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21-24 AUGUST
SCOTTISH EVENT CAMPUS
GLASGOW
2022

# New guidance manual for the monitoring and evaluation of aircraft noise in Vietnam with an experimental application at Noi Bai International Airport

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***ABSTRACT***

*Along with air traffic expansion, an increasing number of complaints from residents regarding aircraft noise from the airport operation has raised an environmental awareness of aircraft noise pollution in Vietnam. It is an urgent task for local authorities to assess aircraft noise exposure reliably. Aircraft noise monitoring systems and suitable policies need to be developed for land use and flight operation control to reduce and prevent aircraft noise pollution. However, Vietnam has had no legal documents or instructions on measurement and evaluation methods or the equipment and monitoring systems for measuring and analyzing aircraft noise. Against that background, the Civil Aviation Authority of Vietnam (CAAV) has developed a new guidance manual to measure and evaluate aircraft noise within the cooperation project on Airport Environment Preservation and Aircraft Noise Monitoring in Vietnam. This project was implemented by the CAAV, the Japan International Cooperation Agency (JICA), and RION Co., Ltd.. As a model case, a system of the*

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*minimum-required equipment with four noise monitors for the continuous monitoring of aircraft noise was installed around Noi Bai International Airport. This study explains the formulation of the new guidance manual and discusses the analysis results of the monitoring data obtained from January 2019 to August 2021.*

## 1. INTRODUCTION

The airport system of Vietnam was built during the war to serve military purposes. Afterward, these airports were gradually converted to serve civil aviation in peacetime. In recent years, Vietnam has witnessed the development of the economy and the expansion of air traffic. The Vietnamese government is actively enhancing the serviceability of air transport with a plan to upgrade the airport system to accommodate approximately 278 million passengers [1]. More than 95% of the population will have access to the airport within 100 km. This plan includes gradual upgrades for 22 existing airports' effective utilization and investment in 7 new airports. However, the economic growth has accelerated the progress of urbanization and made the airport vicinities densely populated. The noise impact study around three major airports in Vietnam found that many residential areas near the major airports were exposed to noise levels higher than the safety threshold [2,3]. The increased occurrence of aircraft noise complaints urges the stakeholders to have suitable measures against aircraft noise. It is also challenging for the management authorities to minimize causes for complaints by reducing noise impact on people's lives while enhancing air transportation.

Since 2014, the Civil Aviation Authority of Vietnam (CAAV) has taken the first steps to develop policies to mitigate the noise impact of the activities of the airports. Acknowledging the importance of predictive noise maps in devising environmental measures, CAAV has commanded major airports to create noise maps as the basis for land use planning and noise control for areas around airports. This task, in turn, requires suitable noise measuring systems that can perform continuous monitoring because the accuracy of noise maps can be verified by monitoring changes in the noise exposure around the airport over a long period. This duty was challenging because there were no equipment and experience operating aircraft noise monitoring systems. Other concerns were issuing specific standards and guidelines and measures that suit the individual airport's actual situation.

Against such background, from 2017 to 2019, CAAV, the Japan International Cooperation Agency (JICA), and RION Co., Ltd. implemented a cooperation project on Airport Environment Preservation and Aircraft Noise Monitoring in Vietnam. This project aimed to formulate a manual for measurement and evaluation so that related authorities could establish a system for continuous noise monitoring in Vietnam. Also, in this project, to facilitate the practice of long-term noise monitoring guided in the manual, a system of the minimum-required equipment was installed for Noi Bai International Airport (called NIA in the following) as a model case. By correctly analyzing and interpreting the monitoring results and observing the transition of the noise situation over time, the authorities can assess devising solutions and preventive measures. This paper explains the formulation of the new guidance manual and discusses the analysis results of the monitoring data obtained at NIA from January 2019 to August 2021.

## 2. THE FORMULATION OF THE GUIDANCE MANUAL

A series of seminars on aircraft noise issues among Vietnamese and Japanese stakeholders was held. The participants discussed Vietnamese technical and facility conditions and cultural customs and reflected the obtained knowledge in the manual's content. Furthermore, technology and experience in aircraft noise monitoring and airport environment maintenance operations accumulated in Japan were referred. Preparation of a guidance manual was done by collaborating with Japanese experts. The manual was firstly composed based on the contents of the corresponding manuals for aircraft noise measurement and monitoring issued by the Ministry of the Environment of Japan. The manual also intended to conform to international standards and match the situation in Vietnam. As a final result, a guidance manual for monitoring and evaluating aircraft noise around airports in Vietnam was issued as a national decision in February 2019.

Vietnam has standards for general environmental noise but no specific criteria and measurement methods for aircraft noise. In addition, nationwide uniform standards and guidelines must be set to protect the environment around many airports through the country and prevent damage before it occurs. Therefore, it was essential to establish procedures for monitoring and measurement, which can become the basis of legal regulations. The project encompassed creating a manual, securing human resources, and conducting education and training sessions to impart the knowledge and skills necessary for proper measurement. The manual was formulated to be a framework for the education and training of human resources in airport environment management. It includes guidance on consistent procedures from measurement to analyzing and evaluating objectively. In the manual, the evaluation indexes, measurement methods, monitoring items, and specifications of monitoring equipment for the initial installation are suggested to be based on the recommendation of the specific regulations for aircraft noise that can be issued in the future. Methods of continuous trend observation over a more extended period are also specified in the manual.

