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EVALUATION OF COMMUNITY RESPONSE TO AIRCRAFT NOISE FOLLOWING COMPLETION OF A NEW RUNWAY AT VANCOUVER INTERNATIONAL AIRPORT

A.J. Grigg, E.F. Haboly, M.C. Cheng

Vancouver International Airport Authority, P.O. Box 23750 Airport Postal Outlet, V7B 1Y7, Richmond, B.c., Canada

Tel.: (604) 276-6393 / Fax: (604) 276-6699 / Email: alison_grigg@yvr.ca

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ABSTRACT
Vancouver International Airport, located in Vancouver British Columbia, Canada, opened a new 3,030 meter parallel runway in November of 1996. In order to scientifically assess community response, the Vancouver International Airport Authority (Airport Authority) commissioned BBN Technologies to undertake "before" and "after" social surveys of nearby residential communities. The Airport Authority is unaware of anther airport completing a noise social survey both prior to and following a similar runway expansion project. Airport Authority staff prepared noise exposure data using computer based modeling so that annoyance could be correlated with BBN's findings, utilizing estimated day-night average sound levels (DNL), assisted the Authority in determining which neighborhoods were annoyed by aircraft noise; their level of tolerance to aircraft noise, and how results compared to the baseline study and communities located elsewhere. Results were similar to those observed elsewhere, and with the dosage-response curve developed by the U.S. Federal Interagency Committee on Noise (FICON). Results also showed that aircraft noise tolerance among residents in this study was lower than comparable communities elsewhere.

1 - INTRODUCTION

Vancouver International Airport (YVR) opened the 3,030 meter North Parallel Runway (North Runway) in November 1996. Use of the North Runway represented a major re-allocation of the landing traffic at YVR. The pattern of aircraft take-offs did not change appreciably, as take-offs remained on the main South Runway due to environmental commitments. Total runway operations in 1997 increased by 17% relative to 1994, with a slightly higher proportion of larger aircraft in the mix. The North Runway is closed at night-time(10:00pm- 7:00am) to all traffic.

In order to scientifically assess community response to this change, the Vancouver International Airport Authority (Airport Authority) commissioned Dr. Sanford Fidell and Laura Silvati of BBN Technologies to complete a "before" and "after" social survey of nearby residential communities.

In August 1995, the first round of telephone interviews was conducted to establish baseline information about the prevalence of aircraft noise annoyance in nearby residential areas. In 1998, almost two years after operations commenced and three years after the initial survey was completed, the Airport Authority commissioned a follow-up survey of the same residential areas, as well as comparison of the results with the baseline conditions.

2 - METHODOLOGY

Survey areas were selected in 1995 based on exposure to existing aircraft noise, as well as anticipated exposure to new noise from the north runway. Airport Authority staff prepared noise exposure data using the U.S. Federal Aviation Administration's Integrated Noise Model (INM) version 4.11 so that annoyance could be correlated with estimated day-night average sound levels (DNL). Actual aircraft operations for 1994 and 1997 were selected as time periods appropriate to the time frame ("last year") about which respondents were questioned.

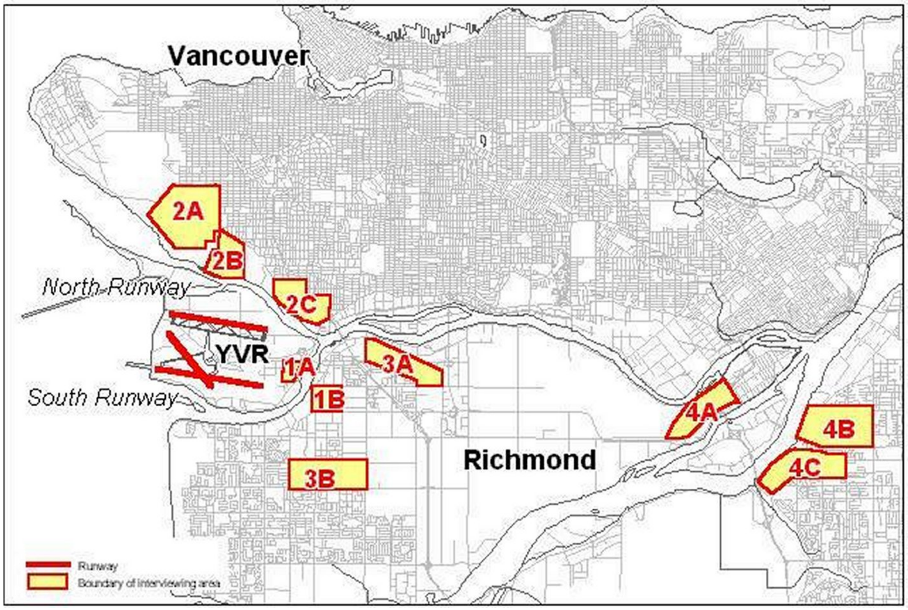

Figure 1: Locations of interviewing areas near Vancouver International Airport.

