PHILIPPINE ENGINEERING JOURNAL
PEJ 2006; **Vol. 27 No. 2**:71–84

THE IMPACT OF AIRCRAFT NOISE ON COMMUNITIES IN THE VICINITY OF THE NINOY AQUINO INTERNATIONAL AIRPORT

Ernesto B. Abaya*, Ricardo G. Sigua and Karl N. Vergel

Department of Civil Engineering
University of the Philippines Diliman
Quezon City 1101 PHILIPPINES

ABSTRACT

This paper investigates the effects of noise emitted by operating aircrafts using runway 06/24 of the Ninoy Aquino International Airport (NAIA) on communities, namely, Barangay San Dionisio and Barangay Rizal, which lie under the flight paths of the aircrafts. It presents the perceptions of respondents from the two communities mentioned on how they are affected by aircraft noise. A profile of the respondents' years of residence, occupation, sex, age and household income vis-a-vis with their perceptions on the effects of aircraft noise was also presented. Analysis showed that individuals experienced the effects of noise in varying degrees but there is a general tendency to foreground their view that they have "'gotten used"' to aircraft noise. Moreover, noise contours in the vicinity of the airport were plotted using Integrated Noise Model along with data on aircraft operations such as frequency of flights of different types of aircrafts, flight paths and weather conditions at NAIA.
Key Words: aircraft noise, noise exposure level, community reactions

1. INTRODUCTION

1.1. Background of the Study

This study emerged from the project entitled "'Aircraft Noise Survey and Assessment for the Major Airports in the Philippines"' (ANSAMAP) conducted by the U.P. National Center for Transportation Studies (UP-NCTS), commissioned by the Japan International Cooperation Agency (JICA) for the Air Transportation Office (DOTC-ATO). This project assessed noise levels in the vicinities of the Ninoy Aquino International Airport (NAIA) and the Diosdado Macapagal International Airport. For both airports, the project used one week aircraft operation, weather, and flight tracks data provided by the NAIA tower as inputs in a simulation software called Integrated Noise Model (INM). As a result, geographical maps of noise contours in the vicinities of each airport were generated, as well as estimated populations and noise sensitive establishments exposed to different noise levels.

*Correspondence to: Department of Civil Engineering, University of the Philippines Diliman, Quezon City 1101 PHILIPPINES. email: ebabaya@up.edu.ph

Received January 30, 2007
Revised May 8, 2008
Accepted December 2, 2008

This study proceeded with exploring the perception of residents on the effects of noise on the community, the results of which would partly inform the recommendations of noise abatement procedures in the area. The scope of the study includes the nearby communities, namely, Barangay Rizal in Makati City and Barangay San Dionisio in Parañaque City and a regression analysis comparing on-site measurements of noise levels using a sound meter with the measurements generated using the simulation software. Furthermore, an annual average weather data was used instead and a different noise metric, i.e., Ldn and Leq, as input data in INM. Generated results were analyzed and assessed using British Standards and standards recommended by the US Federal Aviation Administration (FAA).

A report available on-line by the Federal Aviation Administration entitled, "'Aviation Noise Effects"' contains results of studies conducted on aviation noise. Different topics are discussed such as how aircraft noise is measured, units of measurements and their respective uses, noise level-annoyance relations, effects of aircraft noise and standards used in the United States in the implementation of noise abatements to affected areas or communities. This report has been a major source of robust background on the studies and issues on aircraft noise.

Furthermore, the Office of the Scientific Assistant, Office of Noise Abatement and Control, U.S. Environmental Protection Agency (July 1981) [9] have also made available on-line a handbook "'Noise Effects Handbook"' that contains findings on the physiological effects of noise to humans and strategies to abate it. It discussed the different causes of hearing losses. It also discussed findings on researches about how noise affects quality of sleep that may affect physiological functions of people exposed to impulsive, continuing and intermittent noise. Additionally, it discussed how noise affects performance and safety whether at work or at home.

