AIRCRAFT NOISE ASSESSMENT IN THE VICINITY OF WATTAY INTERNATIONAL AIRPORT, VIENTIANE, LAO PDR

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Abstract: In recent years, concern over the airport noise and its surrounding communities has been spurred by a continual growth in air traffic together with urban development in close proximity to many airports around the world. This study is focusing on Wattay International Airport (VTE) in Vientiane, Lao People's Democratic Republic (Lao PDR). The aircraft noise was modeled by using the Integrated Noise Model version 7.0 (INM.7.0) in order to simulate the current and future noise levels based upon the anticipated steady increase in flight operation and larger aircrafts being brought to operate in VTE. Such forecasts are of particular importance for VTE as the number of flights is expected to grow steadily over the next decade. On-site measurements of aircraft noise were also undertaken to determine noise levels at selected points through the direction of flight tracks of VTE.

Keywords: aircraft noise, aircraft noise levels, WECPNL, Integrated Noise Model

1. INTRODUCTION

Though there has been a lot of cogitation regarding air pollution, water pollution and environmental pollution in general, there is hardly any debate against noise pollution in particular. Unwanted sound is called noise, which is defined as excessive sound. Sound is mechanical energy from a vibrating surface and is transmitted by a cycling series of compressions and rarefaction of the molecules of the material through which it passes (Chanlett, 1973). Sound can be transmitted through solids, liquids and gases. Noise pollution has been recognized as a serious health hazard, it can damage human beings, animals, and properties (Mato, 1998). The finding of a study released by the World Health Organization (WHO) in 2007 suggested that thousands of people around the world might be dying prematurely or succumbing to disease due to the insidious effects of noise exposure. The noise created by aircraft was not a major issue before 1960. However, this has rapidly changed since the introduction of commercial jet aircraft in 1959 (Ashford and Wright, 1979) which led the airport noise problem to be magnified and troublesome to control. The increasing consciousness toward this problem was caused by a combination of different factors such as the following:

- Population increasing makes more demanding and more activities including travel
- Air traffic growth makes it necessary to provide flights utilizing larger and more powerful jet aircrafts, and to expand the facilities of the airports.
- Urbanization, within the vicinity of the airport, is increasing.
- Public awareness of environmental problems is increasing in general and so is the awareness on aircraft noise

Lao PDR is a landlocked country located in the middle of the Indochinese Peninsular. There are 11 airports in the country, one capital international airport (Wattay International Airport or VTE), three regional international airports, and seven provincial domestic airports. The VTE is located around 3 km from city proper of Vientiane as a capital city of Lao PDR, which serves regional flights and operates as the central coordinator of domestic flights, is the main gateway of air traffic in the country. During the last decade (2001-2010), the international passenger traffic in the country has shown a strong growth at an annual average increase of 12%, and domestic passenger traffic has shown an annual average increase of 8%. International passenger aircraft movement at VTE continues to grow at a minimum rate of 9% per annum (Strategic Plan of Department of Civil Aviation 2010-2020 and Action Plan for 2010-2015). These percentages indicated that air traffic has been partial of national economic development in Lao PDR. On the other hand, airports can also increase awareness on environmental issues especially noise pollution.

Figure 1. Location of Wattay International Airport (VTE), Vientiane, Lao PDR

(PHOTO FROM GOOGLE EARTH, 2011)

1.1 OBJECTIVE OF STUDY

The main purpose of this study is to assess noise pollution from aircraft movements in the vicinity of the airport and apply the noise level measurement, specifically the Integrated Noise Modeling (INM) Version7.0, to investigate. Furthermore, this study is to determine the effects of aircraft-induced noise on the residents and institutions surrounding the airport such as schools, hospitals and temples. The main objectives of this study are the following:

- To investigate current noise levels due to airport operations by using INM version 7.0,
- To estimate future noise levels due to airport operations by using INM version 7.0,
- To investigate noise level in the vicinities of the airport by using Digital Noise Meter,
- To compare the noise levels between simulating by INM and conducting by Noise Meter.

2. METHODOLOGY

2.1. Integrated Noise Model (INM)

The Federal Aviation Administration (FAA) has developed the Integrated Noise Model (INM). INM is a computer program used by over 1000 organizations in over 65 countries, with the user base increasing every year. The program can be used directly to assess noise impact with different metrics for various scenarios such as new or extended runways or runway configurations, new traffic demand and fleet mix, revised routings and local airspace structures, alternative flight profiles, and modification to other operational procedures. INM is also used as a noise engine or add-on in many other models, both within and outside FAA. The Area Equivalent Method (AEM), the Noise Integrated Routing System (NIRS), and the model for Assessing Global Exposure to Noise of Transport Aircraft (MAGENTA) all use INM as their noise engine (INM 7.0 Technical Manual, 2007).

