# Analysis of Acceptable Flight Frequency under the Effects of Other People's Noise-Situations

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**Abstract:** This paper examines the effects of other people's noise-situations on an individual's maximum acceptable flight frequency (MAFF). Two scenarios for interview questionnaires: with and without additional noise information were established under a hypothetical setting. Two MAFF models, one that tests for effect of available noise information and another testing for effect of other people living in different noise-affected zones, were estimated using data from a pilot survey based on a developed headphone interview system. Results of the first model indicated a significant effect of the available noise information on MAFF. From the second model, it was found that MAFF would increase if subjects took into account the noise-situations of people living in the high noise-affected zone, all else being held constant. For those located in the moderate noise-affected zone, the results suggest a reduction in MAFF. There was an increase in MAFF if subjects did not consider anyone else's noise-situation.

*Keywords:* Acceptable flight frequency, aircraft noise, headphone interview, other people's noise-situation

## 1. INTRODUCTION

Aircraft noise remains a serious social and ecological problem for airport-area residents and the main barrier to airport growth. To abate with aircraft noise problem, several noise mitigation programs, including integration of new technology for quieter aircraft, operational procedures for landings and take-offs, and airport noise management, have been proposed and improved (see Girvin, 2009). Recent studies have focused on a trajectory optimization procedure aimed at minimizing the noise impact over an airport's nearby areas (e.g., Visser, 2005; Prats *et al.*, 2011). These studies show that each single takeoff/landing flight trajectory, with respect to certain constraints, could be optimized by taking into account the subjective impression of noise (i.e., nighttime sleep disturbance, annoyance by location and time of day), noise exposure level, and airline operating costs (i.e., fuel and time). Further, noise sharing program have been considered and have already been implemented in some airports, including Sydney, London Heathrow, and Boston Logan in order to distribute the impact of noise over the areas near the airport as fairly as possible (Airservices Australia, 1996; FAA, 2002; Britain's TI, 2009). As a case in Australia, the concept of sharing aircraft noise was initiated since late 1990s, and it has attracted more attention from residents living near airport (e.g., Sydney airport). Their interests, in addition to noise descriptors, are commonly more in comparative noise load than in absolute noise load (Southgate, 2011). Comparative noise load implies a consideration of other people's noise-situations. Taking into account this noise sharing concept, several noise-related policies have been established and improved to meet both community expectation and technological capacities. However, the implementation of new noise mitigation programs based on developed noise criteria has often been critical in converting a "social impact" into a more socially acceptable solution (Nero and Black, 2000).

There is a case in Japan that there have been long discussions on how to share aircraft noise arising from flights to/from Tokyo International Airport (known as Haneda airport, HND) in overall metropolitan areas. The flight routes at lower altitude were basically designed only over Chiba area, located east of HND, while minor flight routes were designed over Tokyo area, located west of HND. These flight route settings have resulted in a fairness issue of aircraft noise distributions over the areas in the vicinity of HND, specifically those Chiba people living directly under flight paths. Gaining benefits from being close proximity to HND, Tokyo people enjoy a quieter environment than those Chiba people living far from the airport. Tokyo people have also complained even with little noise while they may not imagine or ignore about other higher noise-affected people living in the same airport vicinity (e.g., Chiba people). The issue has been more seriously considered since air traffic volume has increased. Though some flight routes could be changed after construction of a new off-shore D-runway in 2010, still there have been many restrictions on flight route settings due to the sandwich flights between Narita airport and U.S. Yokota air base, located west of HND. Consequently, Chiba people have been exposed to more noise and they have strongly demanded for noise mitigation. They even suggested to increase the minimum flying altitude over restricted-airspace areas (e.g., Tokyo areas); which in turn, adding workload to ATC and sometimes limiting the runway capacity. So far, there is no progress in sharing aircraft noise at this airport. According to Hirata and Shimizu (2012), if people living at Tokyo areas accept some flights and new flight routes can be operated over these areas approximately four hours per day, especially during peak hour periods, the total capacity at this airport is estimated to be increased by approximately from six to nine percent per day while this operation could also mitigate the noise at Chiba area by providing some respite periods. In this concern, aviation researchers may wish to make an appropriate noise consensus program with people living around the airport.

Efforts have been made to understand people's subjectivity towards aircraft noise, for example, sleep disturbance (e.g., FICAN, 2012), percentage of highly annoyed people (e.g., Schulz, 1978; Kryter, 1982), annoyance index based on fuzzy rule (e.g., Prats *et al.*, 2010), subjective frame of aircraft noise (e.g., Kroesen *et al.*, 2011), and other psychological effects (see Jones *et al.*, 1981). Although previous research has shown that the subjective impression of noise is a direct function of the noise exposure level, a better noise criteria should include not only include the noise exposure level but also other factors, such as the number, duration, and temporal and frequency characteristics of noisy events (Kuwano and Namba, 1996). However, there have been only a few noise-impact studies incorporating the importance of flight frequency (e.g., Rylander *et al.*, 1980; Hume *et al.*, 2003; Carlsson *et al.*, 2004). The number of single flyovers together with the noise exposure level may be the essential variables for improving the prediction of the impact of aircraft noise on people living near an airport.