1.2. Problem Statement

It is generally recognized that it is difficult to model a relation between an individual's dosage of noise level exposure and his corresponding response or annoyance because of complex factors affecting the level of annoyance of an individual to noise. Factors such as the varying socio-cultural backgrounds and adaptive capabilities of individuals make modeling a rather difficult task. Nevertheless, this study attempts to objectively and subjectively present the effects of aircraft noise to affected communities and ways to abate it. This study therefore addresses (1) the need to assess the level of noise using the integrated noise model; (2) the need to explore the perceptions of respondents residing in two communities near NAIA regarding the effects of noise on their daily life, i.e. sleeping, hearing, communication, and moods; and (3) the need to formulate recommendations for noise abatement.

1.3. Specific Objectives

The study aims (1) to measure noise levels in the vicinity of Ninoy Aquino International Airport, (2) to create a table of noise annoyances with corresponding noise levels; (3) to formulate noise abatement procedures appropriate in the case of NAIA; and, (4) to describe statistically the factors affecting annoyance of community residents.

1.4. Significance of the Study

There is a dearth of studies on the impact of aircraft noise on communities in the Philippines. The significance of this study lies in how it provides primary information on noise emitted by aircrafts in the Philippine setting and the responses of affected populations. In particular, this study provides the necessary empirical information such as noise contour maps showing modeled noise levels in the vicinity of the airport using Integrated Noise Model (INM) 6.0, statistical information as to the kind of annoyances experienced by affected residents, and so forth. It is envisioned that such information will help in the development of noise abatement procedures appropriate in the case of Ninoy Aquino International Airport.

1.5. Limitations of the Study

The study focuses solely on noise levels in the vicinity of Ninoy Aquino International Airport affected by aircrafts using Runways 06/24. The effects of runway 13/31 are not considered due to the intermittent operations of runway 13/31 from mid-April to September 2006 which fell during the data gathering period. Noise perception surveys, likewise, were conducted only in Barangay San Dionisio and Barangay Rizal, the communities deemed most affected by aircrafts using runways 06/24.

The surveyors were asked to approximate or draw in the interview form the location of the respondent with respect to the streets and nearby roads. The researcher then located these geographical coordinates in a digital map. The coordinates obtained were needed to derive modeled noise exposure levels.

2. METHODOLOGY

2.1. Perception Survey

To prepare for the perception interviews and noise level measurements in the affected areas, coordination was done with barangay officials of Brgy. San Dionisio, Parañaque City and Barangay Rizal, Makati City two weeks before the scheduled survey and requested for security and assistance. These two barangays were chosen because they are located in areas where noise levels were observed to be high. Figure 1 shows the location (encircled) of the study area with respect to runway 06/24 of NAIA. Brgy. San Dionisio is approximately 2 kms. from the end of the runway while Brgy. Rizal is about 6 kms. away from the other end of the runway.

Prior to the perception survey, a pilot survey was conducted on May 11 and May 20, 2006. Twenty-five samples were gathered. After the survey, two questions were added: (1) How long has the respondent resided in that area; and (2) What is the overall effect of aircraft noise on the respondent. The first question was crucial in order to determine if the respondent's years of stay in the area may have influenced his response to noise. The other question was also necessary in determining the respondent's overall perception on how aircraft noise affects him/her.

The survey in Brgy. San Dionisio took place on July 29, 2006. Two surveyors were assigned to Bonifacio St. and Tramo St. (east side) and two other surveyors were assigned to Tramo St. (west side). Each team was assisted by one barangay policeman. The survey took place between 9 AM and 6 PM. Each surveyor approached a resident of a house, asked designated

Source: Google Earth Satellite Photos (Accessed on September 18, 2006)

Figure 1. NAIA Runways and Study Area (Brgy. Rizal and Brgy. San Dionisio) [7]

questions, and then noted the answers on the interview form. One hundred ninety-three (193) samples were gathered.

In Barangay Rizal, the survey was conducted on August 19, 2006 from 10 AM to 6 PM. One hundred fifty-five (155) respondents were interviewed.

2.2. On-Site Noise Level Measurement

The On-site noise level measurement (1 minute interval and per event 1 second interval) was conducted at the terrace of the Barangay Hall at Brgy. San Dionisio. This was conducted on August 29, 2006. On the previous night of August 28, the survey team arrived at the station at 10 PM and set up the instruments immediately. The per minute measure of the noise level was recorded. Variations of readings with the use of a video recorder for every takeoff and landing were also recorded. The survey duration was from 0000H to 2400H of August 29 (Saturday).

