (*Great Britain Committee on the Problem of Noise. London, H. M. Stationery Office, July 1963*). The report, presents results that exam the community response on aircraft operations at London Heathrow Airport. The **Figure 3-2** adapted from that report, shows the relationship between DNL and the percent of the population disturbed in various activities including sleep, relaxation, conversation and television viewing. Disturbance response categories for startle and house vibration are also included (*FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

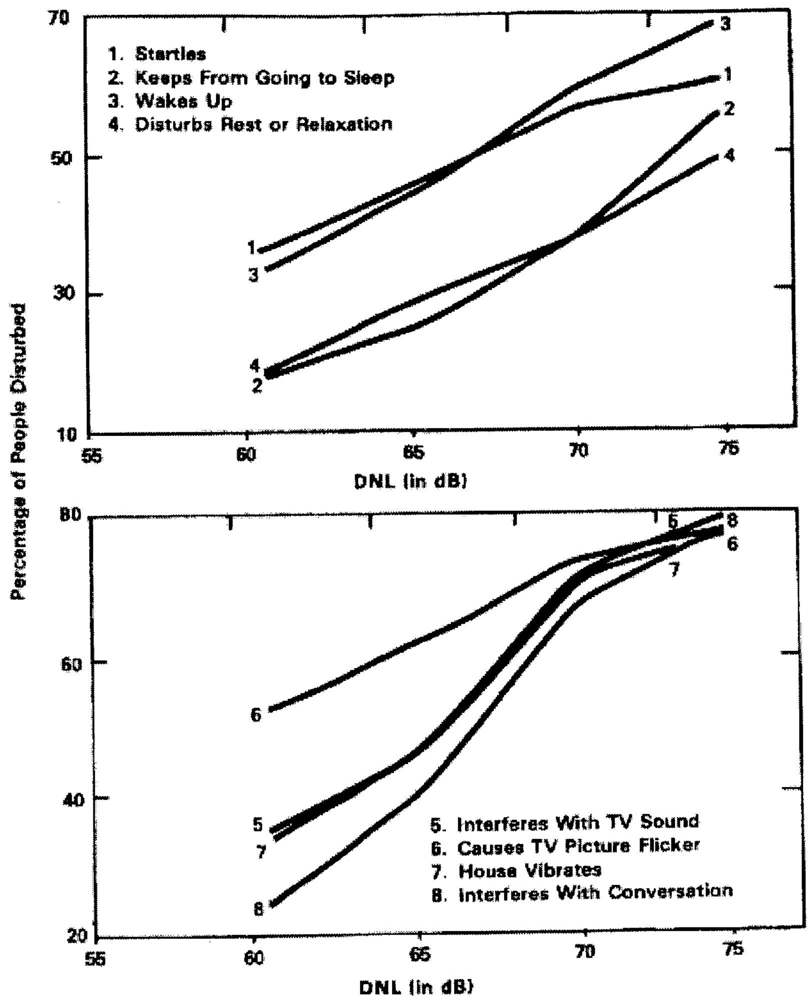

Figure 3-2:Community Response to aircraft operations-London Heathrow airport.

Source: Great Britain Committee on the Problem of Noise. London, H. M. Stationery Office, July 1963.

3.7 Shultz-Kryter Research and Analysis

In early 80s a debate about noise have occurred. The discuss was about the statement that aircraft noise levels should be treated as more annoying to people than the same sound levels generated by other sources. A review of the research shows that very strong positions have been taken both supporting and opposing the theory. The papers, most of them conducted in 80s, support that a differential in response may exist but it cannot be shown to be statistically significant. Consequently Federal Agencies did not adapt any special regulation that distinguishes the source of noise pollution.

Theodore Schultz published an article synthesizing results from many social surveys on noise annoyance. His position was that it is impossible to compare aircraft and other transportation noise equally, and to find and use a median annoyance response curve for them *(R Schultz, Theodore. Synthesis of Social Surveys on Noise Annoyance. J. Acoust. Soc. Am. 64, 1978.ef. 1).* In order to compare these various results, Schultz developed some theories and formulas with which he determined which parts of each survey would fall into the "highly annoyed" category. He also figured the DNL indices for these surveys and plotted them **Figure 3-3** (*FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

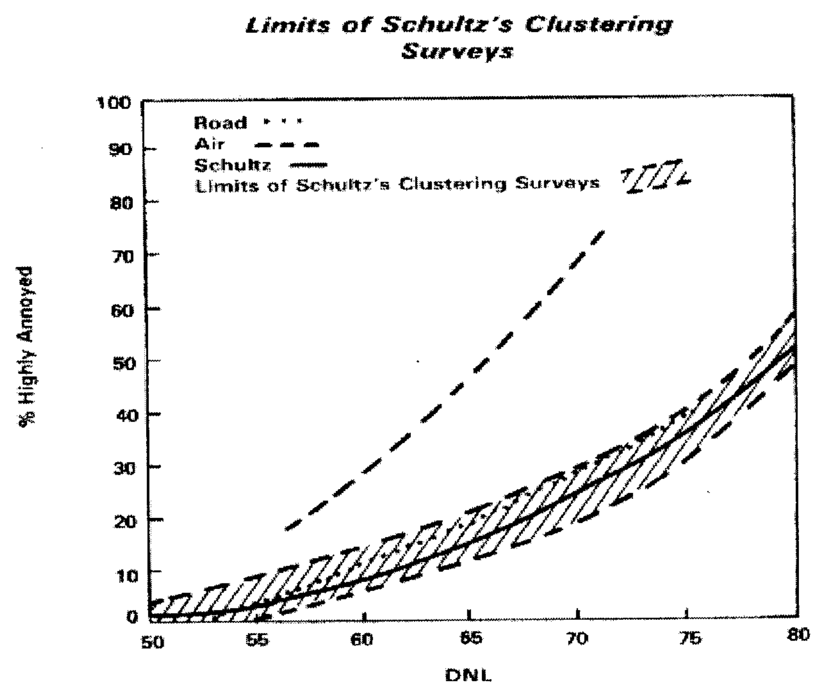

Figure 3-3: Comparison of Air, Road and Schultz Synthesis Curve Source: Schultz, Theodore. Synthesis of Social Surveys on Noise Annoyance. J. Acoust. Soc. Am. 64, 1978.

Karl Kryter, another researcher on noise pollution, observe that the percentage of people feeling annoyance is significantly different for exposure to aviation noise than for exposure to urban ground traffic noise, for equal Ldn noise. This difference, according to Kryter is due to the acoustical factors that lead to less noise (for given equal sound pressure levels measured outdoors near the fronts of houses) reaching the insides of houses and backyard living areas from street traffic than from aircraft operations. While Schultz only considered people who were highly annoyed, Kryter stated that all individuals annoyed should be considered in these comparisons. A 10 db Ldn noise should be added to Ldn values of aviation noise whenever we attempt to compare it with the values of street and road traffic noise measured. Kryter also attempted to explain the poor correlation, of less than 0.5, between exposures to aircraft noise as measured by Ldn and annoyance by individuals. By explaining that, while it is assumed that noise exposure is homogeneous over a given neighborhood, the noise dosages received at the ears of the persons indoors differentiates significalty. He observe also, a high correlation coefficients, equal to 0.90-0.95, between the percentage of people annoyed by aviation noise pollution in different countries and the level of exposure to aircraft noise. Finally he proposed that the Ldn noise exposure should be modified such that the 10-dB penalty for night (10 p.m. to 7 a.m.) should be changed to a 5-dB penalty for the period of 7 p.m. to 7 a.m. *(Karl D. Kryter 2nd edition Academic Press, INC."The effects of noise on man")*

3.8 Sleep Interference

The sleep disruption from noise is an extremely complicate problem to asses. The research that has been conducted on this topic presents widely varying results. The main reasons of that variation are summarizing as follows:

- Sleep can disrupted without causing awakening,
- The deeper the sleep the more noise it takes arousal,
- The same person experienced different faces of sleep during the night,
- Tendency to awaken increase with age,

The FAA *(FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985)* has reviewed literature on sleep disruption in a study of soundproofing a hospital where sleep is an important factor of patient fast recovery. That study identified a level of 40 dbA as a conservative threshold level of noise for sleep disturbance. The EPA in a different study identified 35dbA as a threshold of sleep disruption in the presence of steady, with maximum levels of 40 dbA resulting in a 5% probability of awakening. **(Figure 3-4)**

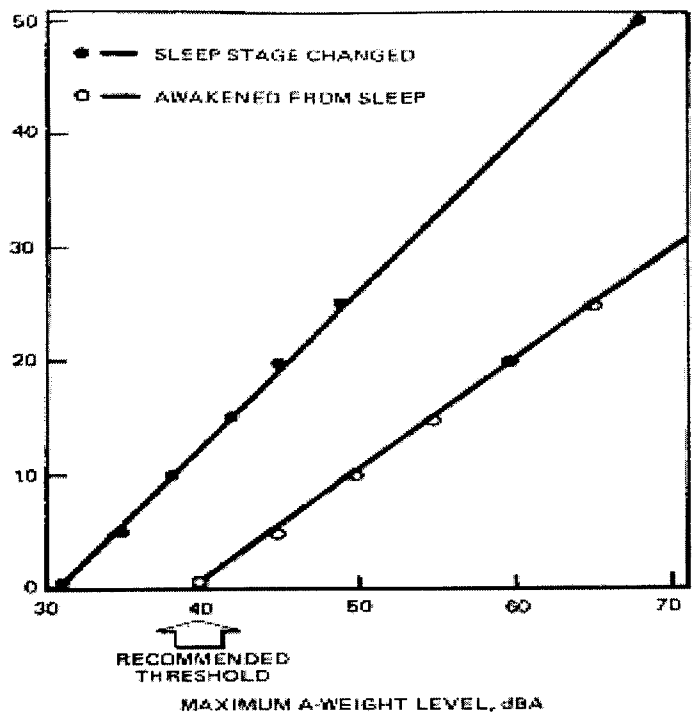

Figure 3-4:Composite of Laboratory Data for sleep Interference versus maximum A-Weighted Noise level

Source: Gattoni&Tarnopolsky, "Aircraft Noise and Psychiatric Morbidity "Psychological Medicine, Vol.3, pp516-520, 1973

By taking in consideration that the reduction of outside-to-inside noise is 15 Dba and the interior threshold level should be approximately 40dbA than the outdoors noise should be 55dbAto cause arousal. *(Massport Noise Abatement Department. "Logan Airport Noise Information Report" July 1991)*

3.9 Speech Interference

One of the main effects of aircrafts noise is its tendency to make difficult or impossible to carry a normal conversation without interruption. The sound level of speech decreases as distance between a talker and listener increases. As the level of speech decreases in the presence of background noise, it becomes harder to hear. As the background level noise increases the person who talks must rise his voice or the individuals must get closer together to continue their conversation.