The core calculation modules of INM are based on standard documents produced by the Society of Automotive Engineers (SAE) Aviation Noise Committee (A-21). This internationally represented committee is composed of research institutions, engineering firms, aircraft and engine manufacturers, government regulatory agencies, and users of noise modeling tools. The core computation modules of INM are also compliant with other international standard documents including European Civil Aviation Conference (ECAC), International Civil Aviation Organization (ICAO). INM is relevant to the other documents such as the Procedure for the Calculation of Airplane Noise in the Vicinity of the Airports (or called SAE-AIR-1845), Method for Predicting Lateral Attenuation of Airplane Noise (or namely SAE-AIR-5662), Standard Values of Atmospheric Absorption as a Function of Temperature and Humidity (called SAE-ARP-866A), Report on Standard Method of Computing Noise Contour around Civil Airport (namely ECAC Doc 29), and Recommendation Method for Computing Noise Contour around Airports (called ICAO Circular 205) (INM 7.0 User's Guide, 2007). INM is designated to estimate long term average effects using average annual input conditions. Because INM is not a detailed acoustics model, differences between predicted and measured values can occur sometimes because important local acoustical variables are not averaged, or because complicated physical phenomena are not explicitly modeled. The use of INM in the computer-based noise modeling not only gives the noise exposure level based on current flights operations, but also allows for prediction of future noise level due to the projected growth in the flight operations. This is particularly useful for a rapidly growing city as Vientiane. When the calculations are made in a consistent manner, INM is a valuable tool comparing the difference of noise level from anticipated changes in the flight operations or/and urban development in close proximity to the airport location. Such forecasts are of particular importance for the VTE as the number of flight operations is expected to increase over the next few decades, together with a strong urban growth for the sides of VTE.

The noise metrics computed by INM are associated with three fundamental groups or metric families (INM 7.0 Technical Manual, 2007) as the following:
A-weighted decibels (dBA) are an expression of the relative loudness of sound in air as perceived by the human ear. In the A-weighted system, the decibel values of sounds at low frequency are reduced compared with un-weighted decibels, in which no correction is made for audio frequency. This weighting provides a good approximation of the response of the human ear, and correlates well with an average person's judgment of the relative loudness of a

noise event.

C-weighted decibels (dBC) are intended to provide means of simulating human perception of the loudness of sounds above 90 decibels, and are more prominent at low frequencies than A-weighting

The last family of noise metrics is based on tone-correlated perceived noise levels. Tone-correlated noise levels are used to estimate perceived noise from broadband sound sources, such as engine of aircrafts, which can have tonal qualities.
There are many noise metrics available in INM, CEXP, CNEL, DDOSE, DNL, EPNL, LAEQ, LAEQD, LAEQN, LAMAX, LCMAX, NEF, PNLTM, SCREEN, SEL, TALA, TALC, TAPNL and WECPNL. Weighted Equivalent Continuous Perceived Noise Level or WECONL was used in this study to monitor the continuous exposure to long-term noise, WECPNL has been widely used in the world to measure aircraft noise. WECPNL is to investigate the continuous exposure to long-term noise of multiple aircraft. WECPNL is defined with the following simplified formula:

$$L_E = 10\log(W_d E_d + W_e E_e + W_n E_n) - 10\log(T)$$

Where:

- L_E: Noise exposure level (dB)
- W_d, W_e, W_n: Weighting factors for day, evening and night time period (7am-7pm; 7pm-10pm and 10pm-7am respectively) which one nighttime operation is worth 10 day-time operations and one evening operation is worth 3 daytime operations, so the weights are $W_1 = 1$, $W_2 = 3$, and $W_3 = 10$.
- E_d, E_e, E_n: Noise exposure ratios for day, evening and night time period
- 10 log(T): The ratio of the averaging time over a reference time.

The WECPNL values are served as criteria in order to mitigate aircraft noise and it would be considered as significant effecting if WECPNL higher than 70 dB, show as the following (Sigua, 2006)

- Area with WECPNL value, higher than 70 would require soundproofing for school and hospital
- Higher than 75 would require soundproofing for housing;
- Higher than 90 would require relocation for housing and higher than 95 would require green belt buffer zone.

2.2. INM Data Input

Data input to the INM includes runway coordinates, flight tracks, flight operations, types of aircraft, and flight profiles. INM computes the overall annual average daily noise exposure at a point on the ground around the airport. All the pertinent airport information was collected, including airport designations, runway identifiers and their coordinates, airport elevation and reference temperature.

2.2.1. Flight Tracks

The total tracks for arrival and departure is six. The tracks used depend on the origin and destination of the flights. The track to the East is named ALPHA, which is used for flights to/from Sepon of Savanakhet province. The tracks to the Northeast are named NOHET and TAGON. The NOHET track is used for flights to/from Hanoi (Vietnam) and Nanning (China), while the TAGON track is used for flights to/from Xiengkhouang, Samnuea province (Laos) and Kunming of China. The track to the North is named LUANGPHABANG, which is used for flights to/from Luangphabang, Luangnamtha, and Oudomsay province (Laos). The track to Northwest is named ANBOK, which is used for flights to/from Houysay (Laos). The track to the Southwest is named CHUMPHAE which is used for flights to/from Bangkok (Thailand), Kuala Lumpur (Malaysia), Phnom Penh (Cambodia), Savannakhet and Pakse province (Laos).

