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Improvement Plan of Aircraft Noise Impact Prediction Technique

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I. Introduction

The effect of the traffic noises generated by road, rail, and aircraft on life environment has attracted concerns, and especially the aircraft noise is a significant environmental problem around an airport due to exercising a far-reaching influence. Because the aircraft noise violates the physical and mental health of a human and degrades the value of the fortune such as buildings around an airport, it occupies an important position among many environmental problems originated from an airport(Figure 1-1).

Figure 1-1. Environmental problem of airport[1]

In order to prevent this aircraft noise problem, it is necessary to formulate the land-use plan considering the effect of the aircraft noise at the early stage of new airport construction or urban(including building site) development around an existing airport. Understanding the influence scope caused by the aircraft noise around an airport is preceded to achieve this goal, and the noise map produced by aircraft noise prediction results and measurement data is widely used to embody the noise impact visually. In particular, the noise map with an aircraft noise prediction model has an advantage of grasping the time variation of aircraft noise easily, which can also include the change of airport topography and operating conditions.

Therefore, the objective of this study is to suggest the improvement plan of aircraft
noise prediction and assessment to upgrade the efficiency of the Environmental Impact Assessment (EIA) in connection with aircraft noise. In order to achieve this goal, it includes preparation plan of aircraft noise map, improvement plan of aircraft noise impact prediction and assessment, and application plan of aircraft noise map.
II. Aircraft Noise Characteristics and Related Statute

1. Aircraft Noise Characteristics

The characteristics of an aircraft noise are as follows: 1) the high-frequency noise components are dominant. 2) the rear noise propagation of an aircraft is superior. 3) the acoustic power of an aircraft is higher than that of other traffic facilities such as road and rail. The principal noise sources of an aircraft are divided into the propulsion noise of an aircraft engine and the aerodynamic noise of an aircraft body (Figure 2-1), and the propulsion noise has a more influence than the aerodynamic noise (Figure 2-2).

2. Related Statute of Aircraft Noise

The municipal laws related to aircraft noise are the regulation law of noise and vibration in Ministry of Environment, and the Aviation Act in Ministry of Construction and Transportation. These laws cover the establishing restriction of facilities in the damage area of aircraft noise as well as the presentation of aircraft noise standard according to regional characteristics (Table 2-1).

Figure 2-1. Principal noise sources of aircraft[2]
Figure 2-2. Noise distribution of aircraft takeoff and landing[3]

Table 2-1. Facility establishment restriction (noise level unit: WECPNL)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Noise damage area</th>
<th>Noise damage expectation area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility &amp; Noise level</td>
<td>1st class 95</td>
<td>2nd class 90 - 95</td>
</tr>
<tr>
<td>Residential facility</td>
<td>Prohibition of new construction, and permission of enlarging and rebuilding</td>
<td>Permission of new, enlarging, and rebuilding</td>
</tr>
<tr>
<td>Educational facility</td>
<td>Prohibition of new, enlarging, and rebuilding construction</td>
<td>Construction including soundproof facilities</td>
</tr>
<tr>
<td>Medical facility</td>
<td>Permission of new, enlarging, and rebuilding construction including soundproof facilities</td>
<td></td>
</tr>
<tr>
<td>Public facility</td>
<td>Permission to establish facilities related to airport operation</td>
<td></td>
</tr>
<tr>
<td>Factory</td>
<td>Permission of new, enlarging, and rebuilding construction which isn’t related to aircraft noise</td>
<td></td>
</tr>
</tbody>
</table>
WECPNL (Weighted Equivalent Continuous Perceived Noise Level) is used as an aircraft noise assessment unit within the country and the calculation progress defined in Japan is applied.

\[ WEC_{PNL} = \overline{L}_{A_{\text{max}}} + 10 \log (N_1 + 3N_2 + 10N_3) - 27 \]

\( \overline{L}_{A_{\text{max}}} \): average value of maximum aircraft noise level per a day
\( N_1 \): flight number at 07:00-19:00
\( N_2 \): flight number at 19:00-22:00
\( N_3 \): flight number at 22:00-07:00

In the case of Japan and USA, a country-based aircraft noise standard is adopted and land-use plans are restricted according to it (Tables 2-2 and 2-3). In Table 3, the noise assessment units such as \( \text{NEF} \) and \( L_{dn} \) are defined as follows.

\[ \text{NEF} = \overline{EPNL} + 10 \log (N_1 + 3N_2 + 10N_3) - 88 \]

