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How should acoustics adapt to meet future demands?

The relationship between civil aircraft noise and community annoyance near Dubai International Airport (UAE)

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ABSTRACT

According to ACI traffic statistics for 2002, Dubai International Airport is the second fastest growing airport in the world. In 2007, it catered to more than 36 million passengers, with approximetly 1000 daily flight events, including take off and landing. In this paper we report the first assessment of community annoyance caused by civil aircraft noise exposure in 9 sites around Dubai International Airport (United Arab Emirates). Our aim is to assess the relationship between aircraft noise levels and annoyance responses in Dubai. To accomplish our goal, we have adapted the WECPNL and L_{dn} as the aircraft noise indices in Dubai, and the percentage of %HA have been used to assess the dose–response of aircraft noise. The %HA was obtained using social surveys that were carried out in 9 sites within close proximity of the airport using the ISO/TS 15666, 2003 questionnaire. Subjects were randomly selected ranging between 20 and 65 years in age. Results show that 41% of the respondents said that they are Highly Annoyed; a percentage considered high, but in agreement with similar studies done near major airports in other countries.

INTRODUCTION

The number of air passengers is predicted to grow by 4.3% until the year 2015 [1], [2]. As a result the number of flights continues to increase especially in developing areas such as the city of Dubai, United Arab Emirates (UAE), which is considered as the second fastest growing airport in the world. The airport handles close to 1000 daily events, including take off and landing [3,4], which are distributed throughout the day and night, see Table 1, with approximately the same number of landings and take-offs. Such high volume of events, consequently led to an increase in the noise pollution in the vicinity of the airport. This raised concerns about the adverse health effects on people living the areas close to the airport. Several organizations such as the World Health Organization (WHO), [5] reports that exposure to high noise level lead to induced hearing impairment; interference with speech communication and performance; sleep disturbance; and cardiovascular and physiological effects. The latest of these studies is that of the Hypertension and Exposure to Noise Near Airports (HEYNA), which assesses the relationship between exposure to noise generated by aircraft and road traffic near airports and the risk of hypertension [6]. The study found statistically significant effects on blood pressure due to aircraft noise.

Table 1: Traffic at Dubai International. This was taken from the arrival departure tables from Dubai International Website over a 7 day period [4].

Time of Day	Average Number of Flights
7:00 – 19:00	260
19:00 – 22:00	105
22:00 – 24:00	80
00:00 – 07:00	200

The number of individuals exposed to aircraft noise is hard to estimate, but it is safe to say that a good number of houses are within the airport vicinity, where the noise levels in these areas produce L_{dn} values of 65 dB(A) or higher. These values are higher than 57 dB(A), which is considered to cause high percentage of community annoyance [7]. It should be noted that L_{dn} is the parameter used as an indicator of the onset of what is referred to as "community annoyance" by the 1985 study, which showed a good correlation between this figure and annoyance. In Dubai, the airport is situated in the heart of the city; see Figure 1, with commercial as well as residential houses in some areas within a few hundreds of meters from the runway.

In this paper, we report the results of the first phase of an extensive study aiming at studying the effect of aircraft noise in the vicinity of Dubai International Airport. The study started in August 2007 and is composed of two phases. In the first phase we use an integrated sound level meter to measure the noise levels at 9 sites near the airport, with aim of instigating 13 more sites by the end of 2008. In the second phase, we assessed the annoyance level by means of social and socio-acoustic surveys. The questionnaire used in the survey is the ISO\TS 15666-2003 (ISO Store Order #: 924549) [8]. The sites were chosen in areas close to the airport with more emphasis on residential neighborhoods.

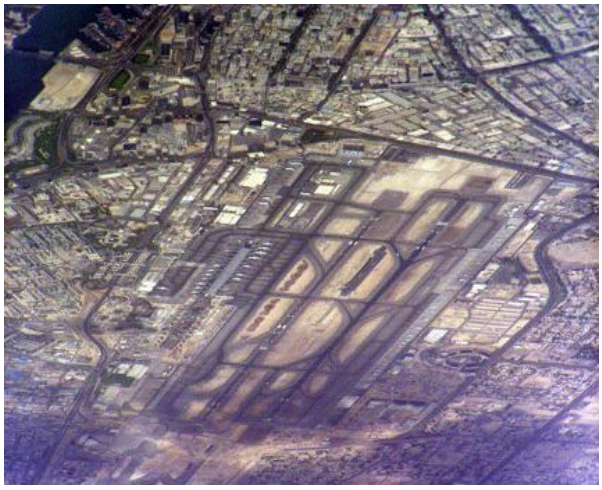

Figure 1: an aerial view of Dubai International. Courtesy of: http://commons.wikimedia.org/wiki/Image:Dubai_Airport.jpg