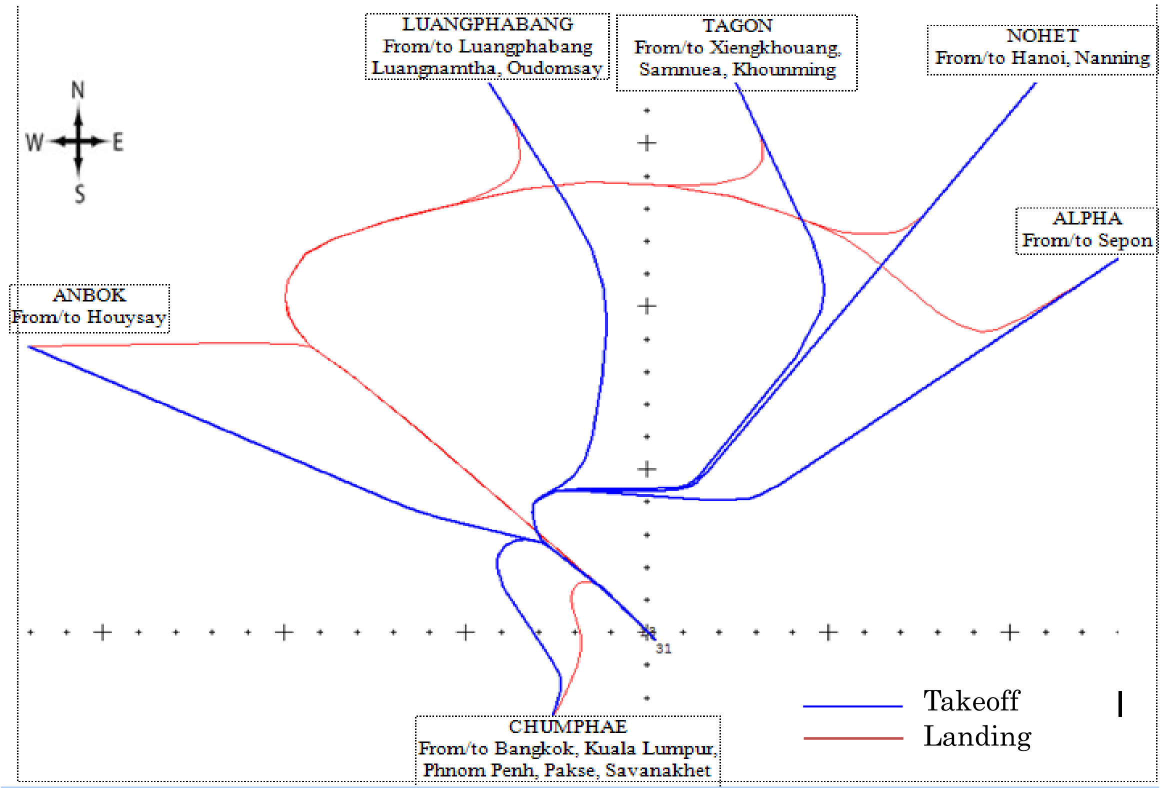

Figure 3.2.1. Flight Tracks of Aircraft operating at VTE

2.2.2. Flight Operations

Based upon actual records of flight operation at the VTE in the baseline year 2011, it was possible to identify the fleet mix and to calculate the average daily flights and type of operation, including arrival/departure time and track, for each type of aircraft. The ATR 72 had the greatest share in flight operations of the 6 types of aircraft serving the airport, followed by the CNA208, MA60, Airbus A320, Boeing 737-400, and CRJ respectively. Aircraft operations at VTE were recorded from respective air traffic control towers (ATCT) for a week. An aircraft operates periodically on a weekly basis, this one week average daily operations would give a good estimate of the annual daily average operations of aircrafts in VTE. The data on flight numbers, runways used, dates and times of arrival and departure, aircraft types, and origins and destinations were collected. These were processed for day, evening, and nighttime which expresses the time periods of 07:00-19:00, 19:00-22:00, and 22:00-07:00 respectively.

Table 3.2.2.1. Flight Volume for a week in VTE

TRACKS	DEP	A320			ATR-72			B734			C208			CRJ			MA-60		
	APP	D	E	N	D	E	N	D	E	N	D	E	N	D	E	N	D	E	N
ALPHA	APP	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
NOHET	APP	8	2	0	5	0	0	0	0	0	0	0	0	3	0	0	1	0	0
LUANGPABANG	APP	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	8	0	0
TAGON	APP	3	0	0	12	0	0	0	0	0	3	0	0	4	0	0	0	0	0
ANBOK	APP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
CHUMPAE	APP	12	3	0	40	0	0	7	7	0	0	0	0	7	0	0	8	0	0
ALPHA	DEP	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
NOHET	DEP	8	2	0	5	0	0	0	0	0	0	0	0	0	1	2	1	0	0
LUANGPABANG	DEP	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	8	0	0
TAGON	DEP	3	0	0	10	2	0	0	0	0	3	0	0	4	0	0	0	0	0
ANBOK	DEP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
CHUMPAE	DEP	14	1	0	35	5	0	7	5	2	0	0	0	7	0	0	8	0	0