In this study, on-site noise level measurements were only conducted in the second station in Brgy. San Dionisio. The measurements for the first station in Brgy. San Dionisio, Brgy. Rizal and Moonwalk village were obtained from data of the previous study conducted by UP-NCTS.

Figure 3 illustrates the basic concepts and their relationships that will be investigated by this paper.

The study investigates the case of NAIA with respect to how aircraft noise exposure level in the vicinities of an airport is defined by factors such as the orientation of a runway, the number of aircrafts operating, the frequency of take-off, the landing and tune-ups, the time of landing, the flight path and the flight procedures. These factors affect the communities in

Source: Google Earth Satellite Photos (Accessed on September 18, 2006)

Figure 2. San Dionisio Stations [7]

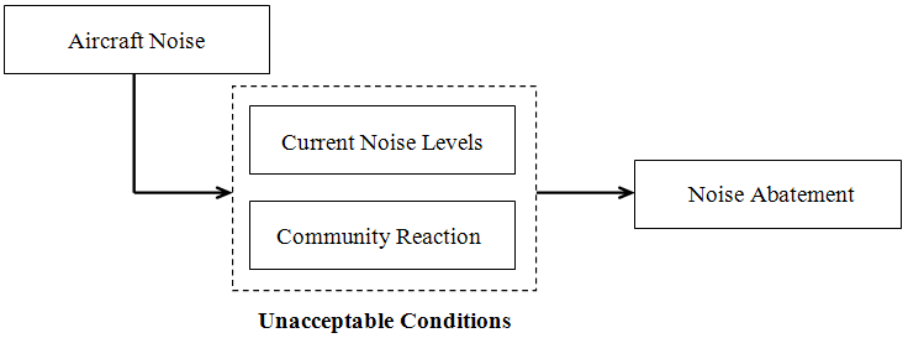

Figure 3. Conceptual Framework

terms of the daily aspects of life, i.e., mood, sleep, communication and the auditory system.

3. DATA ANALYSIS

3.1. Methodology of Noise Level Modeling

As an analyzing tool, INM (Integrated Noise Model) was used in assessing the noise exposure levels at communities in the vicinity of the Ninoy Aquino International Airport. The US Department of Transportation and the Federal Aviation Administration Office of Environment and Energy made this software. It is widely used by over 700 organizations in over 50

countries to assess changes in noise impact resulting from: (1) new or extended runways or runway configurations; (2) new traffic demand and fleet mix; (3) revised routings and airspace structures; (4) alternative flight profiles and (5) modifications to other operational procedures (INM Technical Manual, 2002) [11].

The simulation software simulates aircraft operations and computes for the different noise metrics in the vicinities of the subject airport. The airport noise environment, including aircraft operations and ambient noise, is best described using three noise metrics. These metrics are time above, exposure and maximum level (INM User's Manual, 2002) [11].

For *Exposure Metrics*, the day, evening and night multipliers and the time parameters are used as follows:

$$LE = 10\log\left(W_1E_1 + W_2E_2 + W_3E_3\right) - 10\log\left(T\right)$$

where:

LE = Noise exposure level or average noise level (dB). W_1, W_2, W_3 = Weighting factors (multipliers) for day, evening, and night time periods. These are the number of equivalent aircraft operations relative to one aircraft operation during the daytime. For example, in the DNL metric, one night-time operation is worth 10-day time operations, so the weights are $W_1 = 1$, $W_2 = 1$, $W_3 = 10$ (for DNL, the evening period is considered daytime).

E_1, E_2, E_3 = Noise exposure ratios for day, evening and night periods. These ratios are computed by INM. A-weighted or C-weighted sound exposure ratio is the time-integrated mean-square pressure, in units of $(20\mu\text{Pa})^2$s, divided by a reference sound exposure of $(20\mu\text{Pa})^2(1\text{s})$. Perceived tone-corrected exposure ratio has a reference noise exposure of $(20\mu\text{Pa})^2(10\text{s})$.