\( \overline{EPNL} \): average value of maximum \( EPNL \) per a day
\( N_1 \): flight number at 07:00-19:00
\( N_2 \): flight number at 19:00-22:00
\( N_3 \): flight number at 22:00-07:00

\[ L_{dn} = 10 \log \left[ \frac{1}{24} \left( 15 \times 10^{L_d/10} + 9 \times 10^{(L_n+10)/10} \right) \right] \]

\( L_d \): \( L_{eq} \) value at 07:00-22:00
\( L_n \): \( L_{eq} \) value at 22:00-07:00

<table>
<thead>
<tr>
<th>Classification</th>
<th>Noise level (WECPNL)</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>3rd class</td>
<td>Above 95</td>
<td>Moving and compensation, Formation of shock-absorbing green zone</td>
</tr>
<tr>
<td>2nd class</td>
<td>Above 90</td>
<td>Moving and compensation</td>
</tr>
<tr>
<td>1st class</td>
<td>Above 75</td>
<td>Permission to construct a new house including soundproof facility</td>
</tr>
</tbody>
</table>
### Table 2-3. Control standard of aircraft noise in USA[4]

<table>
<thead>
<tr>
<th>Administration</th>
<th>Classification</th>
<th>Unit</th>
<th>Limit value</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAA</td>
<td>Zone A</td>
<td>NEF</td>
<td>20</td>
<td>Permission to construct a new house</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L_{dn}</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zone B</td>
<td>NEF</td>
<td>30</td>
<td>Regular permission</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L_{dn}</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zone C</td>
<td>NEF</td>
<td>40</td>
<td>Partial permission</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L_{dn}</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zone D</td>
<td>NEF</td>
<td>Above 40</td>
<td>Prohibition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L_{dn}</td>
<td>Above 75</td>
<td></td>
</tr>
<tr>
<td>DOD</td>
<td>Outside of noise zone</td>
<td>L_{dn}</td>
<td>Below 65</td>
<td>Permission to construct a new house</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WECPNL</td>
<td>Below 78</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inside of noise zone</td>
<td>L_{dn}</td>
<td>Below 70</td>
<td>Restriction on new house construction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WECPNL</td>
<td>Below 83</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inside of noise zone</td>
<td>L_{dn}</td>
<td>Above 70</td>
<td>Restriction on new house construction(necessity of noise level investigation inside region)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WECPNL</td>
<td>Above 83</td>
<td></td>
</tr>
<tr>
<td>HUD</td>
<td>-</td>
<td>NEF</td>
<td>Below 30</td>
<td>Permission to construct a new house</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L_{dn}</td>
<td>Below 65</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>NEF</td>
<td>Below 40</td>
<td>Restriction on new house construction(noise reduction : above 10dB)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L_{dn}</td>
<td>Below 75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>NEF</td>
<td>Above 40</td>
<td>Prohibition of new house construction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L_{dn}</td>
<td>Above 75</td>
<td></td>
</tr>
</tbody>
</table>
III. Aircraft Noise Prediction and Assessment

1. Preparation Plan of Aircraft Noise Map

Noise map is the map which presents the distribution of noise values according to time variation based on predictive formula or experiential expression, and the impact assessment conducted over a very wide area is possible with noise map because of showing the noise levels visually[5]. The predictive model such as INM developed by FAA in 1978 is applied to prepare aircraft noise map in the EIA of aircraft noise(Figure 3-1), and this section suggests the effective preparation process of aircraft noise map with INM including detailed explanations and related figures. The summary of proposed computational process and resultant contents is displayed in Figures 3-2 ~ 3-6.

Figure 3-1. Aircraft noise prediction with INM[6]

2. Improvement Plan of Aircraft Noise Impact Prediction

A. Verification of aircraft noise prediction results with measurement data

Verifying the results of aircraft noise prediction is needed to grasp the impact range of aircraft noise around an airport and the proven measurement data of aircraft noise can be put to practical use(Figure 3-7). The final aircraft noise map through combining predictive results and measured data is of
great help in establishing the land-use plan according to the estimation of the impact scope and the exposed population due to aircraft noise.