Table 3.2.2.2. Flight Operation

TRACKS	DEP	A320			ATR-72			B734			C208			CRJ			MA-60		
	APP	D	E	N	D	E	N	D	E	N	D	E	N	D	E	N	D	E	N
ALPHA	APP	0	0	0	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0	0
NOHET	APP	1.1	0.3	0	0.7	0	0	0	0	0	0	0	0	0.4	0	0	0.1	0	0
LUANGPABANG	APP	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0	1.1	0	0
TAGON	APP	0.4	0	0	1.7	0	0	0	0	0	0.4	0	0	0.6	0	0	0	0	0
ANBOK	APP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0
CHUMPAE	APP	1.7	0.4	0	5.7	0	0	1	1	0	0	0	0	1	0	0	1.1	0	0
ALPHA	DEP	0	0	0	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0	0
NOHET	DEP	1.1	0.3	0	0.7	0	0	0	0	0	0	0	0	0	0.1	0.3	0.1	0	0
LUANGPABANG	DEP	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0	1.1	0	0
TAGON	DEP	0.4	0	0	1.4	0.3	0	0	0	0	0.4	0	0	0.6	0	0	0	0	0
ANBOK	DEP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0
CHUMPAE	DEP	2	0.1	0	5	0.7	0	1	0.7	0.3	0	0	0	1	0	0	1.1	0	0

2.2.3. Meteorology Conditions

Meteorological data, such as temperature, barometric pressure, humidity and wind speed, were recorded from the Department of Meteorology and Hydrology at the station in Vientiane during the measurement of the actual noise level at the VTE. The daily and weekly averages of meteorological conditions were calculated and shown in Table 3.2.3.

Table 3.2.3. Meteorological data during noise survey at VTE

Meteorological conditions								
mm/yy	Pressure (hPa)	Temperature (ºC)			Wind Speed (m/s)	Humidity (%)		
		Min	Max	Ave		Min	Max	Ave
Jul-10	985.9	24.8	32.2	28.5	9.0	66.0	95.0	80.5
Aug-10	985.8	24.2	30.6	27.4	5.0	71.0	96.0	83.5
Sep-10	987.5	24.3	32.4	28.4	25.0	66.0	95.0	80.5
Oct-10	988.8	23.6	30.8	27.2	25.0	61.0	92.0	76.5
Nov-10	992.0	20.2	30.2	25.2	23.0	47.0	86.0	66.5
Dec-10	990.7	18.8	28.8	23.8	19.0	51.0	91.0	71.0
Jan-11	993.5	16.3	27.3	21.8	12.0	51.0	88.0	69.5
Feb-11	989.8	19.9	30.9	25.4	8.0	45.0	88.0	66.5
Mar-11	991.7	20.3	29.2	24.8	6.0	50.0	84.0	67.0
Apr-11	988.9	24.2	33.6	28.9	12.0	50.0	85.0	67.5
May-11	986.5	25.0	32.9	29.0	5.0	61.0	93.0	77.0
Jun-11	983.7	25.5	31.7	28.6	19.0	67.0	94.0	80.5
Average	988.7	22.3	30.9	26.6	14.0	57.2	90.6	73.9

Source: Dept of Statistic, Vientiane, Lao PDR

2.2.4. Covered Institution

The VTE is located in the Sikhottabong district which is a really populated area along the highway No.13. to the west of runway includes the villages of Akad, Sikay, Kaoloia, Sisomxuean, Nongniao, Thonhpong, Nongteang. To the east is covered by empty places or rice paddies. However, these kinds of areas tend to be crowded in the near future. The area surrounding the end of runway is occupied by villages of Vattaynoy, Vattayyai, Dongpasak, Nakham, Oupmouang, Xangchieng, Nongduang, Sitaantay, and Sitaannuea, and some institutions. Mapinfo was used to determine the areas located within a 5-km radius from the center of runway, which covered 57 villages belonging to 3 districts, namely, Sikotthabong, Chanthabouly, and Saythany. The number of households is available at the Department of Statistic (DoS). Based on an actual survey, the number of schools, hospitals and temples that belong to the covered villages are shown in Table 3.2.4.