When the redistribution of aircraft noise over the airport-nearby areas is considered such as for airport capacity expansion and noise sharing, understanding individual acceptable flight frequency for some resulting aircraft noise levels is one of the important aspects to be analyzed. It is also important to investigate the effects of fairness condition or consideration of the other people's noise-situations on individual attitude toward aircraft noise management at the airport. We hypothesize that the highest number of flights accepted by each airport-area resident might be affected by the accessibility of information about other noise-affected people living in the airport neighborhood. The consideration of other people's noise-situations is unobservable in general and is usually ignored by researchers. This phenomenon is in line with the "contextual effects" explained by Manski (2000); that is, a person's decision-making is directly influenced by the characteristics of others in his or her social group. If the effects are successfully observed, it will be a useful aspect to be incorporated into aircraft noise management policy. In practical viewpoint, consideration of other people's noise-situations could help policy-makers to evaluate on flight or noise acceptable level (i.e., cases of noise reduction or increase) for airport-area residents before and after an implementation of airport development plan. Particularly, aviation authorities can, under environmental justice concept, better manage and operate the appropriate number of aircrafts for each designated flight route. In social viewpoint, the goal is to make a noise consensus among overall airport-area residents. Since some certain groups of residents could not imagine or were not previously informed about other people's noise-situations, informing these groups about other noise-affected people is a useful message that may make them aware of current and future aircraft noise situations at other places. If they could gradually understand, they would accept some noise more or less. In academic viewpoint, distinct consideration of other people adds progress to the field of modeling of decision-making behavior. It is believed that incorporating the effects of other people into analysis may help improve the prediction power on individual utility or satisfaction level.

This paper examines the effects of other people's noise-situations on individual's maximum acceptable flight frequency (MAFF) values. To confirm the effects, two MAFF models were constructed and statistically estimated using data from a pilot survey-based headphone interview system to examine 1) the effects of the available noise information and 2) the effects of other people living in different noise-affected zones. This paper also describes an innovative conceptual framework that could be used to obtain useful data including MAFF and subjective annoyance corresponding to various noise levels, as well as to capture the effects of other people's noise-situations.

## 2. HEADPHONE INTERVIEW

Headphone interview system was firstly developed by Phun *et al.* (2013) to study the aircraft noise sensitivity for Fukuoka airport-residents. The system allowed to assess the individual noise sensitivity to variation of aircraft noise levels as well as to assess the perceived indoor noise levels inside each dwelling. This study utilized the same system to assess individual acceptable flight frequency for various noise levels.

### 2.1 Noise Sources

Three single-flyover sounds from landings of small, large, and heavy aircraft types were recorded using a binaural microphone (Ronald R05) at a quiet location located approximately 6 km away from B-runway to the northwest of Narita International Airport at an altitude of approximately 305 m. In this study, the maximum sound level ($L_{max}$) measured in "Fast" time weighting was selected as the acoustical unit, and the recorded aircraft sounds were prepared as follows: CRJ-100 of $L_{max}$ = 49.8 dBA with 30 s duration, B777-300 of $L_{max}$ = 55.0 dBA with 40 s duration, B737-800 of $L_{max}$ = 59.9 dBA with 30 s duration, and B777-300 of $L_{max}$ = 64.9 dBA with 40 s duration.

### 2.2 Headphone System

The recorded aircraft sounds were reproduced by a playback system (Ronald R05) and presented to the subjects through headphones (SONY MDR-ZX700). The performance of the headphone system was checked for battery life degradation to ensure the quality of the reproduced sound. With an airtight dynamic system, a pair of soft ear pads can effectively cover the gaps around the subject's ears and offers good insulation for high passive noise. Moreover, headphones can maintain the characteristics of aircraft noise better than other systems, such as earphones or speakers. Compared to a laboratory experiment, the developed headphone system is easy to implement at low cost and serves as a useful tool for assessing community responses to various noise exposure levels in an existing environment. However, the low and high frequencies appear to be slightly plugged-up, contributing to the "dark" sound and making the bass sound slightly muddier than it should.

It should be noted that, to set up the four aircraft sound levels, the reproduced sounds were measured with an integrated noise level meter (RION NL-05A) together with a pseudo-ear made from artificial clay. A hole of one centimeter diameter was created to mimic an ear canal, and the noise level meter's microphone, which works as an ear drum, was placed in this hole. The amplifier output voltages, corresponding to estimates of the sound levels produced by the headphones on the artificial ear, were measured in $L_{max}$.

## 2.3 Questionnaires

The questionnaires for the headphone interviews were initially designed in English and were later translated into Japanese. The back-translating technique was used to guarantee consistency between the two versions.