10log (T) = Ten times the base-10 logarithm of the ratio of the averaging time over a reference time. For example, for a 24-hour averaging time in seconds and a reference time of one second,

$$10\log(24 \times 60 \times 60\text{s}/1\text{s}) = 49.37\text{dB} \tag{1}$$

Day-Night Sound Level (DNL), which belongs to the cumulative energy average metrics, was developed as a single number measure of community noise exposure. It 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 (L_{eq}) defined as the energy average noise level integrated over some specified time, 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. The specified time of integration period is 24 hours but for assessing long term noise exposure, the yearly average DNL (L_{DN}) is obtained. In the assessment of noise exposure of individuals presented in this study, DNL shall be used as the metric (INM Technical Manual, 2002) [11].

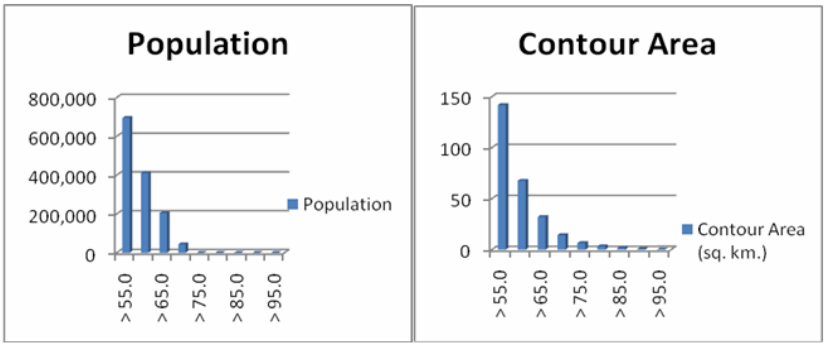

Figure 4. Population and Contour Area Exposed to Noise Levels (DNL)

3.2. Results of Modeling

3.2.1. Population points For the considered area of 6 km radius from runway 06/24, the computed population(LDN), exposed to different levels of noise is shown in Figure 4.

A population of 204,600 is exposed an L_{DN} value between 65dBA to 75dBAwhich is considered a significant exposure where noise is one of the important of adverse aspects and significant community reaction with this exposure is expected. Forty three thousand three hundred (43,300) are exposed to an L_{DN} value between 70 to 75dBA and severe community reaction is expected at this levels. Although 75dBA and above exposure levels yielded zero population, it is possible that some residents are exposed to these levels since INM computes the noise level of designated centroid of a barangay area.

Population	Exposure	Predicted Average Community Reaction	Suggested Action To Be Taken*
43,300	Significant	Severe	Insulation Required
161,300	Significant	Significant	Insulation Required
206,400	Moderate	Moderate to slight	No Insulation Required

Table I. Population with Intensity of Exposure and Predicted Community Reaction

3.2.2. Location Points (Schools, Hospitals and Churches) Figure 5 shows the number of schools, hospitals and churches exposed to different noise levels (L_{eq}). dBAL_{eq} is used as the computed metrics for these location points since the criteria that was used in the assessment of the noise levels of these are in intervals of the units mentioned. In this unit, the weighting factor for evening time (2200H to 0700H) is one.

Follows are description of noise conditions and recommended noise abatement for each case.
Exposed to 66 to 72 dBAL_{eq}

- 3 schools, most undesirable location, permitted only under special circumstances, insulation required

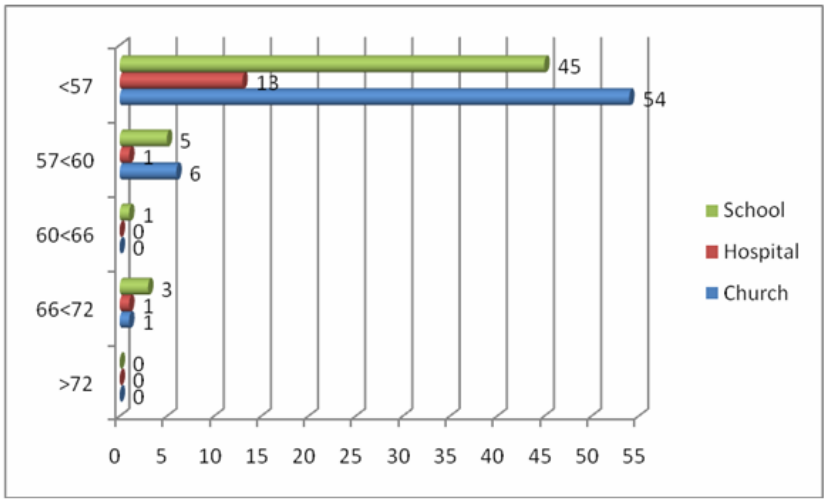

Figure 5. Location/Establishments and Noise Level (dBAL_{eq})