MATERIALS AND METHODS

I. NOISE MEASUREMENT

As reported previously [9], a commercial portable integrated sound level meter was used to measure the noise level, which is an instrument that responds to sound in approximately the same way as the human ear and which gives reproducible measurements of sound levels [10]. For example, a constant sound level of 57dBA indicates that the average noise produced by the source over the measurement period, which ranges from 1 to 24 hours, is 57dBA. The meters were placed either on roof tops or in an area clear of any obstacles. The meter was mounted on a tripod 1.5 m above the ground level and at least 3 meters away from any reflecting surfaces. Since the airport is quite busy throughout the day and night, measurements were performed at different times during the day and night. To confirm reproducibility, measurements were repeated at least three different times during the week.

To analyze community response to aircraft noise around the airport, we used the Weighted Equivalent Continuous Perceived Noise Level (WECPNL), which is given by the following expression [11]:

$$\mathrm{WECPNL} = [\mathrm{dB(A)}]_{ave} + 10\log_{10}(N) - 27 \qquad (1)$$

Where [dB(A)]ave stands for the energy mean of all peak levels of any day, and N = N2 + 3N3 + 10(N1+ N4), where N1 is the sum of the number of aircraft between 0:00 a.m. and 7:00 a.m.; N2 is the number of aircraft between 7:00 a.m. and 7:00 p.m.; N3 is the number of aircraft between 7:00 p.m. and 10:00 p.m.; and N4 is the number of aircraft number between 10:00 p.m. and 12:00 p.m. In addition to WECPNL, we have also calculated the Day-Night Average Sound Level (L_{dn}), which is given by the expression [see for example 11,12],

$$L_{dn} = 10\log\left[\frac{15}{24}\times 10^{0.1\times L_{day}} + \frac{9}{14}\times 10^{0.1\times (L_{night}+10)}\right] \qquad (2)$$

L_{dn} represents the average noise level over a 24 hour period, with a 10 dBA "penalty" in the night time hours (10 p.m. to 7 a.m.) to account for the fact that people typically find noise more disturbing at night while they are trying to sleep. The L_{dn} descriptor is useful for measuring the impacts that road noise might have on a use that may be constantly occupied such as a home. Both WECPNL and L_{dn} were used to assess the relationship between annoyance and public response.

II. SOCIAL SURVEY

For each selected site, an average of 23 subjects were selected randomly within 100-150 meters from the site. The questionnaire included questions about the demographics, noise annoyance, interference with daily activities and psychological as well as physiological health related problems, and general reaction to aircraft noise. We have sued the scale developed by ISO/TS 15666, 2003 questionnaire [8], which used a scale from 0 to 10, ranging from "Not annoyed at all", slightly annoyed, moderately annoyed, very annoyed or "extremely annoyed". The questionnaire was available in Arabic and English and it was left up to the randomly selected subjects to choose the language.

It should be noted that subjects were chosen randomly with no prior knowledge of the questionnaire. Subjects must have lived in their property for at least 12 months. The interviews were done face-to-face and for those who were not available, we came back to interview them on a different day. Many subjects raised questions about the purpose of the questionnaire and it was made clear to everyone that it is a research study, which will be published, but has no implication on improving or reducing the noise level. Subjects were selected with preference to language spoken and everyone was given the choice to take the questionnaire in Arabic or English. The questionnare is composed of three parts including a general part, which documents the number of the site, and date and noise level reading. Part two includes questions about the demographics for each respondent. Part three included the following question:

Thinking about the last 12 months or so, what number from zero to 10 best shows how much you are bothered, disturbed, or annoyed by aircraft noise?

بالتفكير في 12 شهور الماضية ، ماهو الرقم (من صفر الى 10) الذي يصف مدى انزعاجك أو مضايقتك أو اضطرابك بالضوضاء الناتجة من حركة الطيران بمطار دبي؟

0	1	2	3	4	5	6	7	8	9	10
Not at all annoyed		slightly annoyed		moderately annoyed		very annoyed			Extremely annoyed	

0	1	2	3	4	5	6	7	8	9	10
غير منزعج		منزعج قليلا		منزعج نوعا ما		منزعج جدا			منزعج الى ابعد حد	

RESULTS AND DISCUSSION

The respondents were demographically distributed as follows: 27% female and 83% males. 43% ranged from 20 to 40 years of age, 42% were 40-60 years of age and the remaining 15% were above 60 years of age. 86% of the interviewees were married and have children, which is a reasonable number considering the conservative Islamic nature of the society of the United Arab Emirates. The results to the annoyance scale question are summarized in Table 3.