**Figure 3-2. Brief computational process of INM[7]**

**Figure 3-3. Expression of aircraft flight path in INM[6]**
Figure 3-4. Expression of aircraft noise map in INM[6]

Figure 3-5. Expression of noise computational results in INM[6]
Figure 3-6. Proposal of aircraft noise computational process with INM

Figure 3-7. Example of comparison between predictive result and measured data[8]
B. Performance of aircraft noise prediction considering environmental information around airport

![Figure 3-8. Distribution of noise contour(50WECPNL) according to humidity change](image)

- thin line : humidity=70%, thick line : humidity=0%

![Figure 3-9. Distribution of noise contour(50WECPNL) according to wind speed change](image)

- thin line : wind speed=0km/h, thick line : wind speed=8km/h

The aircraft noise is absorbed by the atmosphere during propagation process, and the degree of absorption is influenced by the atmospheric conditions such as temperature and humidity as well as the frequency of aircraft noise. From this point of view, the comparative study of the predictive results according to the variation of the atmospheric humidity and wind
speed is performed to investigate the effect of noise map on the environmental change around an airport. Figures 3-8 and 3-9 show that the environment with the higher humidity and no wind increases aircraft noise impact range. From this result, the accurate environment data such as temperature, pressure, humidity, and wind speed around an airport are necessary, and the change of aircraft noise map according to the seasonal variation can be considered.

Figure 3-10. ICAO standard flight path in Kimpo airport[9]

Figure 3-11. Actual flight path in Kimpo airport[7]

C. Application of actually operating information in an airport

The AIP material published by Civil Aviation Safety Authority, Ministry of
Construction and Transportation is generally used to collect the data about airport and aircraft flight information. However, The ICAO standard flight path in the AIP material and the actual flight route share nothing in common(Figures 3-10 and 3-11), which results in the difference of the impact scope due to aircraft noise(Figures 3-12 and 3-13). In order to keep pace with the researchers in foreign countries(Figure 3-14), the construction of the actual flight information such as aircraft type, flight path including takeoff and landing, flight condition, and flight number must be preceded.

![Figure 3-12. Noise map with ICAO standard flight path in Kimpo airport](image)

**D. Aircraft noise prediction considering terrain effect**

In the EIA of aircraft noise around an airport, the preparation of noise map without terrain effect is mainly performed. However, it is necessary to consider the distribution of real topography or high buildings, which is a main subject in the field of aircraft noise map in foreign countries(Figure 3-15). The preparation of aircraft noise map through the combination of prediction model(INM) and GIS information is largely carried out to embody this effect, and Figures 3-16 and 3-17 show the difference of the aircraft noise distribution with and without terrain effect. The two methods are suggested to consider the terrain effect in preparing the aircraft noise map. One is the prediction or measurement of the aircraft noise distribution according to the
elevation of real topography or high buildings, and the other is the application of aircraft noise prediction model combined with the GIS data including the distribution of real topography or high buildings in the existing and development areas. The latter approach is more important to prevent the influence of aircraft noise before a thing takes place.

Figure 3-13. Noise map with actual flight path in Kimpo airport[7]

Figure 3-14. Study of noise map with aircraft actual flight path[11]
3. Improvement Plan of Aircraft Noise Impact Assessment

A. Establishment of the most suitable land-use plan
Figure 3-17. Distribution of noise contour(50WECPNL) according to terrain effect in landing
thin line : with terrain effect, thick line : without terrain effect

Based on the measurement data and prediction results (including noise map) in present and future airport operations, the feasibility study of location suitability is performed. If the influence of aircraft noise is expected, the most suitable land-use plan such as the change of development region must be established. Referring to the noise regulation standards and guidelines of domestic and foreign countries (Tables 3-1 and 3-2), the regions below 70 WECPNL are assigned as residential areas.

B. Environmental impact investigation in connection with aircraft noise

Because the present condition of aircraft noise is indicated in the stage of EIA, it is necessary to monitor the impact of aircraft noise continuously. To do
it, the comparison study between aircraft noise distribution in EIA and that after EIA (including construction and operation periods) must be performed.

Table 3-1. Land-use guideline in investigation handbook of EIA, Korea[13]

<table>
<thead>
<tr>
<th>Classification</th>
<th>WECPNL</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st class</td>
<td>Below 70</td>
<td>Residential area, Sightseeing and rest area, nature preservation area, school and hospital</td>
</tr>
<tr>
<td>2nd class</td>
<td>70-75</td>
<td>Necessity of building soundproof in residential area, school, and hospital</td>
</tr>
<tr>
<td>3rd class</td>
<td>75-80</td>
<td>Commercial area, Semi-industrial area, Necessity of building soundproof in residential area, school, and hospital</td>
</tr>
<tr>
<td>4th class</td>
<td>80-90</td>
<td>Construction of facility not connected with aircraft noise, Industrial area, Parking place, Warehouse, Farm</td>
</tr>
<tr>
<td>5th class</td>
<td>Above 90</td>
<td>Exclusive-use area of airport</td>
</tr>
</tbody>
</table>