- 1 church location not desirable, insulation required
- 1 hospital undesirable location, insulation required

Exposed to 60 to 66 dBAL_{eq}

- 1 undesirable location, insulation required

Exposed to 57 to 60 dBAL_{eq}

- 5 schools locations permissible, insulation required
- 6 churches locations permissible, insulation required
- 1 hospital location permissible, insulation required

3.3. Affected Communities: Analysis of Data from Two Barangays

3.3.1. The practice of noise proofing The practice of noise-proofing is hardly a norm as only 4% and 2% of the respondents in Rizal and San Dionisio respectively have noise-proofed their houses using "'thick styroform"' to insulate the ceiling.

Noiseproofing	Rizal	San Dionisio
	%	%
With Noiseproofing	4%	2%
Without Noiseproofing	96%	98%
Total	100%	100%

Table II. Noise Proofing

3.3.2. Perception of respondents on what degree they are affected by aircraft noise The respondents were asked for the general effects of noise. They were asked "'In, general, how much are you affected by aircraft noise?"' and the choices are enumerated as *"'not affected, slightly affected, affected or very affected?"'.*

In both barangays, only a minority of 24% and 20% said that they were not affected by the aircraft noise. Of those who said they were affected, a high percentage of 55% in Rizal and 52% in San Dionisio expressed that they were slightly affected. Only a small percentage of 4% in Rizal and 8% in San Dionisio said they were very affected by the aircraft noise.

Those who responded "'slightly affected"' and "'not affected"' said that they have "'gotten used to it"' and "'got immuned"'. These remarks tend to suggest that these respondents have fairly adjusted to the aircraft noise. In addition, majority of the respondents are long-term residents in both areas; hence, they have developed tolerance to the recurrent aircraft noise.

The results further show the respondents in Rizal who said they were not affected reside in areas where ACR (average community reaction) is significant (7%) to severe (17%). "'Slightly affected,"' "'affected,"' and "'very affected"' respondents live in areas where the anticipated average community reaction is significant (28%) and severe (48%). A closer look at the results show that those who expressed not being affected reside in areas where the anticipated ACR is significant and severe-an obvious inconsistency in their perception and the objective NEL and its anticipated ACR; on the other hand, majority of the respondents do experience the effects of aircraft, expressed in varying degrees.

Respondents in Brgy. San Dionisio are exposed to DNL levels encompassing all anticipated ACRs. With respect to the perception of the respondents on how they are affected or not affected by the aircraft noise, 14% of those who said they were not affected live in areas where anticipated ACRs include slight and moderate to slight and only 6% live in areas where anticipated ACR is severe. Of those who said they were affected, 47% live in areas with slight and moderate to slight ACRs. Thirty three percent (33%) were in areas with significant and severe ACRs. The case of San Dionisio portrays a situation where, again, respondents who expressed not being affected were actually exposed to varying degrees of NELs with their corresponding ACRs, albeit not too severe compared to Rizal. This is consistent with the general observation that perceptions may contradict the objective impact of aircraft noise on communities.

A look at the relationship between the degree of perceived effects of aircraft noise and the numbers of years of residency of respondents in both communities show that who said that they were not affected have been there for more than five years (18% in Rizal and 20% in San Dionisio). In addition, in Rizal, those who said were not affected generally have been residents for less than a year and two years to less than 5 years (6%). For those who said were affected, majority of them have been residing there for more than 5 years (49% in Rizal and 74% in San Dionisio). A good number (12%) in Rizal have been staying for less than a year and these residents expressed that they were slightly affected and affected.

Overall, the data shows that a considerable percentage of those who are long-time residents (49% for Rizal and 74% for San Dionisio) recognize the effects of aircraft noise.

3.3.3. Specific Effects of Noise This study probes deeper into the effects of noise on the respondents in the two study areas by asking them about the specific effects of aircraft noise on the following:

- moods – refers to irritability due to aircraft noise.
- communication process – refers to interference in on-going conversation due to aircraft noise.
- sleep – refers to the interruption of sleep due to aircraft noise.
- hearing – refers to perceived impairment of the aural system due to aircraft noise.