Table 3.2.4. Institution distribution within 5-km radius from VTE

Institutions	Districts			Total
	Chantabouly	Sikhottabong	Nasaithong	
Villages	5	51	1	57
Households	2,053	16,129	148	18,330
Schools	7	59	1	67
Hospitals	0	6	0	6
Temples	6	37	0	43

2.2.5. Population Points

Initially, a 5-km radius from center of the runway of VTE was set to determine the covered villages in the vicinity of VTE. The population data as of the 2005 census was used to approximate the population of the bounded villages. Population data is provided by LSB. The district distribution of the villages covered and their population for the year 2005, with the estimated population for 2010, are shown in the table below:

Table 3.2.5. Villages and population distribution within 5-km radius of VTE

No.	Districts	No. of Villages	Population
1	Chantabouly	5	11,855
2	Sikhottabong	51	96,829
3	Naxaythong	1	893
Total		57	109,577

2.3. On-site noise level measurements

Two units of Digital Sound Level Meter Decibel Logger 40~130 dB USB were set up to gather the actual noise level for this study. This meter is an instrument used to measure sound pressure level (SPL) in decibels that can be used as data logger to record noise data into the computer or other storages through USB. This meter is featured with a wide measuring range of 40-130 dB, bar graph indication, A/C frequency weighting, Fast/Slow and maximum hold function. The meter also provides a windscreen to filter out unwanted signal. Actual noise measurement was conducted to investigate the actual noise levels. Materials used for the on-site measurements were sound meters (2 units), laptop computers (2 sets), and USB extension cables (2 sets). The sound meter units were set up and connected to the laptop computers to record the sound pressure level, real time and date of measurement. The measurements were conducted at 06:00-22:30 on June 24, 2011-June 30, 2011. The time when the measurements were recorded is the time of aircraft operations at VTE. Nakham and Nongniao villages were chosen to be the locations where the actual measurement will be conducted. The coordinates of Nakham Station is 17.97396N, 102.58795E, and Nongniao is 18.00659N, 102.54388E.

Figure 3.3. Stations of On-site Measurements

(PHOTO FROM GOOGLE EARTH 2011)

3. RESULTS AND DISCUSSION

The guidelines of Lao PDR are set at the level of the lower adverse health effects. An effect refers to any temporary or long-term deterioration in physical, psychological or social functioning that is associated with noise exposure.

Table 4.1. Criteria of Lao PDR for environmental noise

Applied Area	Standard values (dB)		
	06:00-18:00	18:00-22:00	22:00-06:00
Quiet areas: hospitals, treatment places, schools, libraries	50	45	40
Residential areas: hotels and houses	55	55	45
Commercial and services areas	70	70	50
Small industrial factories located in residential areas	70	70	50

Source: Prime Minister's Office, Water resource and Environment Administration, Lao PDR

3.1. INM Results

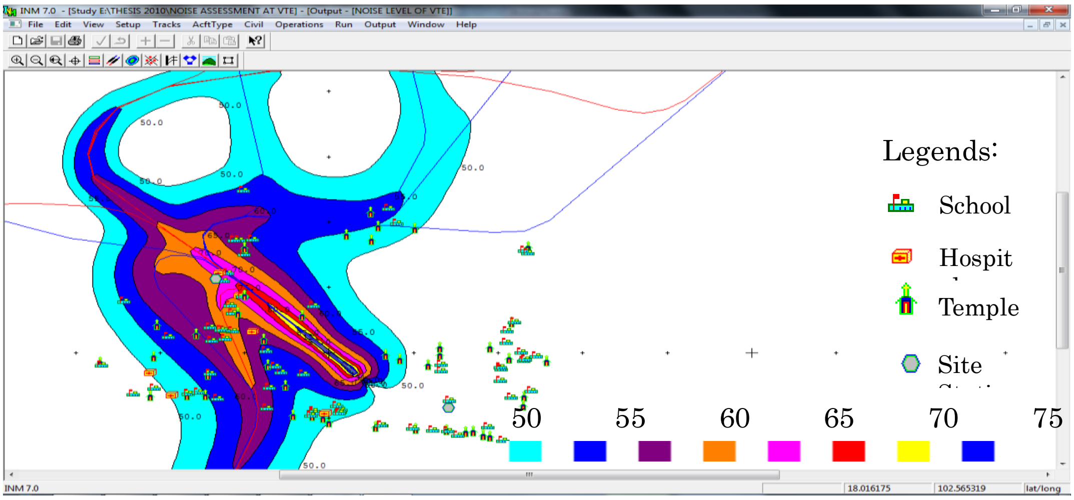

Figure 4.1. Institution distributions on the noise contours at VTE

Table 4.1.1 shows the population distributed, 4529 residents were exposed by WECPNL levels of 70-75 dB which considered as significant affected. The result showed that there were no respondents affected by noise level higher than 75 dB. However, it was possible that there were some residents exposed by noise greater than 75 dB. Although, the result was zero in such levels since the simulation computes the noise level from a single point of the assigned community. Otherwise, the noise level results from that point presented the noise levels through such communities. Table 4.1.2 below shows exposed institutions such as schools, hospitals and temples to different levels of noise. The results showed that there was no institution in noise level of higher 75 dB. However, 3 schools, 2 hospitals and 2 temples were located in areas with noise levels of 70-75 dB which is considered as significant impact, and soundproofing should be installed to these institutions. There were 39 schools, 3 hospitals and 32 temples were not affected by aircraft noise, or having values less than 55 dB.