The research that has been conducted (U.S. EPA) results that for typical communication distances of 3 or 4 feet, an acceptable conversation can be carried on in a normal voice as long as the background noise outdoors is less than about 65 dbA or 45 dbA indoors. If the noise were to exceed either of these levels, as occur when an aircraft passes overhead, intelligibility would be lost unless vocal effort were increased or communication were decreased.

The U.S. EPA has identify an outdoor criterion of Ldn 60 as prerequisite to protect against speech interference indoor, and a criterion level 5 dba less than that to provide for an additional margin of safety. (Information on levels of environmental Noise requisite to Protect public health and Welfare with an adequate margin of safety U.S. EPA Report No.550/9-74-004) *(Massport Noise Abatement Department. "Logan Airport Noise Information Report" July 1991).*

4 Noise contours – Land use

4.1 Noise contours

The main tool for analyzing land use compatibility in the vicinity of an airport is the noise footprint or contour. The noise contour represents a line of equal exposure, expressed using the yearly average day-night sound level, DNL in decibels *(FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

The noise contours are generated using a computer simulation of the yearly average daily operations. The computer program developed for this purpose by the FAA is known as the Integrated Noise Model, or INM. Noise contours are usually presented as overlays on 1" = 2000 feet U.S. Geological Survey quarter sectional maps *(FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

According to the FAA, *(FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985)* the uses of the noise contour include compatibility planning and parametric studies of airport operations such as:

1) "variation in aircraft ground tracks
2) departure profiles
3) aircraft mix
4) introduction of new aircraft
5) changes in numbers of operations, and
6) introduction of new runways"

4.1.1 DNL 65 Contour

Noise contours provide the guidance in order to make sensible zoning and planning decisions, avoiding incompatible land use in areas of high noise levels. The significance that people give in a noise contour and its interpretation increase as the exposure level increases. It is therefore very important to review the strengths and weakness of noise contours in representing noise impact.

The applications of the DNL 65 contour are outlined below. The cautions previously alluded to be also set out below. It is worth noting that these qualifications simply identify possible misinterpretations and do not detract from the important general planning strengths *(FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

Applications According to FAA *(FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985):*

1. "Soundproofing may be required to achieve desired sound levels for certain building uses.
2. Conflicts may exist between certain land uses and predicted noise exposure as set out in FAA compatible Land Use Guidelines.
3. General caution is offered to prospective homebuyers.
4. Contour provides average net change, but may not be applicable at individual locations.
5. Homes within the contour may not be eligible for HUD mortgage insurance (discretionary)".

According to FAA the Precautions that should be taken in consideration when the noise contours of DNL noise are used summarized as follows *(FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

1. It is most important to emphasize that the DNL 65 contour does not form a boundary line between acceptable and unacceptable noise exposure.
2. Locations within contours do not necessarily require soundproofing nor are public buildings within contours automatically eligible for soundproofing assistance.
3. DNL contours or grid analyses do not accurately reflect noise exposure at specific locations. Predicted levels may vary +/- 5 dB around actual measured levels for any given location.

4. Other noise sources in the environment may contribute as much or more than aircraft to the total noise exposure at a specific location."

4.1.2 DNL 75 Contour.

The DNL 75 contour is often considered the boundary between high (75) and moderate (65 - 75) noise exposure. The following interpretations are appropriate for those areas within DNL 75 contours (*FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985):*

1. "Soundproofing is very likely required in many buildings (depending on use).
2. Homes are ineligible for HUD mortgage insurance.
3. Aircraft noise is very likely the dominant environmental noise source.
4. DNL prediction accuracy at specific locations improves to + /- 3 dB.
5. Conflicts very likely exist between predicted DNL values and land uses as set out in FAA Land Use Compatibility Guidelines.
6. Definite caution is offered to prospective home buyers."

4.2 Land use compatibility

4.2.1 FAA Far Part 150 Guidelines

In FAR Part 150, the FAA has identified and determined land uses, which are normally compatible (or non compatible) with various exposures of individuals to DNL noise exposure level. This was done in compliance with the Aviation Safety and Noise Abatement Act of 1979, and is the criteria for use in preparing Airport Noise Exposure Maps and Airport Noise Compatibility Programs submitted under FAR Part 150. All Federal grants issued, for noise compatibility planning or development at airports must be in accordance with FAR Part 150. The noise/land use compatibility criteria according to FAA are summarized in a table in the U.S. Code of Federal Regulations (CFR) (14 Cm150). The Part 150 Table is also compatible in most essential areas with the table published by the American National Standards Institute (ANSI). **Table 4-1** offers sample comparisons of the Part 150 table and the ANSI land use table. (The categories of this table are detailed further in FAA Advisory Circular 150/5020-1.). *(FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

Land Use	ANSI Standard	FAA Standard
Livestock Farming	1. Compatible to 65 dB 2. Marginally compatible to 75 dB 3. Incompatible above 75 dB	Compatible to 75b dB
General Manufacturing	1. Compatible too 70 db 2. Marginally to 80 db 3. Incompatible above to 80 db	Compatible to 85 Db Incompatible above 85 dB
Music Shells	Marginally to 65 dB	Compatible to 64 dB
Playground, Riding, Golf	Compatible to 60 dB Marginally to 75 dB Incompatible above 75 dB	Compatible to 70 Db Compatible with special details up to 80 dB

Table 4-1:Comparison FAA –ANSI Standards for Land Use

Source: (FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985)

4.2.2 Other Federal Criteria

In June of 1980 the federal interagency committee on urban noise, comprised of representatives of the five agencies most involved in noise land use, or environmental publish a guideline for considering noise in land use planning and control. The result was that FAA, DOD AND HUD policy and regulations relative to airport noise and housing to be quite compatible *(FAA "Aviation noise effects" Washington, Dc U.S. Department of Commerce-Mar 1985).*

5 The case of Logan airport

5.1 Introduction

5.1.1 Demographic data

The main airport of New England, Boston-Logan International Airport, plays a vital role in the region's current and future economic prosperity. In 1998, Logan accommodated 26.5 million passengers, which is nearly two-thirds of all New England air passengers, making it the 17th busiest U.S. airport based on passenger volume and the 8th busiest based on aircraft operations (arrivals and departures).

Logan Airport 1998 U.S. Rankings	
18 in Passenger Volume	26.5 Million Passengers
8 in Aircraft Operations	508,000 Aircraft Operations
19 in Cargo Volume	804 Million Pounds
6 in Delays	121,000 Hours of Delay

Table 5-1:Logan Airport 1998 Rankings

Source: FAA, Air Traffic Operations Network (OPSNET) database

In addition, Logan itself is a major contributor to the regional economy. Fifty-six airlines serve Logan and over 100 aviation-related businesses provide airport support services. Approximately 15,000 people work at Logan, 95 percent of whom are employed by the private sector or by agencies other than Massport. Logan generates jobs and economic activity that stimulate the regional economy by $5 billion per year, or an average of $13.6 million every day. *(Massachusetts Port Authority, Economic Impact Report, Fiscal Year 1998)*

In the following table some very important facts about Logan airport are presented and provide a good indication about Logan's flight operations, air passengers and total cargo during the last decade.

YEAR	Air passengers (000)	Annual Percent Change	Flight Operations	Annual Percent Change	Total Cargo And mail (000 lbs.)	Annual Percent Change
1990	22,878	2.7%	425	9.3%	753,253	0.1%
1991	21,450	-6.2%	430	1.2%	766,584	1.8%
1992	22,723	5.9%	474	10.2%	819,522	6.9%
1993	23,579	3.8%	493	4.0%	835,746	2.0%
1994	24,468	3.8%	459	-6.9%	923,557	10.5%
1995	24,192	-1.1%	466	1.5%	869,642	-5.8%
1996	25,134	3.9%	456	-2.1%	911,166	4.8%
1997	25,568	1.7%	483	5.8%	974,170	6.9%
1998	26,527	3.8%	507	5.2%	970,764	-0.3%
Year Ending Sept 1999	26,345	-	503	-	978,162	-
Year Ending Sept 2000	26,838	1.9%	498	-1.0%	961,569	-1.7%

Table 5-2 Air Passengers, Aircraft Operations, and Freight: 1990 to 2000

Sources: Boston-Logan International Airport,1994/1995 Generic Environmental Impact Report

Logan Airport Annual Updates

5.1.2 Forecast of flight and Passenger Movements

Massport has adopted a range of near-and long-term aircraft operations forecasts for planning purposes **(Figure 5-1).** Annual passenger demand for Logan Airport is forecast to reach 29 million passengers early in this decade. Logan's most recent annual passenger level is 27.1 million for calendar year 1999, or 93 percent of the forecast 29 million annual air passengers. If Logan continues with the same growth rhythm, combined with the effectiveness of the regional alternatives, Logan will reach 34 million passengers by 2010 and 37.5 million passengers closer to 2015. Massport's projected operations range from 510,000 for the near-term Low Fleet scenario to 656,000 for the long-term High Fleet scenario. The High and Low scenarios for aircraft operations reflect different assumptions regarding the aircraft fleet mix at Logan. Briefly, a High Fleet scenario is one in which there is a larger proportion of smaller aircraft, and therefore, more aircraft operations are required to service a given number of passengers than in a Low Fleet scenario, which has more larger jets, and therefore can accommodate the same number of passengers in fewer flights or aircraft operations.