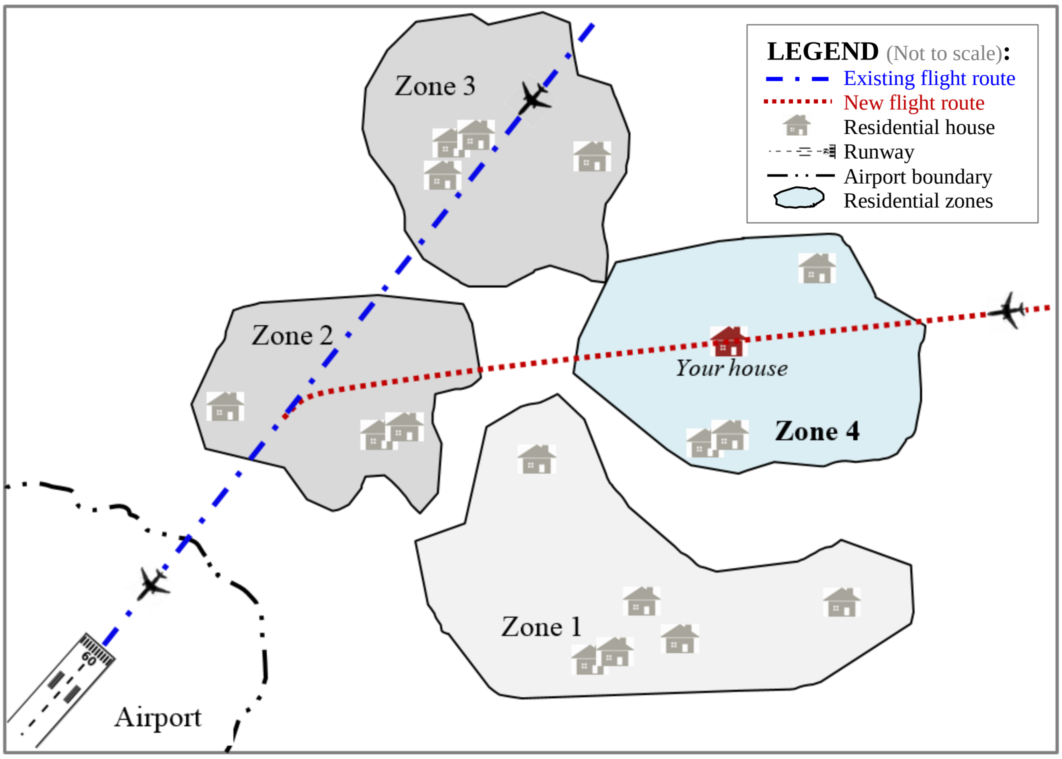


Figure 1. Noise information sheet provided in "With information" scenario

To capture the effects of other people's noise-situations, two scenarios under a hypothetical setting were designed: "With information" and "Without information." In the "With information" scenario, subjects were given detailed information about other people's noise-situations, including housing locations, different noise-affected zones, and current and future flight route settings, as seen in Figure 1. They were informed about the current conditions, that is, only the existing flight route is operational. As the demand for air transportation services increases, air traffic controllers will introduce a new flight route, which will be operated directly over their houses located in Zone 4 in the evening between 7 p.m. and 10 p.m. It was also emphasized that most people living in Zone 2 and Zone 3 are still exposed to more and higher noise levels than those living in Zone 1 and Zone 4, although partial flights will be operated using the new proposed flight route. It should be noted that the noise information was carefully designed to minimize the policy bias with three zone classes: Zone 1, Zone 4, and Zone 2 & Zone 3 corresponded to low, moderate, and high noise-affected zones, respectively.

In the “Without information” scenario, subjects were only informed about the necessity of introducing a new flight route between 7 p.m. and 10 p.m. Although given a questionnaire with a similar structure, these subjects were not provided with the noise information sheet (i.e., Figure 1) or any other information related to their house locations, flight route setting, noise-affected zones, and other people’s noise-situations.

### 2.4 Subjects

Thirty-seven normal-hearing Japanese students, aged 21 to 26 years old and including two women, participated as test subjects in the headphone interview. The subjects were divided into two groups: 24 were interviewed using the “With information” scenario and 13 were interviewed using the “Without information” scenario. The subjects were undergraduate (51.7%) and graduate (37.4%) students from Tokyo Institute of Technology (Tokyo Tech). Their majors were not related to air transport or environmental noise fields. Each subject was recruited with a monetary incentive of 500 yen.

### 2.5 Procedure

Two well-trained instructors conducted the headphone interviews from July 21 to 27, 2012, at two locations: inside a Tokyo Tech library and inside a room of 3.6 m × 6.4 m × 2.5 m. The background sound level was monitored by RION NL-05A, and it did not exceed 40.0 dBA, the lowest limit of urban ambient sound in daytime hours. During each interview, the subjects were instructed to properly wear the headphones to minimize the effects of passive noise. It took between 35 and 45 minutes to complete all four sections as follows:

- Section I inquired about the frequency of hearing aircraft sounds in daily life, evaluated based on a category scale (i.e., “1”: Never, “2”: Rarely, “3”: Few times per month, “4”: Often, “5” Very often, and “6”: Every day) and the similarity of the quality of the recorded sounds to the actual aircraft sounds they often hear, evaluated based on a five-point scale ranging from “Unlikely” to “Likely”.