Table 3: Response to questionnaire

13%	15%	31%	41%
Not at all annoyed	slightly annoyed/ Moderately annoyed	Very annoyed	Extremely annoyed

WHO recommends to take the percentage respondents who felt highly annoyed (%HA) as an indicator to support health effects of noise (annoyance) and its adverse health effects [5,

13]. European, North America as well as Australia also have adapted %HA and annoyance indicator [14, 15, 16]. Since there are no regulations in the UAE, to our knowledge, that clearly indicates what to use, we will adopt WECPLN as a physical descriptor of aircraft noise. We will also use L_{dn} indicator to compare our results to the work of other researchers.

Figure 2 shows the %HA and the corresponding WECPLN values, which were calculated from Equation (1), along with 95% confidence limits for all sites. Each point in the figure represents the calculated WECPLN value at each site and the corresponding number of %HA respondents in that site. The figure clearly indicates a rising tendency of the percentage of highly annoyed people as the values of WECPLN increased. This result is expected and in agreement with other researchers [e.g. 14, 17, 18, 19, 20].

L_{dn}, which was calculated using equation (2), is shown in Figure 3. It should be noted that L_{dn} includes background noise levels, such as that arising from transportation noise, etc. To account for the background noise levels, researchers recommend to subtract 13 dBA from the WECPNL values, i.e. L_{dn} = WECPNL – 13, [14, 21]. When this is calculated, the values of the calculated L_{dn}, seem to be higher than those obtained using equation (2), which may be contributed to the fact that the background noise levels (transportation) is high, as reported previously [9]. This means that the 13 dBA offset may be different for the UAE.

The annoyance levels near Dubai International were found to be high, but comparable to similar studies done near various airports around the world including Korea [14], Sweden [15], Italy [19], USA [21], Taiwan [22], Spain [23], Canada [24], India [25] and Chile [26].

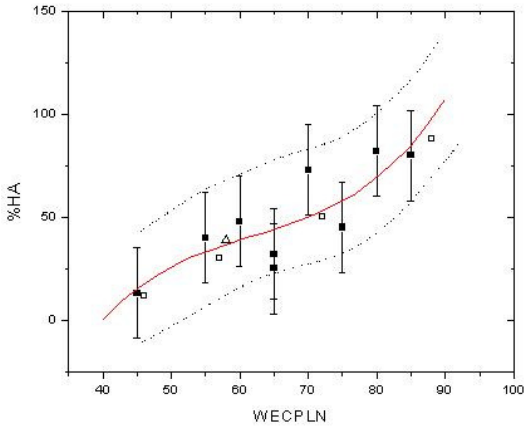

Figure 2: %HA as a function of WECPLN. The middle line is a polynomial fit to the data and the upper and lower lines represent the 95% confidence limits. The open squares is those of reference [14] and the open triangle is that of reference [20].

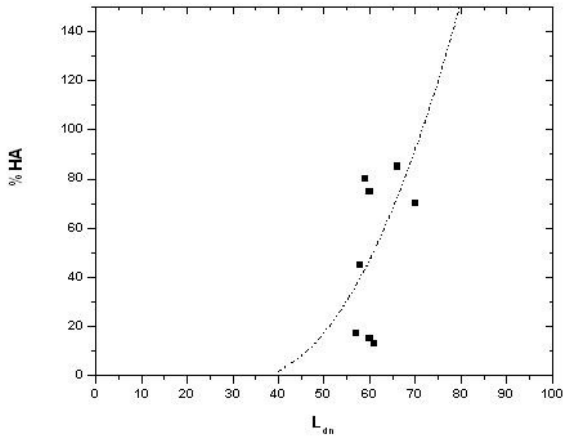

Figure 3: %HA as a function of L_{dn}

CONCLUSION

The general public is increasingly aware of environmental noise and its adverse health effects. In addition, WHO has recognized annoyance as one of the environmental health indicators that has to be accounted for before deciding on various community projects and developments plans. Guidelines of the limits have been drafted in order to protect the general public against exposure to annoyance sources. Among these annoyance sources is aircraft noise, which has higher impact on people living within a close proximity of the airport. In nine sites near Dubai International, where the volume of aircraft activities is considered among the highest in the world, our investigation of the noise descriptors WECPNL and L_{dn} and their relation to community annoyance showed that 41% of respondents felt highly annoyed, 31% rather annoyed, 15% slightly annoyed and only 13% of the respondents felt “not annoyed” by aircraft noise near the airport. To assess the health impact of such percentages, we examined the number of %HA respondents at each site and the WECPLN value at each site. It was found that there is a very good relationship between WECPLN and %HA, which agreed with other researchers. Similar analysis using L_{dn} showed a similar trend. We are currently taking measurements in 13 more sites and we plan to interview more people to further support these results.

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