Logan accommodated 495,000 operations in 1999, or 97 percent of the 29M Low Fleet scenarios indicating that the near-term forecasts are appropriate and valid for the airside operational and environmental impact analyses. (*Vanasse Hangen Brustlin, Inc – The Brown book, SDEIS, February 1999*)

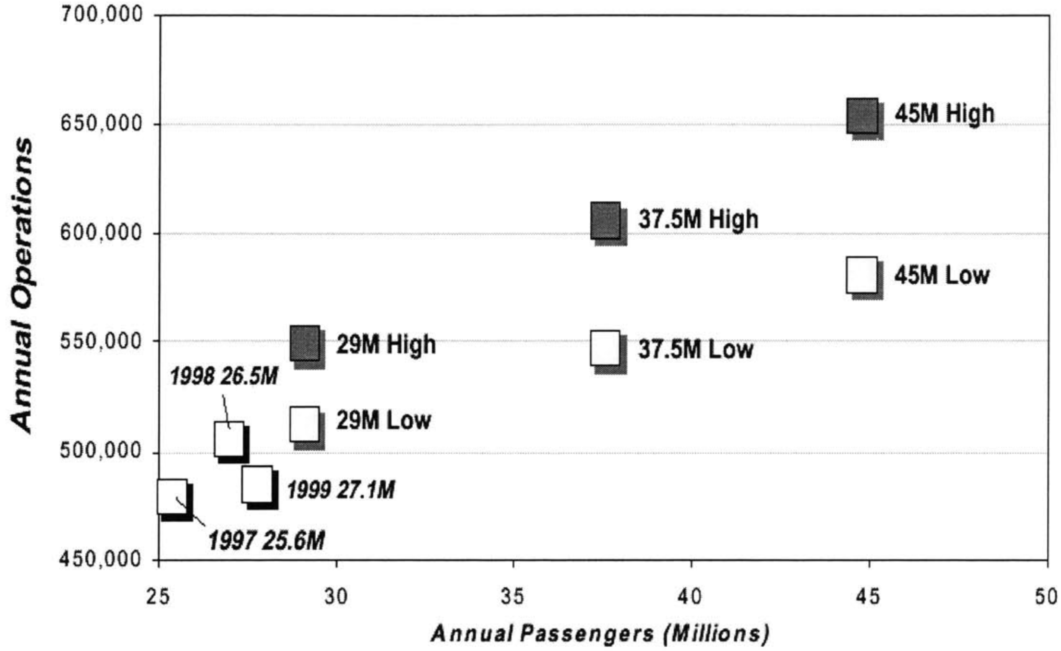

Figure 5-1: Logan Airside and fleet Forecasts

Source: Airside Supplemental Draft Environmental Impact Statement

5.1.3 Problem identification

A serious aircraft delay problem at Logan undermines the airport's ability to provide efficient and reliable access to national and world markets and threatens the region's long-term economic success. According to Federal Aviation Administration (FAA) statistics, Logan is one of the most delayed airports in the country, ranking 6th among U.S. airports in total delays and 3rd in arrival delays. Annual delays at Logan are estimated to result in more than $300 million in unnecessary costs to airlines and air passengers (*Vanasse Hangen Brustlin, Inc- SDEIS," the Brown Book", February 1999).*

Much of the aircraft delays at Logan are caused when reduces capacity occurs during northwest wind conditions. While delays caused by most weather conditions, such as heavy precipitation, icing or fog, are unavoidable, correcting Logan's airfield layout deficiencies can significantly reduce unpredictable delays that occur during clear weather conditions accompanied by northwest winds. (*Vanasse Hangen Brustlin, Inc-SDEIS," the Brown Book", February 1999.)*

Moderate to strong northwest winds can restrict the airport to a low-capacity configuration with two or fewer runways during periods of high demand. As a solution to this serious situation has been proposed the construction of an unidirectional Runway 14/32, operating as a third available runway during moderate to strong northwest winds. The high mix of regional aircraft using Logan Airport further compounds Logan's delay problem in adverse northwest wind conditions. When a three-runway configuration is available, Logan can accommodate the mix of aircraft with minimal delay by segregating large (jet) and Small (non-jet) aircraft operations on different runways. However, when wind conditions force Logan to operate on two or fewer runways, and Large and Small aircraft must share use of a single runway, the longer separation distances required between aircraft of different size leads to significant delays, particularly for arriving flights. (*Vanasse Hangen Brustlin, Inc- SDEIS, the Brown Book, February 1999)*

5.1.4 Runway Configuration

Logan has four major runways, but no more than three runways can be used at the same time. Runway availability is primarily determined by current wind and weather conditions as well as the mix of aircraft seeking to use the airport. Delays occur when low capacity configurations (i.e., less than three active runways) are in effect and demand exceeds available capacity. To operate efficiently under all wind directions, Logan requires three active runways for most of the operating day. There are several primary operating configurations in use at Logan, with over 80 operating subsets of these configurations. As described in the Draft EIS/EIR , (*Vanasse Hangen Brustlin, Inc- SDEIS, " The Brown Book", February 1999).*

The operational capacities of Logan's existing configurations range from a maximum of approximately 120 operations per hour when the weather is good, winds are light, and three runways are available, to fewer than 60 hourly operations for a single runway. Logan's highest capacity configurations have three active runways, which allow FAA controllers to keep apart arriving aircraft of different size classes into two arrival streams and to use the third runway for aircraft departures. High capacity runway configurations are available at Logan, nearly 80 percent of the year. For the remaining part of the year, wind and weather conditions limit the airport to lower capacity configurations with just one or two available runways. The highest capacity configurations at Logan are the north-south configurations. These configurations include the Runways 4L, 4R, and 9 configuration and the Runways 22L, 22R, and 27 configuration **(Figure 5-2).** With three available runways, these configurations maximize the airport's operating efficiency since longer separations between different size aircraft are required less frequently.

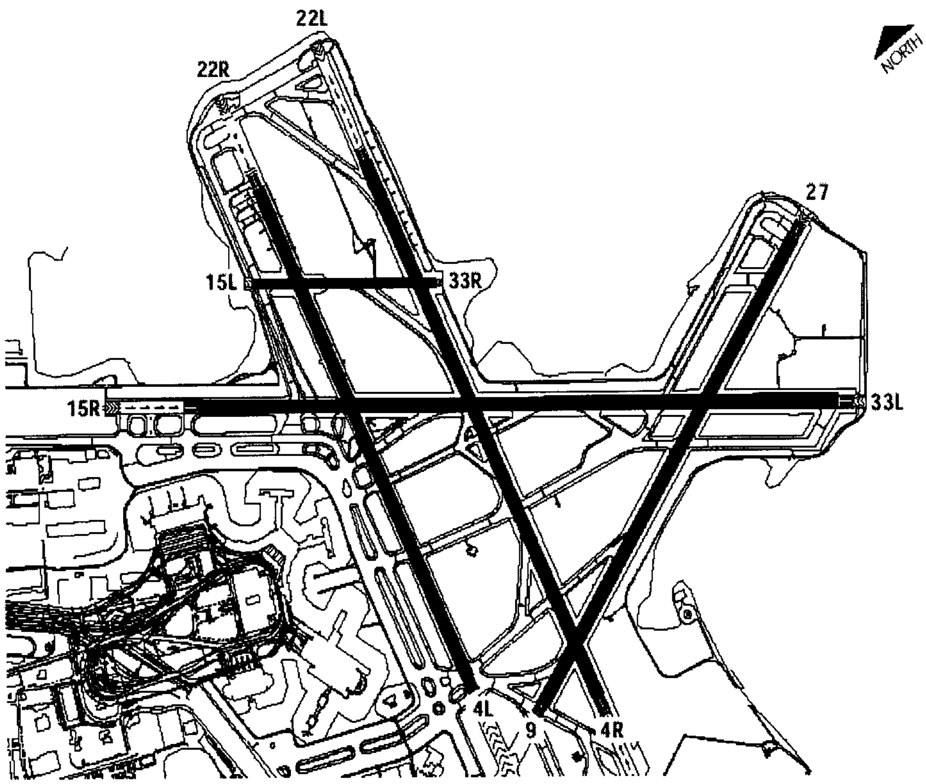

Figure 5-2: Logan Current Runway Configuration
Source: Massport-Interim sumplementary EIS draft, 3/24/2000

Contrary, when the airport is constrained to a two-runway or one-runway configuration with a single arrival stream, this type of segregation cannot occur and therefore delays increase. These low-capacity configurations include the east/southeast configuration of Runways 15R and 9, and the northwest configuration using Runways

27 and 33L or just Runway 33L when the winds are strong (*Vanasse Hangen Brustlin, Inc- SDEIS, " The Brown Book", February 1999).*

Because Logan lacks a third available runway in the east-west direction, the north-south runways are the most frequently utilized runways at Logan. Seventy-seven percent of Logan's 1998 jet operations landed on or departed from runways oriented north-to-south (4L and 4R arrivals, 4R departures, Runway 9 departures, 22L and 22R departures, and 22L and 27 arrivals). As a result, communities to the north and south of Logan bear a unequal share of jet over flights (41.5 percent). On the other hand, 10.5 percent of jet operations were on runways affecting communities west of the airport (Runway 27 and 33L departures, and 15R arrivals) and 12.5 percent utilized over-the-water runways (15R for departures and 33L for arrivals) in 1998. (*Vanasse Hangen Brustlin, Inc- SDEIS, " The Brown Book", February 1999).* It is clear that if a reliable and and accepted solution about the delays problem that Logan airport confront it should be the capacity of the airport for the weather conditions that constraint Logan's capacity without affecting the people in the surrounding communities.