- Section II inquired about the subjective annoyance (based on a 10-point scale ranging from “Not annoyed at all” to “Very annoyed”), interference with reading activity (based on a 10-point scale ranging from “Not disturbed at all” to “Very disturbed”), and MAFF for each presented sound. In this section, the subjects were first asked to imagine a hypothetical setting wherein they were supposed to be relaxing inside their houses and were reading a book on a quiet evening from 7 p.m. to 10 p.m. with windows closed and no other sounds, such as TV or music. Upon understanding the conditions and situations given, the subjects were then asked to choose a book they liked and start reading. While concentrating on reading the book, each of the four-recorded sounds was played repeatedly until the subjects could evaluate their MAFF. The sounds were randomly presented to the subjects with a break of a few minutes between each. To normalize the subjects' hearing and to make them forget about the last presented sound, general conversations between the instructors and subjects were facilitated during each break time.

- Section III used follow-up questions to inquire about information regarding other people's noise-situations. In this section, different questionnaire structures were used for the "With information" and "Without information" scenarios. In the former scenario, the subjects were asked whether they took into account the situations of other people living in different noise-affected zones. Three separate questions based on a seven-point scale ranging from "Unlikely" to "Likely" were asked for Zone 1, Zone 4, and Zone 2 & Zone 3, which correspond to low, moderate, and high noise-affected zones, respectively. In the latter scenario, the subjects were asked whether they had any desire to know about other people's noise-situations prior to giving responses in section II. Evaluations were made based on a seven-point scale ranging from "Unlikely" to "Likely".

- Section IV inquired about details on personal and housing information, including age, tenant status, living expenses, and whether the subjects have an intention to live near the airport (based on a seven-point scale ranging from "Unlikely" to "Likely").

## 2.6 Descriptive Statistics

Table 1. Summary statistics

| Description of variables | Obs. | Mean | S.D. | Min. | Max. |
|---|---|---|---|---|---|
| *Data characteristics* | | | | | |
| Frequency of hearing aircraft sound (OftenHear), category scale | 147 | 2.79 | 0.99 | 2 | 6 |
| Quality of recorded aircraft sounds, five-point scale | 147 | 3.92 | 0.82 | 2 | 5 |
| Subjective annoyance(Annoyance), 10-point scale | 147 | 4.95 | 2.37 | 1 | 10 |
| Interference with reading activity, 10-point scale | 147 | 5.05 | 2.49 | 1 | 10 |
| Maximum aircraft sound level in dBA ($L_{max}$) | 147 | 57.45 | 5.62 | 49.8 | 64.9 |
| Maximum acceptable flight frequency (MAFF) for pooled-data | 147 | 7.07 | 6.83 | 1 | 40 |
| MAFF for "No information" scenario | 51 | 8.96 | 9.43 | 1 | 40 |
| MAFF for "With information" scenario | 96 | 6.07 | 4.68 | 1 | 20 |
| Age of subjects | 147 | 22.87 | 1.45 | 21 | 26 |
| Gender of subjects, 1 if male and 2 if female | 147 | 1.05 | 0.23 | 1 | 2 |
| Living expenses[a] in 10,000 yen per month (LivingExp) | 147 | 4.68 | 1.96 | 2 | 10 |
| Tenant status (Rent), equals 1 if renting and 0 otherwise | 147 | 0.59 | 0.49 | 0 | 1 |
| Living floor levels of an apartment (Apart_Flr) | 95 | 3.15 | 2.37 | 1 | 11 |
| Intention to live near the airport, seven-point scale | 147 | 2.72 | 1.29 | 1 | 6 |
| Desire to know other people's noise-situations, seven-point scale | 51 | 3.27 | 1.98 | 1 | 7 |
| Consideration of other people living in Zone 1, seven-point scale | 96 | 2.13 | 1.46 | 1 | 6 |
| Consideration of other people living in Zone 4, seven-point scale | 96 | 2.63 | 1.47 | 1 | 6 |
| Consideration of other people living in Zone 2 & 3, seven-point scale | 96 | 3.29 | 1.80 | 1 | 6 |
| *Created-dummy variables* | | | | | |
| Intention to live near the airport ($D_{NearAirport}$) | 147 | 0.11 | 0.31 | 0 | 1 |
| Subjects responding to "With information" questionnaire ($D_{Info}$) | 147 | 0.65 | 0.48 | 0 | 1 |
| Consideration of other people living in Zone 1 ($D_{Zone1}$) | 96 | 0.13 | 0.33 | 0 | 1 |
| Consideration of other people living in Zone 4 ($D_{Zone4}$) | 96 | 0.13 | 0.33 | 0 | 1 |
| Consideration of other people living in Zone 2 & Zone 3 ($D_{Zone23}$) | 96 | 0.33 | 0.47 | 0 | 1 |

Note: [a] including transportation, food, health, and other services, except for tuition and house-renting fee.
Variables defined for MAFF models are shown in parentheses.
1 US$ = 78.42 yen as currency exchange rate of July 2012, throughout the text.