Boundaries of the ten interviewing sub-areas used in both rounds of study are shown in Figure 1. The dotted red lines are extensions of runways center lines heading east of the airport.
These ten interviewing regions were aggregated to form seven interviewing areas by combining sub-samples of respondents due to changes in aircraft noise exposure between rounds of interviews in certain sub-areas. Table 1 shows the seven aggregate regions and compares the respondent-weighted DNL.

Interviewing Area	Number of Completed Interviews		Respondent-Weighted DNL	
	Round 1	Round 2	Round 1	Round 2
Burkeville/ Brown Road (1A+1B)	78	88	71 dB	70 dB
South Vancouver (2A+2B)	291	238	44	44
Marpole (2C)	85	158	53	53
Bridgeport (3A)	160	155	54	61
Brighthouse (3B)	136	147	52	52
Hamilton/Annieville (4A+4B)	96	171	46	49
Alex Fraser Bridge (4C)	154	110	50	51

Table 1: Estimated aircraft noise exposure levels by interviewing area and interviewing round.

The same questionnaire was administered to respondents in August 1995 (Round 1) and August 1998 (Round 2) using centrally supervised telephone interviewers who made multiple attempts to solicit the opinion of one English-speaking, adult, verified household member. The brief, structured questionnaire was composed of three open response items and seven closed response category items. The wording of the questionnaire items closely resembled that of other studies of community response to transportation noise.
The questionnaire was introduced as a study of neighborhood living conditions. The first explicit mention of noise occurred in Item 3 ("Would you say that your neighborhood is quiet or noisy?"), following preliminary questions about duration of residence, about the most and least favored aspects of neighborhood living conditions, and about the single most important neighborhood environmental issue. The next item ("Have you noticed any more or any less aircraft noise in your neighborhood over the past year, just since last summer?") solicited information about the issue of central concern. Two subsequent items inquired about long-term annoyance with neighborhood street traffic noise and aircraft noise. The final two items solicited opinions about whether aircraft noise had disturbed sleep or interfered with conversation or listening to the radio or television.
Comparisons of responses from the two rounds of interviews for selected questionnaire items were validated using Chi-square tests (a Chi-square (X^2) test of association evaluates differences between expected

and obtained counts in the cells of contingency tables; smaller values of X^2 indicate that differences between observed and expected frequencies are likely to have occurred by chance, while larger values of X^2 indicate that such differences are unlikely to have occurred by chance; the corresponding p value expresses the probability that a difference occurred by chance alone; for example, if $p<.05$, then the difference may have occurred by chance alone 5% of the time or less; smaller p values indicate an even smaller probability that a difference has occurred by chance alone).

The US FAA Integrated Noise Model (INM) version 4.11 was used to generate the DNL values for years 1994 and 1997. The INM is primarily used for generating noise contours, illustrating the areas of varying noise exposure in the airport vicinity. In this study, the INM was used to generate average noise exposure values (such as DNL) at the approximate geographic centers of each interviewing region.

The DNL values were calculated by time-averaging the annual aircraft operations, considering fleet mix, aircraft range, runway utilization, flight path, and time of day. Night-time (10:00pm-7:00am) operations were weighted by a factor of 10. The INM computed the DNL based on the total aircraft noise exposure at that location. As the INM assumes that the DNL is based on annual airport operations, the complete calendar years of 1994 (before North Runway opening), and 1997 (after) were selected as the input years for the INM.

3 - RESULTS

While increases and decreases in annoyance were observed in all areas, most were not statistically significant and were just as likely to occur by chance alone. Notable exceptions are discussed in more detail below.