Table 3-2. Comparison of aircraft noise regulation standard in foreign countries[7]

<table>
<thead>
<tr>
<th>Country</th>
<th>Noise quantity</th>
<th>WECPNL</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>England</td>
<td>NNI 25-29</td>
<td>65-69</td>
<td>No restriction on construction in house, school, hospital</td>
</tr>
<tr>
<td>USA</td>
<td>Below Ldn 55</td>
<td>Below 68</td>
<td>Permission to construct a house</td>
</tr>
<tr>
<td></td>
<td>(FAA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>Below 70</td>
<td>Below 70</td>
<td>Exclusive-use residential area</td>
</tr>
<tr>
<td></td>
<td>WECPNL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Application Plan of Aircraft Noise Map


EU Directive 2002/49/EC relates to the assessment and management of environmental noise. This Directive requires noise mapping to be carried out
using harmonized noise indicators and evaluation methods, specifying the scope of mapping, the methodology to be adopted, the outputs to be generated, and timetable to be followed. Knowledge on the European noise climate will be collected through noise mapping and standard processes will be in place for the development of action plans to reduce unacceptable noise levels. In the first phase of work, noise mapping will have to be carried out for urban agglomerations with more than 250,000 people, for major roads with more than 6 million vehicle movements per year, for major railways with more than 60,000 train movements, and for major airports (civil airports with more than 50,000 movements per year). All agglomerations of 100,000 or more people, major roads with more than 3 million vehicle movements and railways with more than 30,000 train movements will be covered in the second phase. Strategic noise maps are to be reviewed at least every five year after their date of preparation and action plans are to be reviewed at least every 5 year after their date of approval.

Figure 3-18. Construction of aircraft noise map in domestic airports[7,15]
B. Application of noise map in Korea

In foreign countries, the preparation of traffic noise map including road, rail, and aircraft noise is performed with measurement data and prediction results, which is utilized to establish the strategic plan and policy of traffic noise reduction. In order to keep pace with it, the construction of aircraft noise map in all domestic airports must be carried out with accurate aircraft noise prediction tools and database information about airport operation, and the constructed noise maps must be applied to establish the most suitable land-use plan in the stage of super ordinate plan (Figure 3-18) as well as to forming the plans and policies for aircraft noise reduction. Moreover, the construction of complex noise map covering road, rail, and aircraft noise and the according traffic noise reduction plans are needed from the prolonged point of view. Finally, the important role of constructed traffic noise maps as reference materials is required and the combination of EIASS[16] and constructed noise maps is a good example (Figure 3-19).

Figure 3-19. EIASS[16]
IV. Summary

Because the aircraft noise is regarded as the significant environmental problem around an airport, the weight of EIA about aircraft noise is increasing in the case of developing urban region and residential area around an airport. In order to perform the EIA of aircraft noise effectively, this study is focused on suggesting the improvement plan of aircraft noise prediction and assessment, which includes preparation plan of aircraft noise map, improvement plan of aircraft noise impact prediction and assessment, and application plan of aircraft noise map.

The aircraft noise map is important in aircraft noise impact prediction, and the preparation plan of aircraft noise map covers the detailed explanations with related figures and tables in INM commercial software, which is widely used for aircraft noise prediction in domestic and foreign countries. The improvement plans of aircraft noise impact prediction and assessment are proposed as follows. First, the verification of aircraft noise prediction results is needed and the proven measurement data of aircraft noise can be put to practical use. Second, the collection of the accurate environment data (including seasonal variation) around an airport is necessary. Third, the database construction of the actual flight information must be preceded. Fourth, the application of aircraft noise prediction model including the distribution of real topography or high buildings in the existing and developing areas is required. Fifth, the feasibility study of location suitability must be performed at the base of the measurement data and prediction results. Sixth, it is necessary to monitor the impact of aircraft noise continuously.

The construction of aircraft noise map in all domestic airports must be carried out with accurate aircraft noise prediction tools and database information about airport operation, and the constructed noise maps must be applied to establish the most suitable land-use plan in the stage of super ordinate plan as well as to forming the plans and policies for aircraft noise reduction. Moreover, the construction of complex noise map covering road, rail, and aircraft noise and the according traffic noise reduction plans are needed from the prolonged point of view. Finally, the important role of constructed traffic noise maps as reference materials is required.
References