Because each subject evaluated the four-recorded sound levels, the total number of observations available for the pooled data analysis is 147 (= 37 subjects × four recorded sounds – inconsistent data): 96 observations from 24 subjects who responded to the "With information" questionnaire and 51 observations from 13 subjects who responded to the "Without information" questionnaire. The data summary statistics are presented in Table 1. In daily life, the subjects could hear aircraft sounds a few times per month on average. The average score given concerning the quality of the recorded noise is high, showing that the characteristics of the aircraft sounds reproduced through the headphone system were acceptably maintained. Because it was not applicable to ask about the income levels of the test subjects (as they were students), their monthly living expenses were used instead. On average, they spent approximately 46,000 yen per month on food, transportation, health, and other service fees; this value does not include tuition and housing fees. The majority of the subjects (69.2%) were living in rented houses with an average renting fee of 55,200 yen per month.

The average scores and corresponding standard deviations of subjective annoyance and reading interference based on a 10-point scale were plotted against $L_{max}$, as shown in Figure 2. The level of disturbance increases with noise level. Annoyance is a complex experience involving multiple factors, including perceived loudness, individual personality, and other perceptual characteristics of the sound. Average judgments were quite similar but differed slightly at the highest presented noise level. The slight decrease in annoyance score at $L_{max}$ of 64.9 dBA may be due to the sound characteristics of the B777-300 itself rather than individual personalities.

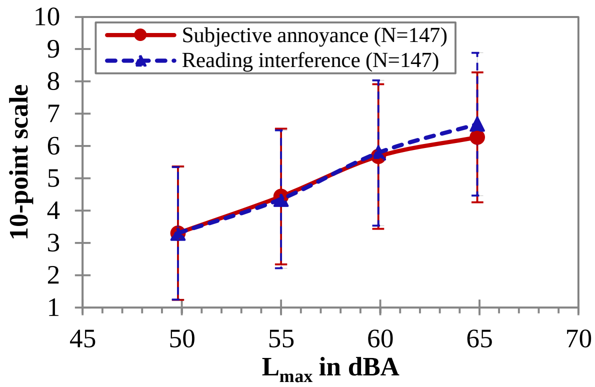


Figure 2. Average annoyance and reading interference scores against $L_{max}$

For the pooled data, the MAFF values evaluated by subjects under the hypothetical setting between 7 p.m. and 10 p.m. are between one and 40 with an average of approximately seven, as seen in Table 1. In the "With information" group, the MAFF ranges from one to 20 with an average of approximately six. The average MAFF under the two scenarios for each recorded sound are given in Figure 3. The average MAFF observed in the "Without information" group is higher than that observed in the "With information" group, implying that subjects seriously considered whether they were informed about other people's noise-situations. A one-way analysis of variance (ANOVA) was performed, and the results indicated that the two tested groups had significantly different MAFF values ($F$ (1, 145) = 6.17, $p$ = 0.014). This result suggests that other people's noise-situations affect an individual's MAFF. For the "With information" group, the ANOVA results also show significant differences among the average MAFF values for the four presented sounds ($F$ (3, 92) = 6.08, $p$ < 0.000).

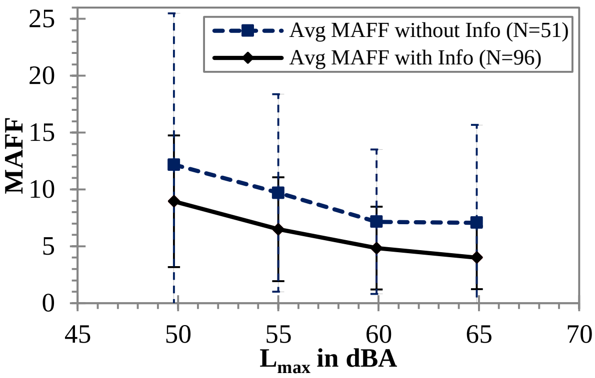


Figure 3. Average MAFF against $L_{max}$

The term "Created-dummy variables" in Table 1 refers to those dummies created from the seven-point scale of the original variables. For example, the original seven-point score of whether subjects have an intention to live near the airport was transformed into a dummy variable, $D_{NearAirport}$, equals to 1 if the given score was higher than "4" and 0 otherwise.

It should be noted in the "Without information" scenario that the information on whether subjects have an intention to know about other people's noise-situations could not be used as a control variable because the information itself is ambiguous. That is, if subjects gave a score of "2," it could mean that either they had already considered and had no intention to know about other people's noise-situations or they did not consider and had no intention to know about other people's noise-situations.