Barangay Rizal Those who expressed that their moods are not affected at all by aircraft noise constitute 31%, who are themselves long-time residents in the area (more than five years, 24%), despite their NELs (noise exposure levels) with expected ACRs of significant to severe. Those who are seldom/sometimes become irritated by the noise comprised 40% and reside in areas where the anticipated ACR is significant to severe. In this group, 25% have been residing there for more than 5 years. Respondents who get irritated often and very often due to noise comprised 29% and 19% of whom have been living in the area for more than five years. These results suggest that the respondents have been largely putting up with the noise and its negative effects on their moods.

Communication is a vital component of social life. Noise can undermine the flow of communication. Only 14% said that noise does not disrupt conversations, and 11% of these are long time residents. Half of the respondents (50%) said that noise seldom or sometimes interferes in daily conversations, majority of whom, (35%) are not only long time residents, but also live in areas where the anticipated ACR is severe (35%). Those who said that the noise often and very often disrupts conversations (37%) have been residing in the area for more than five years where anticipated ACR is severe. Respondents have developed ways to deal with this burden. They said that they simply "'stop talking and resume when the plane has passed by."' Some respondents remarked that the passing aircraft disturbs TV and telephone signals.

Majority (55%) of the respondents are not affected by the noise while asleep and these are long time residents in which the expected ACR is severe. Those that are seldom or sometimes affected comprised 25%, slightly higher than those who said that they are affected often (21%). Interestingly, not a single respondent said noise very often affects his or her sleep. Over time, the respondents have learned to cope with this situation saying that they just "'sleep again,"' "'watch TV until one falls asleep again."' One said, "'I make it my alarm clock early in the morning, which help me prepare for work."'

Of the respondents, 66% felt that noise has not impaired their hearing. Fifty percent of the group are long time residents, living in areas with anticipated ACRs of significant and severe. Thirty three percent (33%) among the respondents expressed differing degrees of having experienced symptoms of hearing defects.

Brgy. San Dionisio Only 29% expressed not getting irritated by aircraft noise, majority of whom are long time residents in areas with anticipated ACRs of slight and moderate to slight. Like the respondents in Rizal, respondents here have expressed mood change due to aircraft noise. But, unlike those in Rizal, respondents here often and very often get irritated by the noise, despite relative low NELs. In addition, like the ones in Rizal, they are also long time residents in the area.

In terms of interference of noise in daily conversations in San Dionisio, only 5% declared that they are not at all affected, despite their having stayed in the area for more than 5 years, with

expected ACRs of significant to severe. On the other hand, despite the low degrees of NEL, a greater percentage (48%) among the respondents observed that communication is seldom or sometimes disrupted, and an almost equal percentage (47%) declared that the noise often and very often interferes with daily conversations. Among the coping strategies stated were: "'We just stop talking and repeat what we say, after the plane has passed by."' Like the ones in Rizal, they also observed that TV and audio signals are interrupted because of the passing aircraft.

Sixty three percent (63%) of the respondents have expressed varying degrees of sleep disturbances due to aircraft noise, with 40% saying that they are seldom or sometimes affected and 23% saying that their sleep is often and very often affected. Only 37 percent said that they are not at all affected. It appears that the respondents have lower tolerance for noise as their sleep gets easily disrupted by relatively lower NELs. Note also that 91% of these respondents have been long time residents in the area.

Majority of the respondents (55%) said that they do not experience symptoms of hearing defects. Objectively, these respondents are exposed to areas where the expected ACR is slight and moderate to slight (39%) and have been living in the area for more than five years (50%). Thirty three percent (33%) said that they do seldom and sometimes experience symptoms of hearing impairment and that objectively, they live in areas with anticipated ACRs of significant to severe. Twelve percent (12%) expressed symptoms of hearing impairments often and very often and are in areas where all anticipated ACRs are likely to occur. They are long term residents in the area. Quite similar to the remarks obtained in Rizal, respondents here described the symptoms of hearing defects in terms of deafening, pain in the ears, ringing in the ears. They alleviate the symptoms by taking paracetamol, covering the ears, and having an ear check-up.