From the above it can be concluded that actions should be taken to correct this deficiency in the airfield layout, otherwise Logan's dependence on north-south runways will increase to more than 90 percent in the 37.5M high scenario. With the Preferred Alternative, Logan's dependence on north-south configurations drops dramatically to 41 percent. By making a third runway available in the east-west operating direction, the Preferred Alternative allows for a more balanced geographic distribution of jet over flights – 41 percent north/south and 30 percent east (over water), and 29 percent west. For approximately 20 percent of the year, poor wind or weather conditions restrict the airport to configurations with just one or two runways. *(Vanasse Hangen Brustlin, Inc-SDEIS, the Brown Book, February 1999)*

5.1.5 Proposed Solutions- Unidirectional Runway 14/32

Many alternatives have been proposed to deal with the problem of the increasing demand in the airport and of the delays problem. The results have been showed in the following table

Improvement Concept	Alternative 1 All Actions	Alternative 1A All Actions Except Peak Period Pricing	Alternative 2 All Actions Except Runway 14/32	Alternative 3 No Build	Alternative 4 No Actions
Runway 14/32	■	■			
Taxiways:					
Centerfield	■	■	■		
Extend Delta	■	■	■		
Realign November					
South West Corner Optimization	■	■	■		
Operational:					
Reduced Minimums	■	■	■	■	
Peak Period Pricing	■		■	■	

Table 5-3: Evaluation of Alternatives for the expansion of Logan Airport.
Source: (Massport, FAA-"Interim supplement draft SDEIS",March 2000)

The comparative benefits and impacts of the different alternatives were fully evaluated by Massport and FAA and are described in the Airside Draft EIS/EIR. After careful review of the extent and causes of delays at Logan and the comparative benefits of each alternative, FAA and Massport selected Alternative 1A as the Preferred Alternative because it significantly reduces delays without imposing the economic costs on regional carriers and small communities associated with Peak Period Pricing. Alternative 1A achieves certain environmental benefits that include improved air quality and a reduction in noise for the most severely impacted communities, while causing minimal environmental impacts that will be mitigated. FAA, following a detailed study came out with a solution that proposed the construction of Unidirectional Runway14/32.

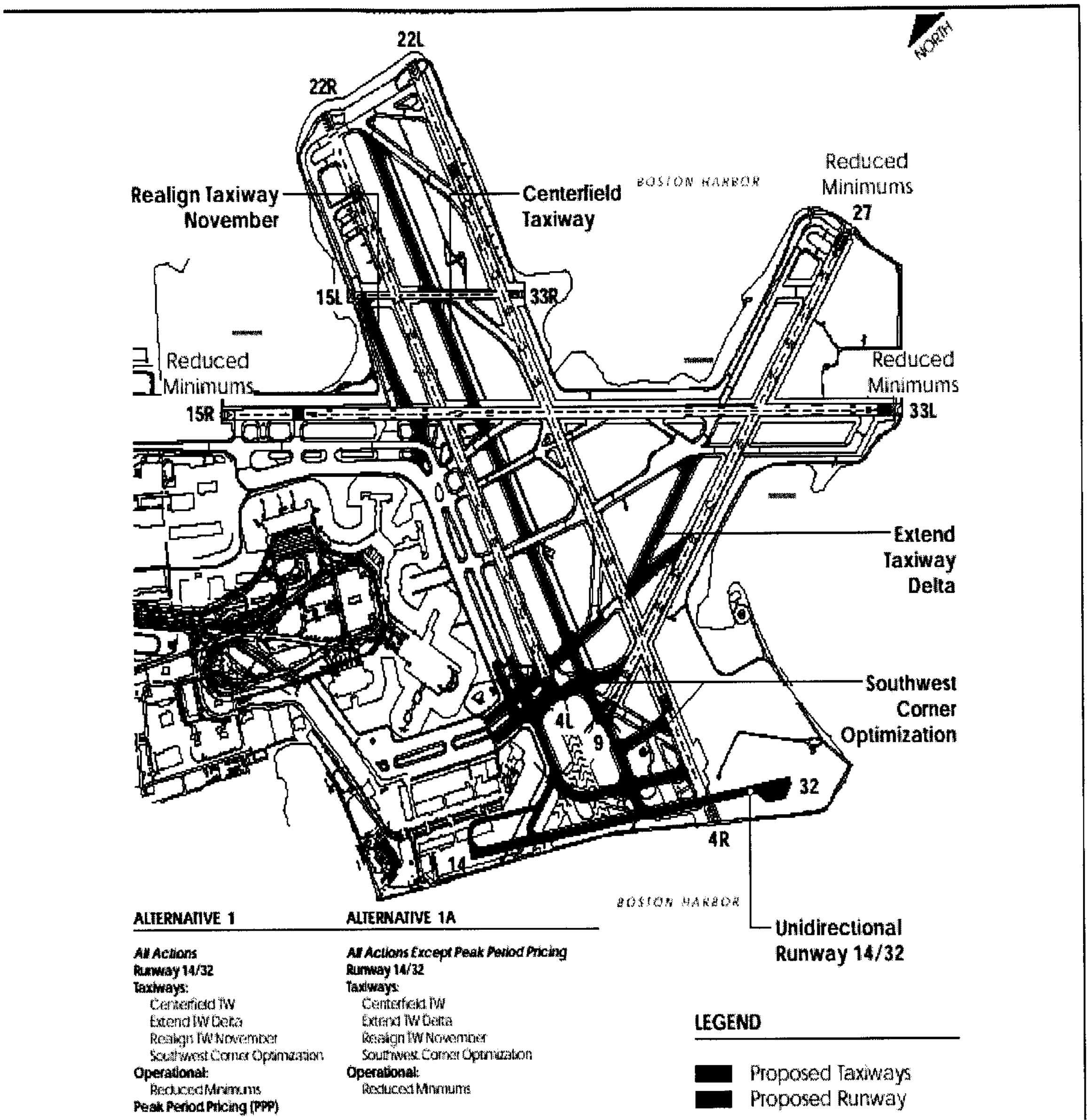

Figure 5-3:Alternatives solutions for the expansion of Logan

Source: (Massport, FAA-"Interim supplement draft SDEIS", March 2000)

Unidirectional Runway 14/32 would be located along the southwestern edge of the airport. All arrivals would be from the east over Boston Harbor and would touch down at the Runway 32 end and taxi toward the Runway 14 end. All departures would leave from the Runway 14 end, and take off heading east over the harbor Runway 14/32, which would address the two major causes of delay at Logan. First, wind and weather (particularly moderate to strong northwest winds) often limit Logan to two-runway configurations and sometimes to one-runway configurations, which is a major cause of delay. With three runways in visual flight rule (VFR) weather conditions, Logan's capacity is approximately 120 operations per hour. Two runways can accommodate up to 90 hourly operations and one runway provides 60 or fewer hourly operations. *((Vanasse Hangen Brustlin, Inc- SDEIS, " The Brown Book", February 1999).*

The high proportion of smaller, regional aircraft in the fleet at Logan is an additional major source of delay, because the separation distance required between large and small aircraft using the same runway is greater than for two aircraft of the same class. Delay would be reduced if the two classes of aircraft could be segregated onto different runways. When greater separation distances are required, the time needed to complete each aircraft operation (e.g., landing or takeoff) increases, which can result in additional delay for subsequent operations *(Massport, FAA-"Interim supplement draft SDEIS", March 2000).*

5.2 Historical Noise Measures

5.2.1 1976 Logans master plan.

Developed in consolation with the airport stakeholders, and adopted by Massport in 1976 the plan defines a series of policies that even today continuous to guide Massports airport noise abatement programs.

The main substitute of the program summarize as follows:

- Aircraft use restrictions promulgated through noise
- A preferential runway advisory system
- Changes in departure procedures and flights traks
- Sound insulation of schools and residents beautiful romantic poetic shine
- A noise monitoring system
- Open planning with full participation

(Massport "Logan Airport noise information report"- 1991).

5.2.2 Noise rules

Massachusetts Port authority establish higher costs for the aircrafts that do not meet federals Aviation Regulation Part 36 noise limits through a revised fleet noise rule and introduce a noise component to landing fees. The first noise rules adopted in 1976, revised in 1980, and 1986.

The main parts of the 1986 revised rules establish a

- New fleet Mix Rule to replace the old compliance ratios
- Expand the restrictions for the night Rule
- Improvements to airport regulations

With the Federal Aviation regulation Part 91 Stage 2 jets were prohibited from flying in or out of U.S. airports after 1999. Consequently beginning in January 1, 2000 every aircraft greater than 75,000 pounds should met FAR Part 36 Stage 3 noise limits. *(Massport "Logan Airport noise information report"- 1991, FAA-MASSPORT "Draft EIS Report" February 1999)*

5.2.3 Runway advisory system

The Congress charged the responsibility for management of the national airspace to the Federal Aviation Administration. In Logan airport the FAA Air Traffic Control tower has the responsibility of Runways for Landings and Takeoffs, at any given time. In 1981 the Preferential Runway Advisory System (PRAS) Committee set the objectives for the system as follows:

Long Term:

"Annual: Reduce the annual average total noise impact from Logan operations on the population residing in affected communities without significantly increasing the impact on any populated area within the 65 Ldn contour.