## 3. MODEL

The general regression model for MAFF that takes into account the effects of other people's noise-situations is given in model (1):

$$y = \alpha + \beta_i x_i + \gamma_j z_j + \varepsilon \qquad (1)$$

where

- $y$ : an ($n$×1) vector of the explained variable (e.g., MAFF),
- $x_i$ : an ($n$×$i$) vector of the personal, dwelling, and environmental attributes (e.g., socio-economic and demographic variables, housing characteristics, and noise exposure level),
- $z_j$ : an ($n$×$j$) vector of the control variables (e.g., the effects of other people's noise-situations),
- $\alpha$, $\beta_i$, $\gamma_j$ : the associated parameter vectors, and
- $\varepsilon$ : an ($n$×1) vector of the error terms for which the distribution is assumed be normal.

To examine the effects of other people's noise-situations on MAFF, model (2) and (3) were developed based on model (1). In model (2), it was hypothesized that subjects would have a different MAFF when answering the two questionnaires. To test this hypothesis, a dummy $D_{Info}$ was created as a control variable, taking a value of 1 if subjects responded to the "With information" questionnaire and 0 if subjects responded to the "Without information" questionnaire. The estimated coefficient of $D_{Info}$ and its sign are important to determine how seriously the subjects considered the available noise information provided when judging their own MAFF.

Model (3) was developed to test the effects of other people living in different noise-affected zones on MAFF, which was evaluated by the group responding to the "With information" questionnaire. Based on the three classes of noise-affected zones described in Figure 1, dummies $D_{Zone1}$, $D_{Zone4}$, and $D_{Zone23}$ were created as control variables. These variables were transformed from the original seven-point scale shown in Table 1; these variables equal to 1 if subjects took into account other people's noise-situations by giving a score higher than "4" for Zone 1, Zone 4, and Zone 2 & Zone 3 and 0 otherwise.

$$\text{MAFF} = \alpha + \beta_i x_i + \gamma_0 \text{D}_{\text{Info}} + \varepsilon \quad (2)$$

$$\text{MAFF} = \alpha + \beta_i x_i + \gamma_1 \text{D}_{\text{Zone1}} + \gamma_2 \text{D}_{\text{Zone4}} + \gamma_3 \text{D}_{\text{Zone23}} + \varepsilon \quad (3)$$

where

MAFF : individual's maximum acceptable flight frequency under the hypothetical setting between 7 p.m. and 10 p.m.,

$\gamma_0$, $\gamma_1$, $\gamma_2$, and $\gamma_3$ : parameters of the control variables to be estimated.

## 4. RESULTS

### 4.1 Statistical Tests

Various specifications were tested for the two developed models. The error terms were assumed to be normally distributed, and the classical ordinary least square error (OLS) method was applied. To enhance the models' predictabilities, multicollinearity was verified, and a White test was performed to reveal the existence of a heteroscedasticity problem.

The problem of multicollinearity occurs when there is a high correlation between explanatory variables. While it does not cause the regression coefficients to be biased because their probability distributions are still centered over the true value, the problem of multicollinearity would lead to a high standard error or a low *t*-statistic (Dougherty, 2012). A pair-wise correlation matrix was constructed to verify that there are no serious multicollinearity problems in both models.

The problem of heteroscedasticity exists when the variance of the distribution of the disturbance term is not constant for each observation (Dougherty, 2012). That is, an individual who accepts more flights may have a larger variance of disturbance term than those who accept fewer flights. This problem leads to two main consequences: one consequence is that the standard errors of the regression coefficients are incorrectly estimated and the *t*-tests are invalid, and the other consequence is that the OLS estimation technique becomes inefficient. This problem causes OLS standard errors to be biased on finite samples, thereby leading to incorrect statistical inferences. The results of the White test indicated that heteroscedasticity problems were detected in model (2) and model (3) with Chi-sq. (31) = 84.67, $p < 0.000$ and Chi-sq. (37) = 53.70, $p = 0.037$, respectively. To remedy this problem, a method called "White's Robust Standard Errors" was applied to both models.

## 4.2 Results with Robust Standard Errors

Table 2. Estimate results with robust standard errors in parentheses

| Dependent variable = MAFF<br>Independent variables | Model (2)<br>Coefficient | Model (3)<br>Coefficient |
|---|---|---|
| Intercept | 9.5887**(4.5483) | 14.2211**(3.9586) |
| *Personal and dwelling variables* | | |
| OftenHear | 1.6459**(0.5121) | |
| LivingExp | 1.0474**(0.1955) | 0.9686**(0.2088) |
| Apart_Flr | | 0.4147**(0.1161) |
| Rent | 1.2995* (0.7289) | 1.0154 (0.8964) |
| $L_{max}$ | –0.1100 (0.0826) | –0.1895**(0.0674) |
| Annoyance | –1.1437**(0.1833) | –0.6607**(0.1765) |
| $D_{NearAirport}$ | 5.7903**(1.9298) | 1.7734 (1.4121) |
| *Control variables* | | |
| $D_{Info}$ | –2.1715**(0.9949) | |
| $D_{Zone1}$ | | –0.2487 (1.3424) |
| $D_{Zone4}$ | | –2.2987**(1.1332) |
| $D_{Zone23}$ | | 1.3880* (0.7872) |
| Observations | 147 | 96 |
| Prob. > *F* | 0.0000 | 0.0000 |
| *R*-square | 0.5201 | 0.5182 |

*Note*: Regressions were performed in MS Excel 2010.
Descriptions of each variable are shown in Table 1.
*Prob. < 0.1 and **Prob. < 0.05.