Table 4.1.1. Population distribution on the noise contours at VTE

WECPNL (dB)	Population	Area (sq.km)
50-55	55821	79.911
55-60	35129	35.323
60-65	117796	17.092
65-70	7435	7.335
70-75	4529	3.137
75-80	0	1.337
80-85	0	0.559
85-90	0	0.213
90-95	0	0.093

Table 4.1.2. Affected institutions by various WECPNL

WECPNL (dB)	Schools	Hospitals	Temples
<50	29	0	19
50-55	10	3	13
55-60	11	0	5
60-65	8	1	3
65-70	6	0	1
70-75	3	2	2
75-80	0	0	0
80-85	0	0	0
85-90	0	0	0
Total	67	6	43

4.2. Result from on-Site Measurements

On-site measurements from June 24-30, 2011 were summarized in three time periods: daytime, evening and nighttime periods (7am-7pm, 7pm-10pm and 10pm -7am respectively).

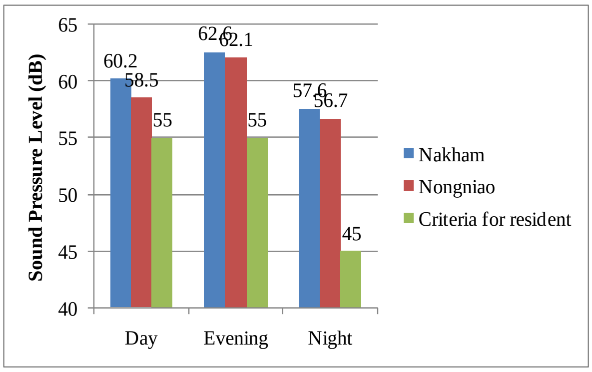

Figure 4.2.1. Friday, June 24, 2011

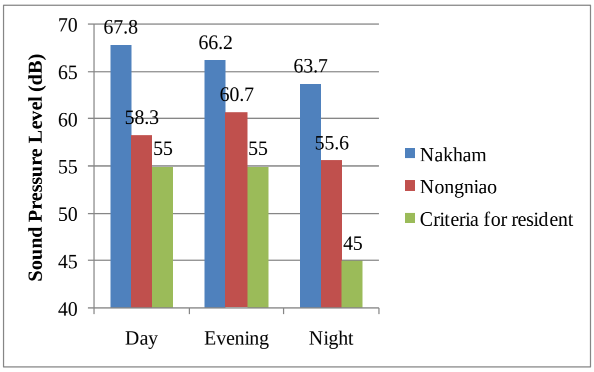

Figure 4.2.2. Saturday, June 25, 2011

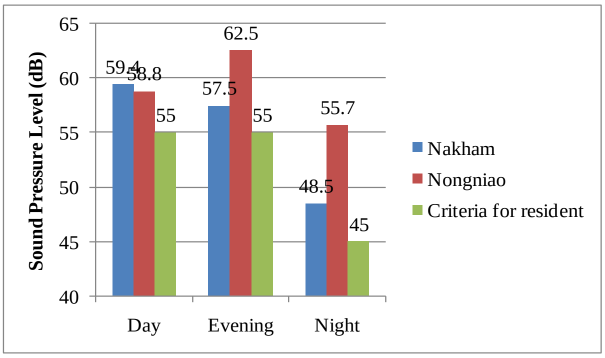

Figure 4.2.3. Sunday, June 26, 2011

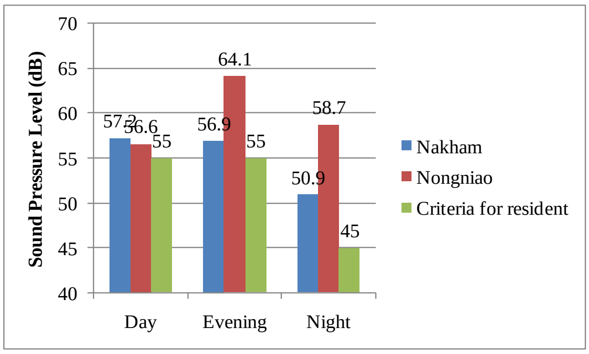

Figure 4.2.4. Monday, June 27, 2011

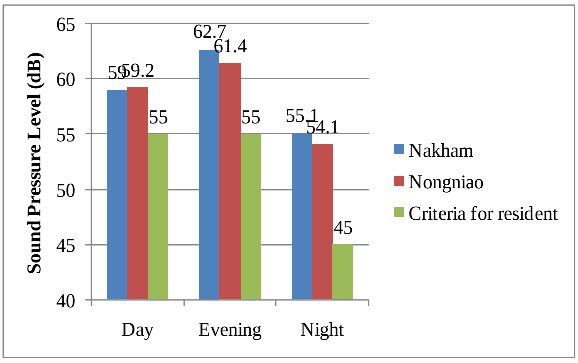

Figure 4.2.5. Tuesday, June 28, 2011

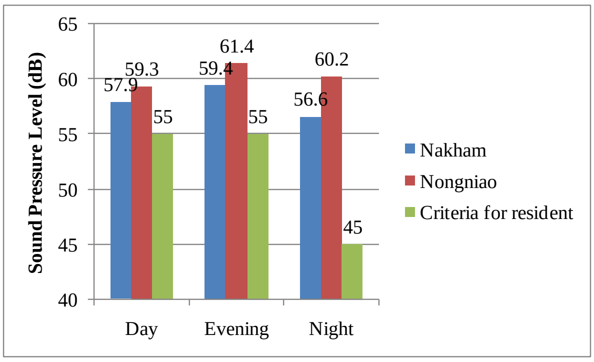

Figure 4.2.6. Wednesday, June 29, 2011

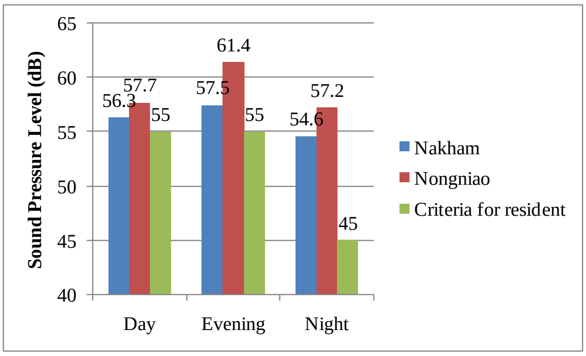

Figure 4.2.7. Thursday, June 26, 2011

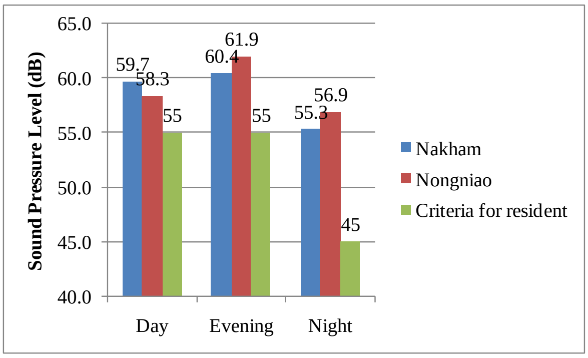

Figure 4.2.8. Monday, June 27, 2011

4.3. Comparison between model (INM) and on-site measurements

From the results of LAeq (A-Weighting Equivalent Sound Level) from the INM, it was computed that the noise levels from the data sets, including airport description, flight operations, meteorological conditions, etc., where data was recorded for a week, would be assumed as annual data for the INM input in order to generate the noise levels. This is then compared with the actual conditions from onsite measurements using the Digital Sound Level Meter Decibel Logger 40~130 dB USB, during flight operation of VTE. The table below shows the noise levels from INM and on-site measurement on Nakham and Nongniao Stations.

Table 4.3. Comparison of model (INM) and on-site measurements

Stations	Method of measurement	
	INM Simulation (LAeq)	On-site measurement (LAeq)
Nakham	24 (dB)	58.4 (dB)
Nongniao	54.2 (dB)	59.1(dB)

The results showed that there were noise values of different levels on both stations. In station Nakham, the result from INM simulation was only 24 dB, which was much lower than the on-site measurement of 58.4 dB. There was no flight path passing Nakham but due to safety and environmental problems the government allowed to land or takeoff on the Nakham. Moreover, the result from INM simulation on Nongniao station was 54.2 dB which was slightly lower than the result of on-site measurement of 59.1 dB. This might be due to the INM computation which was only for aircraft noise. On-site measurement was not only effected by aircraft noise but also effected by other sources of noise such as motor vehicle passing or activities on the ground around the station.