Preference: Maximize the use of runway 15R for over-water departures and of 33-L for over water approaches." *(Massport "Logan Airport noise information report"- 1991)*

Short Term:

"Dwell: provide a relief during each day from dwell, the continuous operation of aircraft over any one neighborhood.

Persistence: Provide relief during a period of several days from persistent of operation of aircraft over one neighborhood"

The computer aided PRAS system after taking in consideration the wind, the weather, the traffic level provides recommendations to the FAA supervisor on a long and short term runway use. The system has been upgraded in 1992 and provides:

- More acceptable definitions on runway capacity
- More advanced planning of weather information and runway use by the tower.
- More timely measurement of adherence to the goals

The goals and the runways utilization targets can be modified only through a process in which participate surrounding communities and Massport authorities. *(Massport "Logan Airport noise information report"- 1991)*

5.2.4 Noise abatement procedures

The main effort of Massport is the development of noise abatement procedures and flight tracks, although that FAA has the exclusive responsibility for flight tracks. By taking into consideration the density of population in the area surrounding the airport, departure corridors have been developed to minimize noise for people that are subject to the highest levels of noise.

Departures on runways 4R,9, 15R, and 22R were all designed in the late 1970s to over fly the ocean, returning over shore at altitudes of at least 6,000 feet above Mean Sea Level (MSL). Departures on runways 27 and 33L are deigned to overfly water and commercial/industrial areas, to the maximum practical extent, prior to overlying residential areas.

In the Runways 4R, 15R and 22R the aircraft land at a point further down the available pavement. That point at which the aircraft first makes contact with the runway results a reduce noise impact on the communities since the aircraft at the approach runway will be higher as it over flies populated areas, and hence cause slightly less noise. *(Massport "Logan Airport noise information report"- 1991)*

5.2.5 Relocation Program

In early 1970s the residents of the Nepture Road Neighborhood in east Boston experienced extreme noise levels of aircraft operations, approximately equivalent to an Ldn of 84 Db, and asked to be relocated. In Response to the community in August 16, 1973, the Massport Board formally adopted the "Napture Road Property Acquisition and relocation Program", a strictly volunteer program, under which 169 families relocated during 80s.

Under the Nepture Program Massport has developed 29 units of prefabricated one – and two- family homes for relocating families in an effort to allow residents to remain in their community while providing a quitter residential environment. *(Massport "Logan Airport noise information report"- 1991)*

5.2.6 Sound insulation Programs

5.2.6.1 Residential

In 1983 Massport Board voted to fund a residential pilot project, aimed to identify treatments of different construction types , typical of the area, exposed to different types of noise. Based on the success of this pilot program, Massport received a grant from the FAA to treat up to 250 homes in East Boston and Winthrop. Under Grant II insulated through 1994, 750 homes at an estimated total cost of 25$ million.

The FAA states that all homes in 65 Ldn noise contour are eligible for noise abatement programs, Massport with the assistance of an acoustical consultant, developed criteria that take into account noise caused by both over flight (A-weighted) and ground noise from takeoff roll and reverse thrust (C-weighted low frequency noise).

The following table summarizes the criteria:

Treatment Area Criteria Residential Sound Insulation Program			
Criteria	Grant I	Grant II	Grant II expansion
A-weighted decibels	110 dbA	107 dbA	106 dbA
C-weighted decibels	116 dbC	113 dbC	112 dBC
Ldn		73 Ldn	72 Ldn

Table 5-4: Residential Sound Insulation Programs

Source: ***(Massport "Logan Airport noise information report"- 1991***

The process includes the cooperation of homeowners on an individual basis in order to have the most effective treatment to their homes. The objective is reduce noise , usually done through a specified replacement of windows and doors that enter directly into living quarters. The homeowner can also have a room in which additional acoustical work on exterior walls and in some cases ceiling is conducted to further reduce the aircraft noise. An agreement is made with the homeowner who describes in detail the work which is required. This is used as basis for a bid document for a group of houses. An acoustical test is performed to measure the effectiveness of the work. The results of those tests show that window replacement work provides a 30 to 35 db reduction and room of preference treatment a 40 to 45 db noise reduction. *(Massport "Logan Airport noise information report"- 1991).*

5.2.6.2 School

In 1979 Massport initiated a feasibility study of weathearization and sound insulation of public buildings in the district of Logan airport. Preliminary findings suggest sever measures such as new windows, better seals and miscellaneous building modifications to reduce infiltration and noise.

In 1981 the program was further developed, using 8-hour school day noise exposure levels, to categorize relative impacts of the aircraft noise. Twenty nine schools were identified as sensitive and with the contribution of FAA a ranking mechanism was established to identify those locations benefiting most from sound insulation *(Greiner "Technical Memorandum School Day Noise Exposure Study, Boston Logan Airport", February 1981.*

The same year, Massport became the recipient of the 1st FAA grant ever awarded for the purpose of sound insulating a school. East Boston High Schools had its windows replaced, resulting a noise reduction of 25-dbA, which compared to the previous status. Based on the success of this program, the FAA has established a permanent program of financial assistance to insulate schools from aviation noise nationwide. Massport has new soundproofed 33 schools, resulting an average noise reduction of 36 dbA *(Massport. "Logan Airport noise information report"- 1991).*

Building a Record of Responsiveness with Boston Neighborhoods: 1974-1999 Environmental Mitigation Noise Abatement	
1975	Logan became one of the first airports in the nation to install a noise monitoring system and a noise abatement hotline.
1976	First Noise Rules adopted which included a compliance schedule for late-night flights (revised in 1980, 1984)
1977	Noise Abatement Office established First over-the-water departure implemented for Runway 22R
1981	Massport obtained the first-in-the-nation grant from the FAA to test the benefits of soundproofing a public school- East Boston High soundproofed.
1983	• Preferential Runway Advisory System (PRAS), a computer enhanced support system for air traffic controllers to select runways to minimize noise. • Residential Soundproofing pilot program instituted
1998	84% of aircraft operations flown met FAA stage 3 standard (the quietest jets in the fleet), well ahead of the national average of 78%.
1999	Continued prohibition of Stage 2 aircraft (the noisiest) from operating at Logan between 11:00 PM-7:00 AM
2000	• 6,736 dwelling units soundproofed in East Boston, Winthrop, Revere and South Boston for a total cost of $98 million. • To date, 29 schools in East Boston, Roxbury, Winthrop, Chelsea and South Boston have been soundproofed at a total cost of $ 7.65 million • Conducted "Hill Effects" study with the FAA in order to increase soundproofing eligibility for residents of South/East Boston. • Committed $700,000 in funding for soundproofing of new school in Winthrop

Table 5-5: Logan airport key dates 2000

Source: Massport. "Logan airport official web site" 2001

5.3 Current situation noise pollution

5.3.1 Logan Neighborhood

Logan Airport extends to an area 2,400 acres within the boundaries of the East Boston area of the City of Boston, Massachusetts and the Town of Winthrop, Massachusetts. The airport is surrounded by Boston Harbor on the east south and north side. The East Boston neighborhoods of Jeffries Point, Eagle Hill, Harbor view, and Orient Heights are west and northwest of the airport. The Town of Winthrop is east and northeast of the airport, separated by the waters of Boston Harbor. The Downtown Boston Central Business District is located to the west, and South Bostonis located to the southwest across the Inner Harbor **(Figure 5-4)**, *(FAA-MASSPORT "Draft EIS Report" February 1999).*

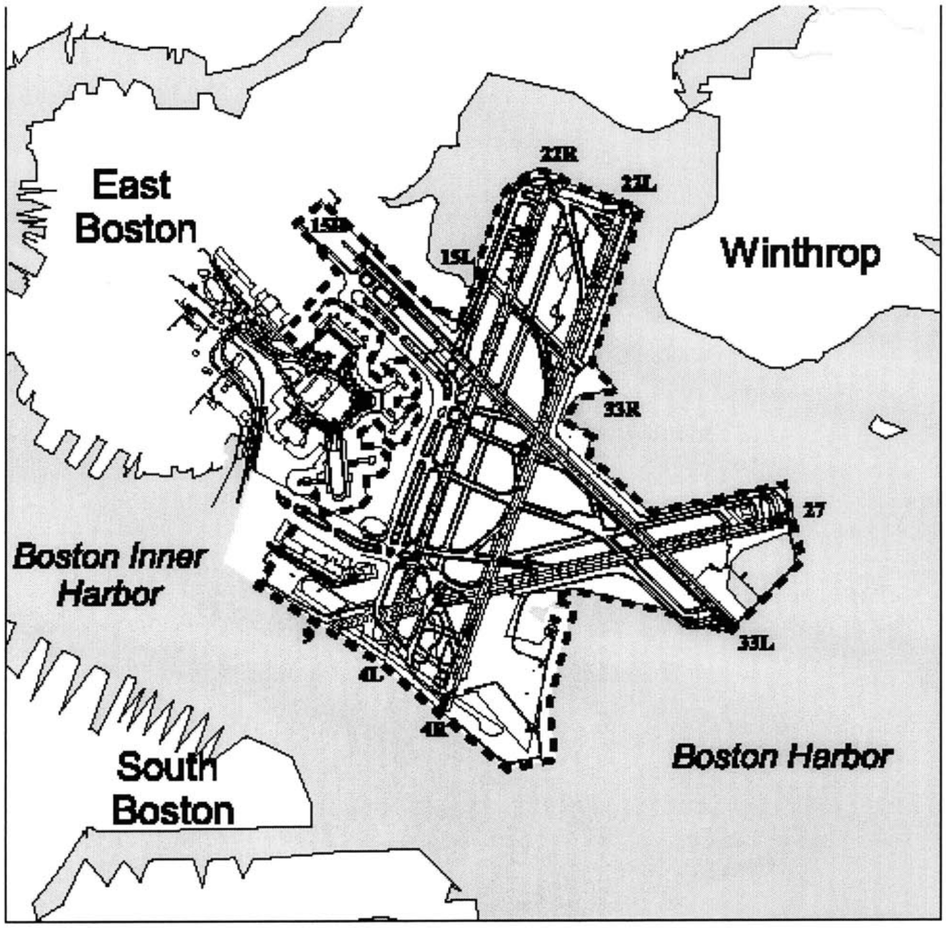

Figure 5-4:Logan Airport Nrighborhood

Source: (Massport, FAA-"Interim supplement draft SDEIS",March 2000)