After correcting for heteroscedasticity, the estimated results with robust standard errors for our best-selected models are presented in Table 2. As observed, both models' goodness-of-fits are highly satisfactory, suggesting that approximately 50 percent of MAFF can be described by the models. Many estimated coefficients are statistically significant with expected signs. As expected, $L_{max}$ and subjective annoyance have negative effects on MAFF. The higher the noise exposure and annoyance level are, the lower the MAFF that would be accepted. This trend is because aircraft noise, in general, has a negative impact on humans (see Berglund *et al.* (1990) for a review of the adverse effects of aircraft noise). Furthermore, the estimated coefficient LivingExp is positively significant; those subjects who spend more on monthly living expenses would accept higher MAFF values. In model (2), the significant coefficient of $D_{NearAirport}$ suggests an increase in MAFF if the subjects have an intention to live close to the airport. The effect of this coefficient is positive because these subjects may have considered the benefits of being close to the airport, including business improvement, job opportunities, and easy accessibility. Similarly, the coefficient of Rent, which is positively significant at the 10-percent level, implies that the subjects would accept more MAFF if they are living in a rented house. In model (3), the positively significant coefficient of Apart_Flr suggests an increase in MAFF if the subjects were living on a higher floor level of an apartment building. Yet, there is no clear explanation of this positive effect. One possible explanation is that people living closer to flying aircraft are more frequently exposed to higher noise levels, and they may become more accustomed (or less sensitive) to that noise than those living on lower floors. Because the aircraft sound levels were assumed to be identical for all living floors in the hypothetical situation of this study, less noise-sensitive subjects may accept more flights. In addition, they may consider the benefits of living on higher floors, such as good scenery and air quality and being farther from other noise sources, such as road and rail traffic.

However, the variables of primary interest in Table 2 are those labeled $D_{Info}$, $D_{Zone1}$, $D_{Zone4}$, and $D_{Zone23}$. Based on the *t*-tests, $D_{Zone1}$ is not significant, $D_{Zone23}$ is positively significant at a 10-percent level, and $D_{Info}$ and $D_{Zone4}$ are negatively significant at a 5-percent level. Some significant coefficients of these control variables indicate that other people's noise-situations have some effect on MAFF.

## 5. DISCUSSION

### 5.1 Effect of Available Noise Information

The effect of the available noise information was tested in model (2) by incorporating the created dummy variable, $D_{Info}$, which takes a value of 1 if the subjects responded to the "With information" questionnaire and 0 otherwise. Model (2) was estimated based on the pooled data from both questionnaire scenarios. As seen in Table 2, the results indicate a significant impact of available noise information on MAFF. A negative coefficient of $D_{Info}$ suggests that MAFF would be decreased by approximately 2.2 if the subjects were informed about other people's noise-situations. The subjects who responded to the "With information" questionnaire considered other people's noise-situations more seriously than those who responded to the "Without information" questionnaire. These subjects would hypothetically compare the noise-situations of their own house locations to that of other people living in different noise-affected zones. One interpretation of this result is that people who have less noise information about the expansion plan may not carefully consider their future noise situations, which may be the reason why they are willing to accept more flights. Nevertheless, once they realize the actual environmental impact upon the implementation of the expansion plan, their MAFF will eventually decrease, and they may also make complaints. The empirical results from this study indicate that the insufficient noise information provided to the public could be an obstacle to the airport development plan. Appropriate and sufficient noise information released by the government could minimize the airport-area communities' contentions following the airport expansion plan. It should be noted that we initially expected the sign of $D_{Info}$ to be positive. However, when detailed information on housing locations, flight route settings, and other people living in different noise-affected zones was provided in the "With information" scenario, we observed that subjects' consideration of their MAFF evaluation became deeper and took a longer time (approximately ten minutes on average) than those who responded to the "Without information" scenario.

### 5.2 Effects of Other Noise-Affected People

The effects of other people living in the three classes of noise-affected zones on MAFF were tested in model (3). These effects were incorporated into the model using three control dummy variables, $D_{Zone1}$, $D_{Zone4}$, and $D_{Zone23}$, which corresponded to low, moderate, and high noise-affected zones, respectively. These dummies take a value of 1 if the subjects took into account other noise-affected people living in Zone 1, Zone 4, and Zone 2 & Zone 3 and 0 otherwise. Model (3) was estimated using only the data from subjects responding to the "With information" scenario. In this scenario, the subjects' houses were supposed to be located directly below the new proposed flight route in the moderate noise-affected Zone 4.