4. CONCLUSIONS

A population of 43,300 is exposed to noise levels from 70 to 75dBA (L_{DN}) and 161,300 from 65 to 70 dBA(L_{DN}) due to the noise produced by aircrafts operating at the Ninoy Aquino International Airport. As summarized in Table II, these populations are significantly exposed to aircraft noise in which significant to severe community reaction is expected. Moreover, aircraft noise impacts negatively on the communities.

The Integrated Noise Model, as mentioned in its Users Guide, is designed to estimate long-term average effects using average annual input conditions. A supplemental analysis may be performed to know the seasonal variations of traffic demand, e.g., during holiday seasons.

As the study showed, respondents tend to foreground their feeling of having gotten used to the noise emitted by the aircrafts. However, further probing proved to be productive in terms of knowing the real sentiments of the respondents with respect to the effects of noise on sleep, moods, conversation, and hearing. At the same time, the study found out that in many instances their claim that they are not affected was not born out by the objective exposure to noise levels based on objective measurements in used in the study. However, it can be surmised that their expressed tolerance of noise may be due to some physiological adaptation borne out of their prolonged exposure to noise as well as their bodily attributes shaped partly by their socioeconomic status. Expressed tolerance may also be a function of the nature of the research, i.e., the research questions on the effects of noise on the community might have been regarded

as a sensitive issue that may affect their security of tenure.

True to the commonplace notion of human flexibility, this study found that the communities have developed adaptive strategies to deal with noise. But such strategies are limited to palliative measures. Very few respondents have embarked on housing insulation to minimize noise pollution.

5. RECOMMENDATIONS

The perception study has shown that although most of the residents from the two subject communities (Brgy. Rizal and Brgy. San Dionisio) responded mostly "'not affected"' or "'slightly affected"', it proved that they responded differently when asked of the specific effects of noise. So even if generally the study population appears to have adjusted to aircraft noise, it is imperative that the authorities should look into the matter. In the discussion that follows, some recommendations for noise abatement are presented. It should be noted that these recommendations are derived from noise abatement strategies applied in others countries but are believed to be applicable in the Philippine setting. In part, these recommendations are also informed by the results of this study as well as by relevant legislations promulgated by the Philippine Government.

5.1. Restrictions of Noisy Aircrafts

The International Civil Aviation Office (ICAO) recommends technical standards to limit noise and emissions from civil air transport aircrafts. Aircrafts and engines are independently assessed and certified for compliance with the appropriate ICAO standards before they enter service. Aircrafts are identified as Chapter numbers. Chapter 2 aircrafts are subsonic jet airplanes certified before October 6, 1977. Chapter 3 aircrafts are subsonic airplanes certified on or after October 6, 1977, propeller driven airplanes over 12,500 pounds (5700 kg) on or after January 1, 1985 and before November 17, 1988 and propeller driven airplanes over 2000 pounds (900 kg) certified on or after November 17, 1988. In 2006, ICAO will apply a new noise standard-Chapter for new aircrafts which are 10dB stricter than the Chapter 3 standard.

In the Philippines, it has campaigned for the reduction of Chapter 2 aircrafts. Follows is the schedule of phasing out of fleets using NAIA: Starting January 1, 2003 - airlines must start removing Chapter 2 aircraft from their fleet as follows: (Source:http://www.boeing.com/commercial/noise/ninoy.html)

- 25% by December 31, 2003
- 50% by December 31, 2004
- 75% by December 31, 2005
- 100% Chapter 3 compliance by December 31, 2006;

Due to this, concerned authorities can implement restrictions of Chapter 2 aircrafts at the start of year 2007.

5.2. Land Use Management

Careful planning and implementation of policies of land use in areas in the vicinities of airports could greatly prevent residences, schools, hospitals and churches from being subjected to

exposures to noise either subjectively or objectively. The control of the construction of these in areas with high noise levels depends mostly on the urban planners and concerned government policy makers. Implementation of land use policies requires mapping of noise contours in the vicinity of airports will provide adequate information as to what noise levels different areas are exposed to. To achieve this one can employ the use of modeling software such as the Integrated Noise Model. A comprehensive criterion for the control of development in the vicinities in conjunction with the spatial contour map generated by the recommended simulation software can also be a basis of who are eligible for insulation or soundproofing.

5.3. Insulation

Given the condition that communities have already been established, noise proofing of affected buildings is the best short term noise abatement scheme that NAIA authorities can implement. Issues of who will bear the cost will have to be settled by concerned authorities.