The proposed improvements are located on the existing airfield and do not change existing land use for the adjacent communities. Under FAA, NEPA guidelines, the compatibility of existing and planned land uses in the district of an airport are usually associated with the noise impacts related to that airport. In order to respond to the concerns of surrounding communities and on-site issues, two study areas have been conducted: one which includes communities impacted by airport noise, as directed by

FAA guidelines, and a second which consists of the Logan airfield. *(Massport, FAA-"Interim supplement draft SDEIS",March 2000).*

5.3.2 Community study area

The community study area includes those neighborhoods within the 60-decibel (dB) Day-Night Sound Level (DNL) noise contour for aviation noise. As we saw in Chapter 4, the Department of Housing and Urban Development (HUD) and the FAA define an annual average Day-Night Sound Level of 65 dB as the threshold of noise compatibility with residential land uses. Massport extend the limits of its DNL and population analyses to the 60 DNL contour in order to take into consideration the fact that Logan airport is in residential area with high population density. Moreover, since there is annoyance within the 65 DNL noise contour areas, the FAA ask for a general characterization of land uses within the 60 dB DNL contour area. Logan Airport's noise contours are produced using an FAA-approved computer program known as the Integrated Noise Model, or INM. *(Massport, FAA-"Interim supplement draft SDEIS", March 2000).*

The INM uses data such as the physical runway configuration, the numbers and types of aircraft using the airport, whether the flights occur during the day or night, how often they use each runway, and which flight paths they follow. Each of these affects the noise cumulative level exposure in surrounding neighborhoods. The geographic area of the 60 DNL or greater contours, changes depending on the year's activity and the operational scenario that is being evaluated. Generally includes the communities of Boston (including downtown Boston, East Boston, South Boston, Dorchester, Roxbury, and the South End), Winthrop, Chelsea, Revere, and Everett). *(Massport, FAA-"Interim supplement draft SDEIS", March 2000)*

5.3.3 Noise calculations

As was presented in Chapter 2 there many different ways to measure noise pollution in airports. The most applicable are:

(a) the Day-Night Sound Level, or DNL, and

(b) times above designated "threshold" sound levels, commonly referred to as "Time-Above", or TA.

And actually are those which have been used to most of the studies that asses noise aviation pollution on airports.

5.3.4 Noise Model

The basic tool used to model aircraft flight operations is the Integrated Noise Model, or INM. The model, utilizes airport geometry, descriptions of aircraft operations, and an internal database of noise and performance characteristics to compute the noise of individual flights. The final result is cumulative contours and/or noise calculations at specific points. Operational inputs to the INM fall into three categories:

- Daily numbers of daytime and nighttime takeoffs and landings by aircraft type
- Typical flight path and runway geometry
- Average statistics on usage of each runway and flight path by aircraft groups

Historical data as those from Massport's noise monitoring system, which records and saves FAA radar data from Logan's Air Traffic Control Tower, are used to develop descriptions of past noise environments. Predicted aspects of an airport's operations are used to evaluate alternative assumptions regarding growth, future aircraft fleets, shifting of flight paths, new runway and taxiway configurations, delay, noise mitigation measures, and other critical planning efforts.

INM users do not normally modify internal noise and performance databases as a part of the modeling process. However in 1996, Massport applied for and received permission to make adjustments to the INM to better account for Logan's location surrounded on nearly all sides by water. The water's surface affects propagation of sound into shorefront neighborhoods and is not normally accounted for in the standard INM algorithms. *(Massport, FAA-"Interim supplement draft SDEIS",March 2000)*

5.3.5 Fleet Mix And Operations

In order to compute the 24-hour Day-Night Sound Levels (DNL's) in the form of noise contours, annual operations at Logan are divided into average daily operations by specific aircraft types, and in some cases by engine model as well. The data are taking in consideration into average daily take offs and landings for daytime hours (7:00 AM to 10:00 PM) and nighttime hours (10:00 PM to 7:00 AM), the periods used in DNL calculations. Radar data are used to determine actual, rather than scheduled, arrival and departure times. General aviation operations, formerly excluded from modeling, have been approximated in the Airside analyses and are included in the 1998 scenario, using FAA radar data to determine the numbers and times of operations by these specific aircraft types. *(Massport, FAA-"Interim supplement draft SDEIS",March 2000)*

The average daily operations at Logan for 1998 are summarized in **Table 5-6.** The noise certification level classifies commercial jet operations. Noisier "Stage 2" aircraft (such as the older Boeing 727s and 737s, and McDonnell-Douglas DC-9s) meet initial Federal Aviation Regulation (FAR) Part 36 noise limits issued in 1969, but not the more stringent "Stage 3" limits applicable to newer aircraft (such as the Boeing 737-300 and 737-400, the Boeing 757 and 767, McDonnell-Douglas MD-80s, and Airbus A-300s and A-320s). The Stage 3 operations include Stage 2 aircraft that have been renovated with new engines to meet the Stage 3 criteria. The number of Stage 3 aircraft has increased based on the continuing replacement of Stage 2 operations by Stage 3 aircraft in the Logan fleet mix. In 1993, 69 percent of the commercial jet operations at Logan were in Stage 3 aircraft; in 1998, that percentage increased to 87 percent. The 87 percent also compares favorably to the 1998 national average of 82 percent, due in large measure to the benefits of Massport's Noise Rules that have required conversion to Stage 3 aircraft faster than federal regulations. *(Massport, FAA-"Interim supplement draft SDEIS", March 2000)*

1998 Operations	Stage 2 Jets	Stage 3 Jets	Turboprops	Totals		
	Day/Night	Day/Night	Day/Night	Day	Night	Daily
Commercial	85/6	541/96	553/22	1,179	124	1,303
General Aviation	5/0	31/4	37/16	73	20	93
Total	90/6	572/100	590/38	1,252	144	1,396

Table 5-6:Average daily aircraft operations per type

Source:Boston-Logan International Airport 1998 Annual Update

5.3.6 Runway Use

Runway use refers to the frequency with which aircraft utilize each runway during the course of a year, as permitted by weather, aircraft weight, air traffic conditions, and noise considerations. The more often a runway is used the more noise is created in communities located at the ends of that runway. Runway use statistics for 1998 are based on traffic counts from radar data processed by Massport's noise and operations monitoring system. Takeoffs and landings are counted separately and sorted into daytime and nighttime operations, then further separated by groups of aircraft having different performance characteristics (for example turboprops separately from 747's), A summary of the computed usages by all jet aircraft was previously published in the *Logan Airport 1998 Annual Update.* **(Table 5-7)**

Runway	1998 Actual Usage		1998 Effective Usage	
	Arrivals	Departures	Arrivals	Departures
4L	2%	0%	36.7%	0.0%
4R	41%	8%		6.6%
9	0%	35%	0.0%	29.9%
15R	2%	6%	1.2%	10.9%
22L	27%	5%	11.9%	30.9%
22R	0%	28%	0.0%	
27	28%	14%	21.7%	16.6%
33L	19%	5%	28.6%	5.2%
Total	100%	100%	100.1%	100.1%

Table 5-7:Annually Runway usage

Source: Boston-Logan International Airport 1998 Annual Update

Where effective utilizations are the usage at night weighted by a factor of ten .

5.3.7 Noise From Flight Operation

The sixty, 65 and 70 dB DNL contours generated by the INM for 1998 actual operations are presented in **Figure 5-5**