The estimated results indicate significant impacts on MAFF of other people living in the moderate and high noise-affected zones. The positive coefficient of $D_{Zone23}$ suggests an increase in MAFF by approximately 1.4 if the subjects accounted for the more highly noise-affected people living in Zone 2 and Zone 3, all else being held constant. The subjects may be willing about sharing some of the noise burden caused by flights to decrease the noise levels of other people who are currently exposed to higher noise levels. At an airport, the conventional flight routes over some specific areas may occasionally result in noise equity issues for residents living in those areas. However, the airport will eventually reach its capacity, and a new flight route will result in more noise-affected people if a capacity expansion plan is implemented. Thus, sharing flights with other nearby areas or regions by informing airport-area communities about more highly noise-affected areas is one of the important issues to be discussed to mitigate environmental noise complaints. The noise distributions resulting from a shared-flight protocol should also be properly designed to meet communities' acceptable flight levels.

Conversely, for individuals living in the moderate noise-affected zone, the results suggest a reduction in MAFF by 2.3 flights if the subjects considered the lower noise-affected people living within the same zone. Individuals may carefully consider other people whose houses are not directly under the new proposed flight route. Recalling the hypothetical noise situations shown in Fig. 1, individuals would feel negatively when only their houses would experience flyovers and higher noise exposure compared to other people living in the same zone. In this context, it appears that individuals would accept more flights when considering the highly noise-affected people, while accepting fewer flights when considering the lower noise-affected people. These results may suggest that the noise distribution should be shared across wider areas in the regions rather than being focused on a few specific groups of people.

In addition, the situation of other people living in the low noise-affected zone does not appear to have a significant impact on MAFF. However, it is important to acknowledge that this zone was defined in parallel with the actual conditions of residents living near the airport. The insignificant effect of $D_{Zone1}$ may stem from the fact that the low noise-affected zones are usually omitted from most residents' consideration. Even so, the negative sign of this variable suggests a reduction in MAFF if individuals considered the noise-situations of other people living in lower noise-affected zones.

Nevertheless, the total impact is a reduction of approximately 1.2 (= –0.2487 –2.2987 +1.3880) in MAFF if individuals considered all three noise-affected zones. In other words, MAFF would be increased by approximately 1.2 flights if they did not consider anyone else's noise-situation, all other factors remaining constant.

## 6. CONCLUSION

This paper examines the effects of other people's noise-situations on MAFF. To capture the effects, two scenarios, "With information" and "Without information", were constructed with similarly structured questionnaires. Interview questionnaires were carefully designed under a hypothetical setting to minimize the possible policy bias. Data from a pilot survey based on a developed headphone interview system allowed us to examine 1) the effects of the available noise information and 2) the effects of other people living in different noise-affected zones on MAFF. The hypotheses were tested with two separate models using different control variables. The empirical results indicate that most of these control variables are statistically significant.

In the first model, we tested for the effect of the available noise information on MAFF. Estimated results suggest a reduction in MAFF if the subjects were informed about other people's noise-situations, all else being held constant. The subjects who responded to the "With information" questionnaire appear to consider more deeply and accept fewer flights than those who responded to the "Without information" scenario. The results indicate the importance of the provision of sufficient noise information to the public before the implementation of the airport expansion plan. The government should carefully consider the appropriate amount of noise information to be released to the public to assure a socially acceptable level of air traffic growth in terms of the number of flights accepted by airport-area communities.

In the second model, we tested for the effects of other people living in different noise-affected zones on MAFF. Other people living in the high noise-affected zone were found to have a positive impact on MAFF, all else being held constant. For individuals located in the moderate noise-affected zone, the results suggest a reduction in MAFF. It can be concluded that individuals would accept more flights if they considered other people living in the highly noise-affected zone but would accept fewer flights if they considered the lower noise-affected people. Understanding an individual's intention of accepting more or fewer flights may be useful for the government for considering a socially acceptable noise distribution over the airport areas or over wider regions. In summary, MAFF would be increased if the subjects did not consider anyone else's noise-situation, all other factors remaining constant. This study indicates that MAFF may also be affected by some other unobserved factors, including differences in sound characteristics corresponding to different aircraft types, individual mood, and whether the selected book is really interesting or not.

Acceptable flight frequency to some particular aircraft noise levels together with consideration of other people are the vital features which can be used to evaluate the impact of noise re-distribution policy on individual satisfaction or utility, especially those who have considered the fairness issues. Although the effects of other people's noise-situations were detected in MAFF models, the empirical results from this pilot study may not be generalizable due to the limited sample size (i.e., noise exposure levels and age range of the test subjects). For this research to be practice-ready, future work should be conducted on a larger and more diverse subject pool of actual airport-area communities living in low, moderate, and high noise-affected zones. Lastly, the methodology introduced in this paper may serve as a useful approach for studying aircraft noise effects, specifically for aviation planners when considering additional flight routes, noise-sharing programs, and noise criteria for trajectory optimization.

## ACKNOWLEDGMENTS

The authors wish to record their special thanks to the two anonymous reviewers for their insightful comments on an earlier version of this paper. We also thank Chen-wei LI and Kento FUKUI for helps in data collection and AUN/Seed-Net JICA for financial support. Any remaining errors are our own.

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