4. NOISE LEVEL ESTIMATIONS UNTIL 2020

The transportation policy of the government has established the transport system to be the central transit of the region to promote international commercial, tourism and investment. Therefore, the government has revised lateral air travel agreements with Russia, China, Vietnam, Cambodia, Thailand, Singapore and Malaysia. The Lao PDR has signed lateral air transport agreement with Hong Kong, South Korea, Japan, the USA, France, India, the United Arab Emirates, the Philippines, Turkey and others. In addition, the government has signed the multilateral air traffic agreements with the European Union.

4.1. Assumption

Expectations from these agreements indicate that air traffic volume will be increasing, and larger planes will also be brought to operate in VTE. On the other hand, the growing demands invisibly bring environmental problems, particularly noise issue to the airport and its vicinity. Therefore, this study estimated the possible noise levels that occur in VTE and its surrounding areas over the next decade, and the noise level estimations were simulated for 2015 and 2020. The estimation assumed that growth rate was constant from the last 10 years (an average of 10%), and assumed that larger aircrafts, such as A321 and A300, being brought to operate in VTE from 2015, bound for the countries that have signed an agreement with Lao PDR. For population and location points were assumed to be as the same as current conditions. The population was estimated until 2020 by Department of Statistic, it is increasing by 6.89% for 2011-2015 and 6.56% for 2015-2020

4.2. Results

The results indicated that the growth of flight operations and bringing larger aircrafts to operate in VTE significantly influenced the noise levels in the airport and its vicinity. It is found that the area of noise contours was increased from 2011(Figure 5.2.). It can be noticed that more institutions were covered by higher noise contours. Additional three schools were exposed by noise level of 75-80 dB which were not covered by noise contours of such levels in 2011. Moreover, the number of affected population also increased as shown in the Table 5.2.1 and 5.2.2.