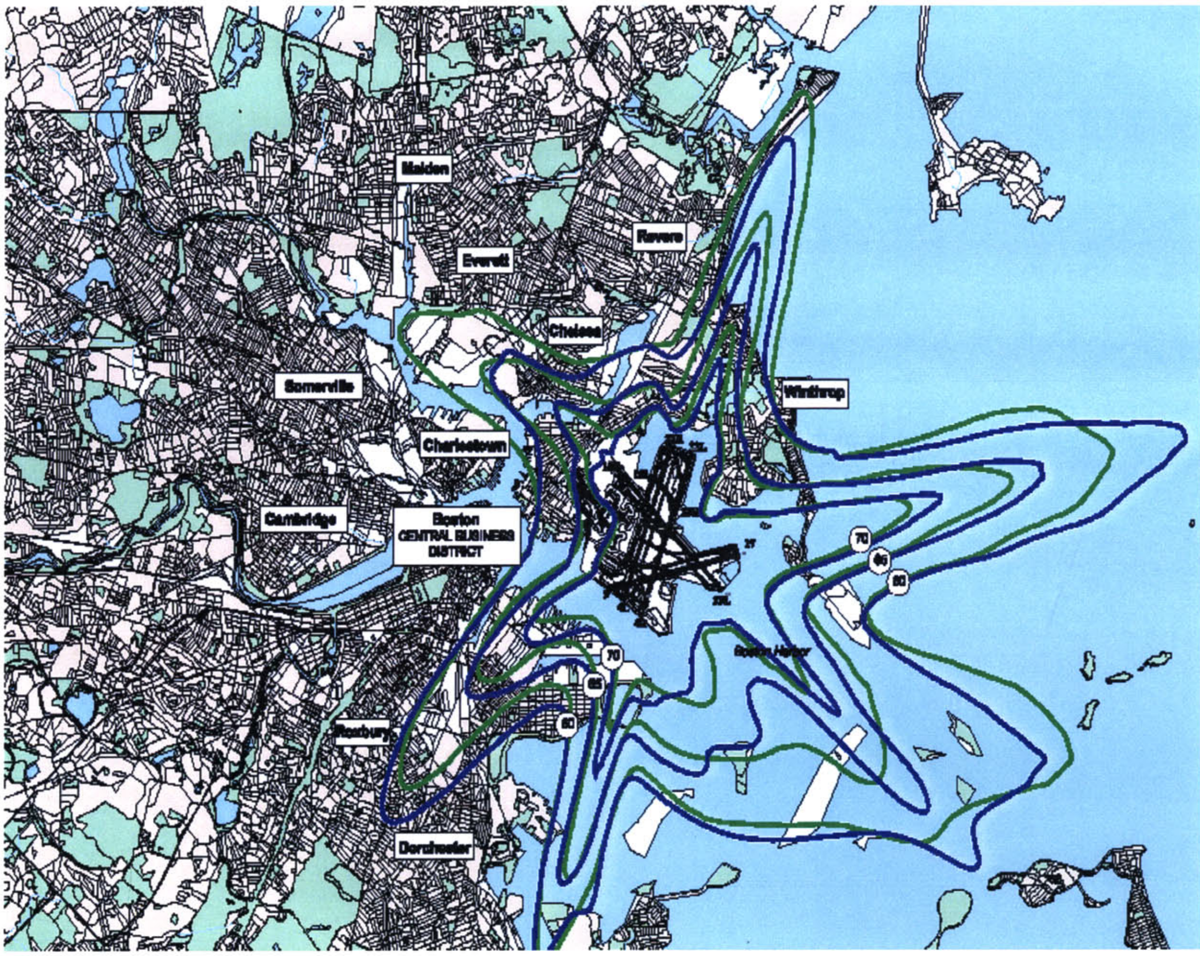

Figure 5-5: 60 , 65 and 75 dbA noise contours.

Source: Massport, FAA-"Interim supplement draft SDEIS", March 2000

With the green color are pictured the historical noise contours of 1993 (Year with the Highest operation) and with the blue color the noise contours of 1998. Both the Department of Housing and Urban Development (HUD) and the FAA define 65 DNL as the threshold of noise incompatibility with residential land uses. Thus, the 65 DNL contour is important for population impact assessments. In addition, this study contains data in response to the MEPA Certificate, which requested Massport to include the 60 dB DNL contour. The INM produces population estimates at the same time with the development of DNL contours. **(Table 5-8).**

The 1998 population counts shown above and presented first in the *Logan Airport 1998 Annual Update* are based on the same 1990 federal census as used for the Airside Project. Winthrop and East Boston are most affected, with significant numbers of residents experiencing noise greater than 70 DNL, and some experiencing levels above 75 DNL. South Boston and Revere are generally next most affected. *(Massport, FAA-"Interim supplement draft SDEIS" ,March 2000)*

Community	DNL 60 and Above	DNL 65 and Above	DNL 70 and Above	DNL 75 and Above
Boston	10,809	0	0	0
Chelsea	9,222	0	0	0
East Boston (other than Jeffries Point)	28,108	7,962	590	58
East Boston (Jeffries Pt.)	2,288	0	0	0
Everett	0	0	0	0
Quincy	0	0	0	0
Revere	5,300	3,168	0	0
South Boston	22,511	3,553	48	0
Winthrop	15,120	8,613	2,041	519
Totals	**93,358**	**23,296**	**2,679**	**577**

Table 5-8: Numbers of people residing within each noise contour

Source: Massport, FAA-"Interim supplement draft SDEIS", March 2000

5.3.8 Noise Level At Specific Monitoring Locations

Massport maintains a state-of-the-art noise monitoring system that continuously records noise levels at each of its permanent noise monitor locations. There are 29 installed and operational noise monitors in residential neighborhoods recording noise from flight operations, 21 of these sites, plus 2 additional locations (A and E) were selected for detailed location-specific analysis. These selected monitoring locations included all of the highest noise level measurement sites close to the airport, as well as those further from the airport that are consistently overflown. Five sites were not included since they did not meet one of these criteria. Their measurements were expected to contain enough noise of local origin such that their correlation with modeled aircraft noise would be low

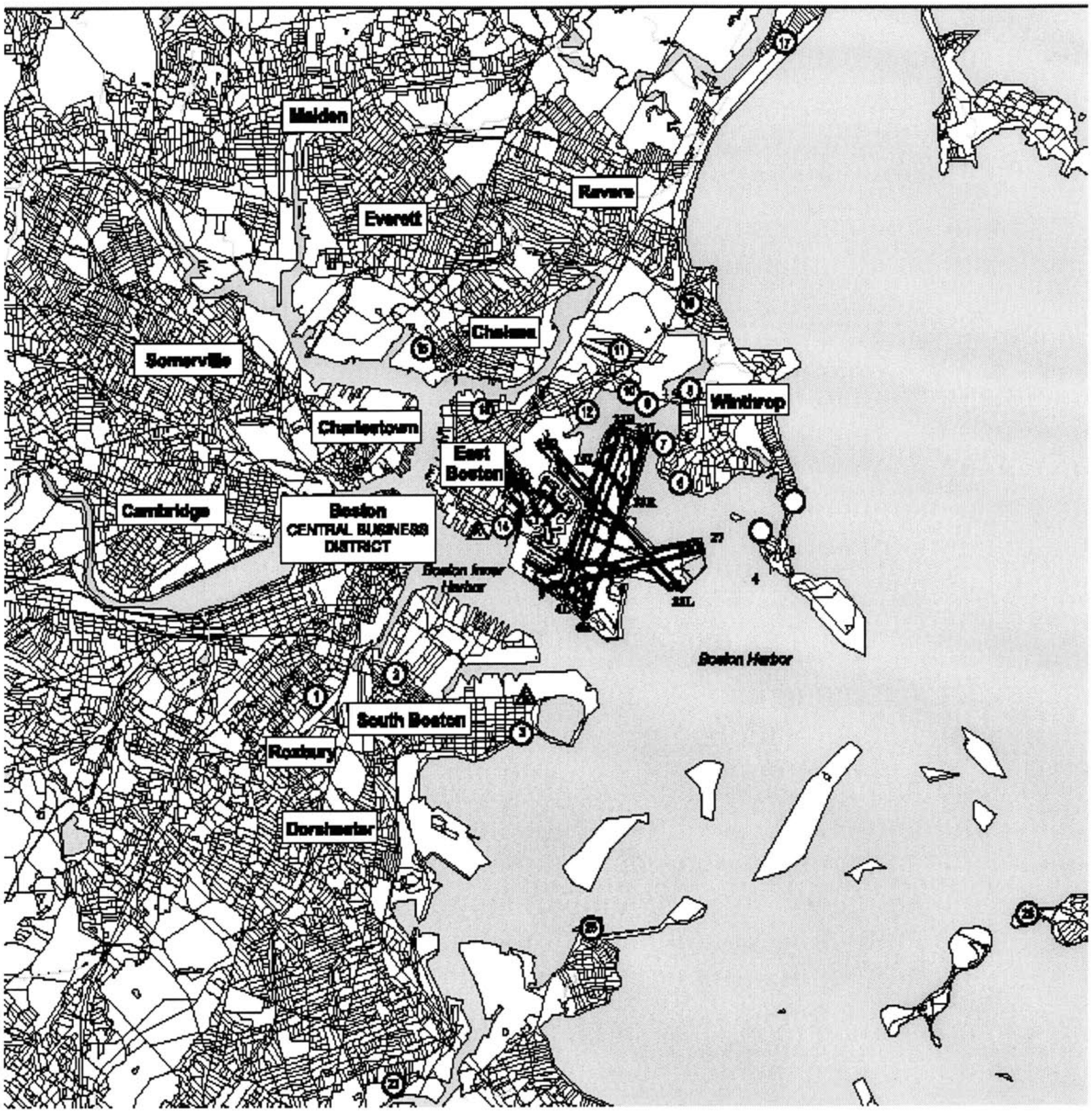

Figure 5-6:Noise Monitoring Locations, Logan Airport

Source: Massport, FAA-"Interim supplement draft SDEIS", March 2000

At each of these 23 specific locations, a number of noise computations were completed and reported in the Draft EIS/EIR. These included:

(a) n Day-Night Sound Level (DNL)

(b) n Maximum Sound Level (Lmax)

(c) n Night (10:00 PM to 7:00 AM) Equivalent Sound Level (LeqN)

(d) n Times Above Sound Levels of 55, 65, 75, 85, and 95 dB at night (TAN)
(e) n Times Above Sound Levels of 55, 65, 75, 85, and 95 dB for 24-hour days (TA24)