3.1 - Bridgeport

The western-most edge of Bridgeport is located approximately 4 km from the threshold of the North Runway and extends under the extended runway center line. The North Runway is used for arrivals and is only open during the hours of 7:00am to 10:00pm (exceptions are made for emergencies, maintenance or snow removal; according to environmental commitments, the North Runway will only be used for takeoffs when demand approaches capacity at YVR). Due to prevailing wind conditions, arriving aircraft over-fly Bridgeport primarily in fine weather, about 50% of the days, while in foul weather, there tends to be little traffic over the community. Bridgeport is the single largest source of complaints out of all the communities in the vicinity of YVR.

An estimated 7 dB increase (from DNL = 54 to DNL = 61 dB) in aircraft noise exposure level was accompanied by an additional 29% of respondents who reported noticing more aircraft noise (69% in Round 2 compared with 40% in Round 1). This difference was unlikely to have arisen by chance alone ($X^2_{(1)} = 26.7$, $p<0.1$).

The greatest increase in the prevalence of high annoyance was in Bridgeport ($X^2_{(1)} = 59.8$, $p<0.1$), where the percentage of respondents reporting high annoyance increased form 11% in Round 1 to 52% in Round 2, a 41% increase. Greater percentages of respondents in Round 2 than in Round 1 reported sleep disturbance due to aircraft noise during the past year in all interviewing areas, but a statistically significant difference was found in Bridgeport ($X^2_{(1)} = 27.5$, $p<0.1$). with an additional 27%.

3.2 - Hamilton and Annieville

Hamilton and Annieville are located approximately 20km from Vancouver International Airport and see aircraft most typically on approach during fine weather. Hamilton has limited traffic from the older runway as it departs eastward, typically during foul weather. An estimated 3 dB increase (from DNL = 46 to DNL = 49 dB) in aircraft noise exposure was accompanied by an additional 38% of respondents who reported noticing more aircraft noise (60% in Round 2 compared with only 22% in Round 1). This difference was statistically significant ($X^2_{(1)} = 35.3$, $p<.01$). None of the respondents in Hamilton or Annieville reported high annoyance due to aircraft noise in Round 1, but 18% of respondents reported high annoyance in Round 2 ($X^2_{(1)} = 19.7$, $p<0.1$).

3.3 - Comparison with standard dosage-response relationship and with other locations

With the exception of Bridgeport, roughly similar percentages of respondents were highly annoyed by aircraft noise as in 281 other communities elsewhere, and of those predicted by the U.S. Federal Interagency Committee on Noise.

Cumulative noise exposure alone, as quantified by DNL, does not account for all of the observed variability in the prevalence of noise-induced annoyance in different communities. In fact, no dosage-response relationship based on a purely acoustic predictor variable is likely to account for more than about half of the variance in annoyance data, leaving the other half unexplained by noise measurements. Non-acoustic factors that might account for the remainder of the variance include the economic dependence of a community on the operation of a noise source, as well as a variety of attitudes such as fear of crashes, necessity of noise exposure and controllability of noise exposure.

A theoretically derived model developed by Green and Fidell characterizes the aggregate effect of all non-acoustic determinants of annoyance into a single value of 70.2 dB. Based on results from 281 other communities, respondents in Round 2 tolerated only 63.6 dB, about 6 dB less noise exposure than other communities tolerated, before describing themselves as highly annoyed. In comparison, respondents in Round 1 were about 2 dB less tolerant of noise exposure than residents of other communities before describing themselves as highly annoyed. Again, this decrease in tolerance was for purely non-acoustic factors.

In all areas, respondents were more willing to describe themselves as highly annoyed by aircraft noise for non-acoustical reasons in Round 2 interviews. In addition, respondents were less tolerant on average by several decibels of comparable aircraft noise exposure than those interviewed elsewhere.

4 - CONCLUSIONS

A series of social surveys is an objective tool which is ideally suited for gauging community reaction to a new runway. Whereas complaints monitor behavior, a social survey quantifies annoyance. When combined with representative noise exposure data such as DNL, residents' annoyance may be compared between communities within the vicinity of interest, those communities with comparable studies elsewhere as well as to standard dosage-response predictors.

In recent results obtained by BBN technologies and the Vancouver International Airport Authority, respondents were more willing to describe themselves as highly annoyed by aircraft for non-acoustic reasons in post-runway operating conditions. Furthermore, respondents in all areas of this study were less tolerant on average by several decibels of comparable noise exposure than those interviewed elsewhere in other communities. For example, in one study area an estimated 7 dB increase in noise exposure was accompanied by an additional 41% of respondents reporting high annoyance due to aircraft noise.

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