Innovative strategies could be employed using the concept of energy damping to economically determine the best noise proofing scheme that could be applied on affected establishments. Materials such as cork, styro foam and other materials of the same nature could be used to insulate ceilings and walls of rooms of residences, schools, churches and hospitals.

5.4. Redistribution of Aircraft Operations

By redistributing the number of aircrafts operating at Manila International Airport to nearby international airports like the Diosdado Macapagal International Airport and Subic International Airport, surely, noise levels at the vicinities of NAIA will be reduced.

5.5. Time of operations restrictions

In the computation of noise levels in the vicinities of airports, a 10 dBA penalty is imposed on flights occurring from 10pm until 7am. Therefore, a restriction in this time zone is appropriate. Implementing such policy would lessen if not eliminate flights during this time period.

5.6. Noise Abatement Flight Procedures Compliance

NAIA has been implementing noise abatement flight procedures (NAP) as stipulated in the Aeronautical Information Publication Philippines, published by the Aeronautical Information Service authorized by the Air Transportation Office under the Department of Transportation and Communications. This NAP is described at RPLL AD 2.21 (Noise Abatement Procedures).

Since noise levels depend on height and power used by the aircrafts at landing and take-off, planning in executing the NAP would reduce noise exposures beneath the flight path. For safety measures, it was mentioned that for cases when climbing performance is affected, the NAP shall be terminated and normal procedure will take effect. Notwithstanding this safety measure, aircrafts operating at NAIA should be monitored of their compliance to this NAP.

5.7. Building of New Runways

Careful planning in locating where to build airports and runways will avoid situations of affecting most populated areas. In other countries, such as Japan, some runways are located where its vicinities are water areas. This ensures that no residential and other noise sensitive

buildings are affected by aircraft noise.

REFERENCES

1. AI'S Home Improvement Center *"'Reduce Sound in your Home or Business"'*. http://alsnetbiz .com/homeimprovement/faq10.html. Date Accessed: November 5, 2006.
2. Ashford, et al., 1997. *"'Airport Operations"'*, 1997 N.Y., Mc Graw Hill, p. 57 to 88.
3. Bronze, A., 1998. *"'A Voice to End the Government's Silence on Noise"'*, Hearing Rehabilitation Quarterly, Volume 23. http://www.lhh.org/hrq/23-1/voice.htm. Date Accessed: June 15, 2006.
4. Chan/Robles Website. Local Government Code and PD 1152. http://www.chanrobles.com. Date Accessed: November 5, 2006.
5. Europäische Akademie zur Erforschung von Folgen Wissenschaftlich-technischer Entwicklungen Bad Neuenahr-Ahrweiler GmbH, 2002 (Compiled and Edited by Jorge Guerra Gonzlez). *"'Environmental Noise, Main Focus: Aircraft Noise"'*. A Conference on the Assessment and Management of Environmental Noise. http://www.europaeische-academie-aw.de/pages/publikationen/graue_reihe/36.pdf. Date Accessed: June 28, 2006.
6. Federal Aviation Administration, 1985. *"'Aviation Noise Effects"'*. Washington, DC. http://www. nonoise.org/library/ane/ane.htm. Date Accessed: June 28, 2006.
7. Google Earth Website. *Metro Manila Aerial Photos.* http://earth.google.com. Date Accessed: September 18, 2006.
8. National Pollution Control Commission, 1978. *Official Gazette.* Vol. 74, No. 23, P. 4477-4479. As provided by the Environmental Management Bureau (Air Quality), Q.C.
9. Office of Noise Abatement and Control, Office of the Scientific Assistant, U.S. Environmental Protection Agency, 1981. *Noise Effects Handbook,* A Desk Reference to Health and Welfare Effects. http://www.nonoise.org/library/handbook/handbook. Date Accessed: June 28, 2006.
10. UP National Center for Transportation Studies, 2006. *"'Aircraft Noise Survey and Assessment for the Major Airports in the Philippines"'*, A Study commissioned by the Air Transportation Office, sponsored by the Japan International Cooperation Agency. Diliman, Q.C.
11. US Federal Aviation Administration, 1999. *INM Technical Manual and User's Guide.* Washington, DC.