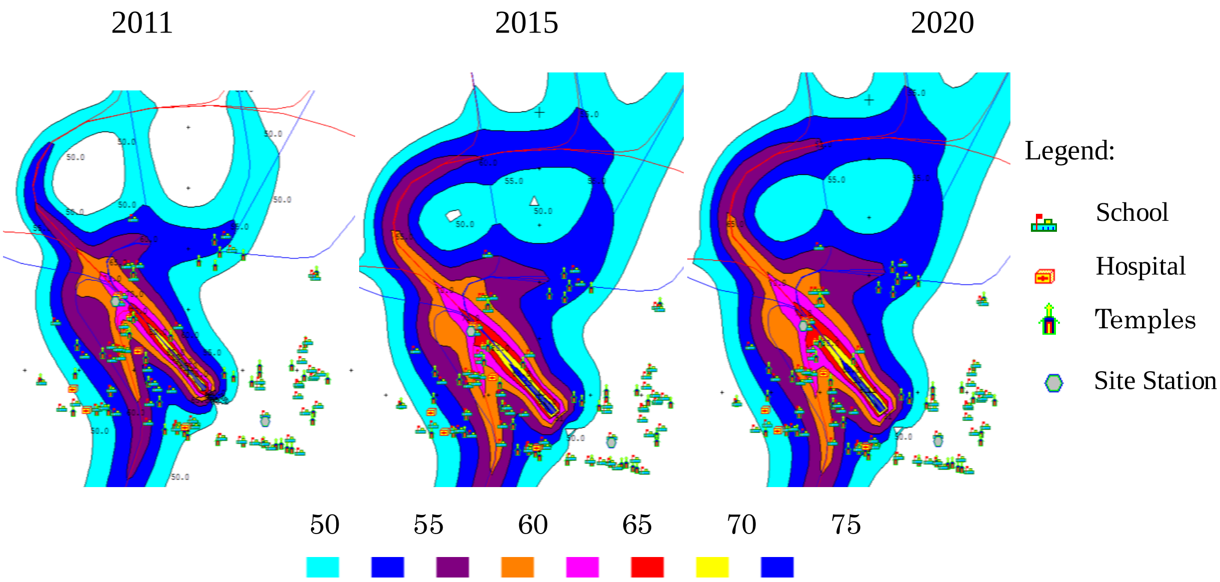

Figure 5.2. Noise Levels at VTE in 2011, 2015 and 2020

Table 5.2.1. Aircraft noise affects to institutions in 2011-2020

WECPNL (dB)	Schools			Hospitals			Temples		
	2011	2015	2020	2011	2015	2020	2011	2015	2020
<50	29	28	28	0	0	0	19	18	17
50-55	10	1	1	3	2	2	13	5	4
55-60	11	14	14	0	1	1	5	11	11
60-65	8	8	8	1	0	0	3	4	6
65-70	6	8	8	0	1	1	1	2	2
70-75	3	5	5	2	0	0	2	1	1
75-80	0	3	3	0	2	2	0	2	2
80-85	0	0	0	0	0	0	0	0	0
Total	67	67	67	6	6	6	43	43	43

Table 5.2.2. Affected population and noise contour area in 2011-2020

WECPNL (dB)	Population			Area (sq.km)		
	2011	2015	2020	2011	2015	2020
50-55	55821	63611	72163	79.911	149.10	155.71
55-60	35129	55592	59237	35.323	71.583	76.295
60-65	117796	29373	35926	17.092	31.416	33.695
65-70	7435	19022	20269	7.335	13.951	14.934
70-75	4529	7947	8468	3.137	6.041	6.475
75-80	0	0	0	1.337	2.784	2.958
80-85	0	0	0	0.559	1.197	1.269

5. CONCLUSIONS AND RECOMMENDATIONS

The aircraft noise was investigated by using Integrated Noise Model (INM) version 7.0 based on actual records of flight operations at the airport baseline for a week which was assumed as an estimation of the annual daily average operation of aircraft operating. The results found that, a population of 4529 is exposed to noise levels of 70-75 dB (WECPNL) which was higher than the recommended limits causing annoyance and constituting gross health risks. The results of noise predictions revealed that the noise levels were also increasing in order to anticipate growth of flight operations and larger aircrafts being brought to operate in VTE over the next decade. Extensive on-site measurements were undertaken in Nakham and Nongniao Station to conduct the actual noise levels in the vicinities of VTE. It is found that the noise levels on both sites were slightly higher than recommended limits based on criteria of Laos. Qualitative comparison revealed that the INM modeling is indeed capable of providing some data for noise abatement procedures as to judging the extent to which the various locations are affected by aircraft noise.

Not only civil aircrafts are operated in VTE. Military aircrafts are also the main sources of noise especially during run up and low flying. The main sources of aircraft noise are during takeoff and landing, however the effect of noise due to taxiing, run-up and low flying can be considered for future studies. The effect of aircraft noise on the wildlife species around VTE can also be considered for future studies.

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