The threshold levels of 65, 75, and 85 dB were identified in the *Annual Update* as covering different degrees of speech interference depending on factors such as whether people are outdoors, or indoors with windows open or closed. Observations regarding TA calculations for 1998 are similar to those for DNL. The highest exposure levels occur at Sites 4 and 7 at Bayview and Grandview in Winthrop and along Loring Road in Winthrop, where DNL values are 79 and 76 dB, respectively. These same locations experience sound levels exceeding 85 dB for about 21 to 23 minutes per day, and also experience daily levels above 75 dB for almost an hour at Site 4 to nearly an hour and a half at Site 7. Sites 9 and 12 at Bayswater near Annavoy in East Boston and at the East Boston Yacht Club also experience high exposures. Their DNL levels are 72 and 74 dB, respectively, and they are exposed to sound levels above 85 dB for 8 and 16 minutes per day. In fact, the five most highly exposed sites, both at night and over 24 hours, are located in Winthrop and East Boston – the same communities identified earlier as having high numbers of people residing in areas where the DNL exceeds 70 dB. *(Massport, FAA-"Interim supplement draft SDEIS" ,March 2000)*

5.4 Noise Pollution for the future chosen scenario

For the proposed solution of Runway14/32 Massport and FAA conducted a study to asses the consequences of the expansion of Logan airport in terms of noise pollution. The main conclusions of that study are summarized as follows *(Massport, FAA-"Interim supplement draft SDEIS", March 2000).*

Runway 14/32 results a reduction noise exposure in the highest-exposed communities around Logan Winthrop, parts of East Boston, and Revere. Depending on the fleet forecast, all three have residents exposed to DNL values of 70 dB and above. With the 29M Low Fleet scenarios, Runway 14/32 will allow approximately 180 fewer people in these communities to live in areas exposed to noise above 75 DNL, and some

60 fewer people to in areas of 70 DNL and above. Under the 37.5M high forecast, the situation significantly improved since 77 percent and 73 percent reduction, in the total number of population living in this high impact communities exposed to 75 and 70 dbA DNL respectivly.

The reduction in exposure at the highest DNL values is achieved by redistributing aircraft onto other runways. This causes increases in exposure at lower DNL values. With the 29M Low Fleet scenario, the Preferred Alternative is estimated to increase the number of people exposed to noise above DNL 65 by about 380, or about 2 percent of the total population in that contour compared to the No-Action Alternative. At the 37.5M High forecast, the Preferred Alternative increases the number of people above 65 DNL by 508, a 4 percent increase.

No one residing in an area exposed to noise above DNL 65 is projected to experience an increase in level in excess of 1.5 dB due to the Preferred Alternative; however, approximately 400 people in Winthrop will experience decreases in noise of more than 1.5 dB compared to the No Action Alternative.

In addition to reducing noise exposure at the highest DNL levels, the Preferred Alternative allows for a more balanced geographic distribution of jet operations. Under the 37.5M Low scenario, the Preferred Alternative results in 53 percent of jets utilizing runways affecting communities north and south of the airport, compared to 88 percent for the No Action Alternative. Conversely, the percentage of jets flying over the water increases significantly from 7 percent in the No Action alternative to 24 percent with the Preferred Alternative.

The Preferred Alternative with its unidirectional Runway 14/32 and Centerfield Taxiway reduces delay and consequently the number of nighttime operations by approximately 5 percent compared to the No Action Alternative under the 29M Low Fleet scenario.

The Preferred Alternative is even more effective at reducing delays under the 37.5M High Fleet forecast. In that scenario, the number of nighttime operations is reduced by approximately 20 percent compared to the No-Action Alternative.

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The new configuration will have as a result less people to be affected by noise pollution.

Day-Night Sound Level in dB	1998 Actual Operations	No Action Alternative	Preferred Alternative (Alt. 1A)	Preferred Alt. Compare to No Action	Percent Change re No Action
29M Low Fleet					
DNL 75 Db and above	577	257	77	-180	-70%
DNL 75 Db and above	2,969	1,521	1,459	-62	-4%
DNL 75 Db and above	23,296	17,531	17,909	378	2%
DNL 75 Db and above	93,860	59,523	60,418	895	2%
37.5M High Fleet					
DNL 75 Db and above	577	257	58	-199	-77%
DNL 75 Db and above	2,969	3,828	1,028	-2,800	-73%
DNL 75 Db and above	23,296	11,499	12,007	508	4%
DNL 75 Db and above	93,860	52,153	52,153	10,494	25%

Table 5-9: Comparison in terms of population exposed to DNL noise, of the two Alternatives

Source: Massport, FAA-"Interim supplement draft SDEIS", March 2000

6 Conclusions-Recommendations

Aviation noise pollution is an extremely complicated topic due to its strong correlation with the subjective perception that people have for the noise. Despite the major number of studies that have been conducted, no answer has been given on how the variables related to the subjectivity of noise should be quantified.

FAA part 36 , that certifies the different type of aircrafts, should be revisited in order to compensate for the innovations and technological developments that have taken place in aeronautics in recent years. FAA part 36 was constitute in 1969 when the available technology in civil aviation industry was a main constraint for the definition of the threshold noise level of an aircraft in order to be in a particular category.

Cumulative noise relations as Ldn noise can provide a reliable measure of the correlation between noise level and human annoyance, and would be a useful tool for engineers and Urban Planners to use whenever an expansion of an airport is being considered. In the case of airports vicinity, the FAA regulations should be modified, in a more conservative way, to allow for the high density of population. In example can be found at Logan airport, where Massport imposed the calculation of the boundaries of 60 dbA DNL zone in order to determine the houses and the number of people that are affected by this level of noise.

For facilities particular sensitive to noise pollution such as hospital and schools the cumulative noise should be calculated for the period that these facilities are being used since a 24-hour DNL noise calculation will provide us with fuzzy results as to the level of noise which the facilities are being exposed. Massport was the first authority at a National level that receives funding from FAA for sound insulation of schools.

The expansion of Logan airport is more than necessary in order to keep its leading role in New England's Economy. With the construction of the Runway 14/33, it appears that a solution will be given to the serious delay problem of Logan airport. Moreover a significant improvement will be observed in terms of noise level exposure of the surrounding communities. Massport and FAA should further investigate the new noise conditions with the new runway and expand the study to include other noise metrics such as the Leq noise for time periods in which particular noise sensitive facilities are being used. They should also examine incidents of high noise events, to which the surrounding areas are being exposed.

The expansion of airports is becoming more and more a necessity in order to meet the increased demands of aviation sectors. The main challenge that decision makers, planners and engineers will have to face will not only be the appropriate location of the airport but the optimum or the proper choice of the location on which the new runways should be construct in order to have the less environmental impacts with the highest capacity benefits.

7 References

Al-Kadi, N, Baak, M, Kamphuis, A, Scholler, M and Yong JS. Open Design Methodology for Schiphol Airport as a Sustainable City, a paper submitted at the MIT-TUD Open Design Methodology Workshop. January 8-19, 2001.

Annual Report of Schiphol Group 1999.

ATSDR (Agency for Toxic Substances and Disease Registry). "Toxicological Profile for Ethylene Glycol and Propylene Glycol", prepared by Research Triangle Institute for the US Department of Health and Human Services, Alanta, Georgia, September 1997.

Boutatis, A, Ebrems, J, Fer, S, Pol, M. Schiphol as a sustainable city: a redesign option, a paper submitted at the MIT-TUD Open Design Methodology Workshop. January 8-19, 2001

Capuno, RE, Holvoet, M, Rubenstein, E and Williamson J. Schiphol: A Sustainable Airport?, a paper submitted at the MIT-TUD Open Design Methodology Workshop. January 8-19, 2001.

Federal Aviation Administration. "Report to Congress: National Plan of Intergrated Airport Systems (NPIAS) 1998-2002, " Washington, D.C., 1997

Federal Aviation Administration. "Report to House Committee on Transportation and Infrastructure and Senate Committee on Commerce, Science, and Transportation: Airports Located Adjacent to Environmentally Sensitive Areas." Washington, D.C., March 1996

G.J.J. Ruijgrok "Elements of Aviation Acoustics". Delft University press, 1993.

Hassall, J.R. and K. Zaveri. Acoustic Noise Measurements. Bruel & Kjaer, January 1979.

Pearson, Karl. Handbook of Noise Ratings. Bolt, Beranek and Newman, Inc. NASA CR-2376, April 1974.

Spicer, C.W. et al. (1990). Aircraft Enissions Characterizations F101 and F110 Engines. Batelle Report, ESL-TR-89-13.

Stenzel, Jennifer. "Flying Off Course: Environmental Impacts of America's Airports." National Resources Defense Council, October 1996.

Ulbrich, I. Estimating Aircraft Emissions in Northeastern United States, 1999.

U.S. Departement of Commerce, National Technical Information Service. "Aviation Noise Effects".

US EPA, Letter from Stephen Kramer, Octagen Process Inc. to Shari Zuskin, April 26, 1999.

Vanasse Hangan Boustlin, Inc. for Massachusetts Port. "Generic Environmental Impact Report Environmental Studies 1994 and 1995 Annual Update".

Vanasse Hangan Boustlin, Inc. for Massachusetts Port. "Boston-Logan International Airport 1998 Annual Update".

Massport. "Logan Airport noise information report"- 1991

Massport, FAA-"Interim supplement draft SDEIS", March 2000

Federal Aviation Administration: "Aviation Noise Effects" Washington, Dc. U.S. Department Of Commerce National Technical Information Service. Mar 85

Schultz, Theodore. Synthesis of Social Surveys on Noise Annoyance. J. Acoust. Soc. Am. 64, 1978.

Kryter, Karl D. "The effects of noise on man". Second Edition, 1985.

Grandjean, P. Graf, A. Lauber, H.P. Meier, and R. Huller. Survey on the Effects of Aircraft Noise in Switzerland. Inter-Noise 76, Washington, D.C., April 1976.

Greiner "Technical Memorandum School Day Noise Exposure Study, Boston Logan Airport", February 1981)

Massport, FAA-"Interim supplement draft SDEIS",March 2000

Vanasse Hangen Brustlin, Inc- "SDEIS, the Brown Book for Logan Airport", February 1999