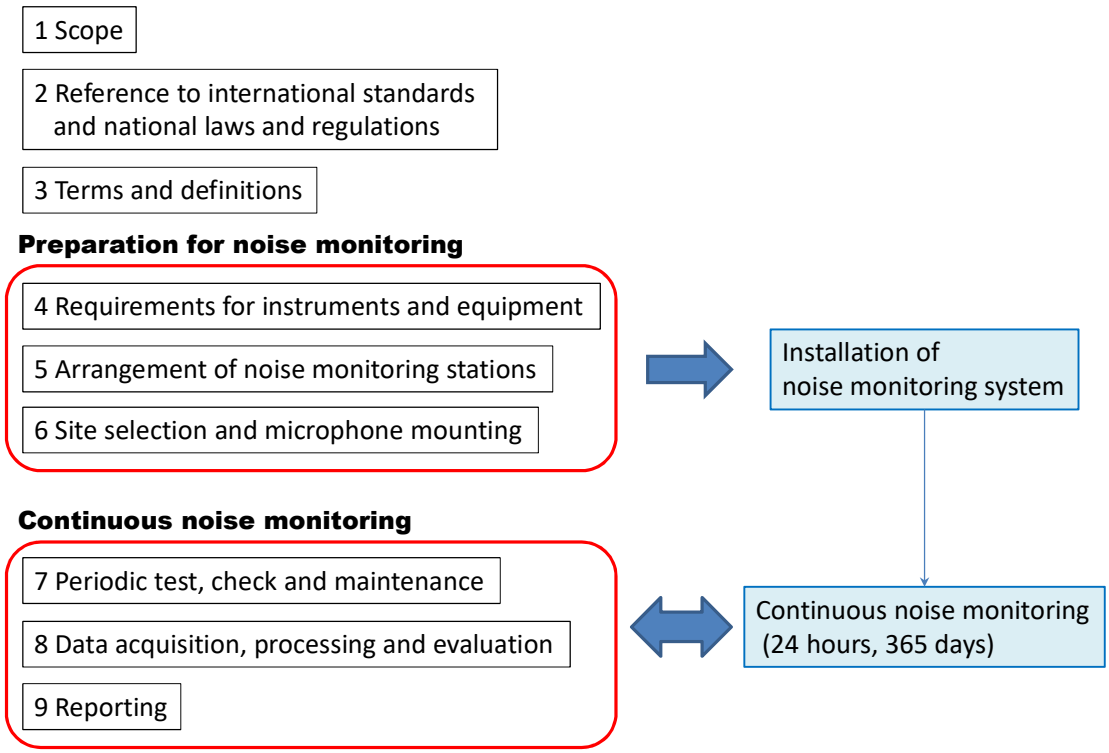


Figure 1: A procedure for the monitoring and evaluation of aircraft noise in Vietnam

Figure 1 shows the outline of actual procedures for monitoring and measuring aircraft noise, following the description and requirements specified in the manual. Individual steps of the working process, i.e., preparation for noise monitoring, implementation of continuous noise monitoring, and reporting, correspond to the content of each chapter in the manual. The main focuses are the selection of monitoring locations and specification of the noise monitoring system, which is described concerning the installation and maintenance of the monitoring system. In addition, as part of formulating environmental policy, it is necessary to assess the noise impact predicted by the noise map. The data needed for creating a noise map and confirming the validity of the noise map can be provided by the observations collected from the noise monitoring system.

## 3. BUILDING A NOISE MONITORING SYSTEM FOR NOI BAI AS A MODEL CASE

### 3.1. Outline of the preliminary noise monitoring system at NIA

Selecting NIA as a model case, we built a preliminary aircraft noise monitoring system as a minimum setup of four noise monitors necessary to grasp the status of all take-off and landing operations and noise event generation at the airport. NIA has two closed-parallel runways in the east-west direction (11L-29R and 11R-29L). Since the operational directions of the runway are influenced by the wind direction, the flights toward the east occupied the majority of the total movements.

To track flight directions and operation of these two runways and estimate flight information from the noise monitoring results, one monitoring station near both ends of each runway, three stations inside and one outside the airport, were set up. The station outside the airport, named VOR/DME, is functioned to provide primary data for confirming the validity of the prediction in parallel with monitoring. The data processing center is located inside the headquarters building of the NIA. Figure 2 shows the configuration of NIA's two runways with flight paths and the locations of the four monitoring stations, i.e., 'K1' at the west end of the northern runway 11L-29R, '29L' and '11R' at the east and west end of the southern runway 11R-29L, respectively. 'VOR/DME' station is located outside the airfield on the east side of NIA.

The construction of the basements and device installation was completed in December 2018. The system started to be in operation in January 2019. The sensor failure happened due to lightning and made the data processing system stop working. This problem was soon later repaired and returned to regular operation. The system is designed to ensure that the CAAV and related authorities can handle themselves for continued operation and tracking of noise situation after installation and trial operation. Technical training was conducted so that the Vietnamese side could measure to assess on-site conditions and take measures to solve problems. The collaboration project comprised lectures by Japanese experts and Rion engineers providing hands-on training utilizing the equipment installed in the field around the airport and the data processing software installed at the Noi Bai airport office. Furthermore, methods for daily inspection of equipment were demonstrated on the actual devices.

The current aircraft noise monitoring system at NIA, introduced through this project, is preliminary. Still, it is vital to carry out continuous monitoring on a long-term basis and carefully observe the transition of the noise situation over time. According to the airport master plan for the 2021 to 2030 period with a vision for 2050, the government will prioritize investment in the construction, expansion, and upgrade of the major international airports. In particular, new runways and terminals will be formed during this period to support NIA's existing system. The plan to expand Terminal T2 (accommodating 15 million passengers annually) and build Runway 3 at Terminal T3 in the south of the port has been approved and prepared for implementation. The system, therefore,

must be able to become part of a full-scale system with more monitoring devices and functions to be established in the future.

Although urbanization has already progressed considerably around NIA, the population is less dense than in the other two major airports, Tan Son Nhat and Da Nang in Vietnam. The land-use measures can still be effective for NIA. By learning proper measurement techniques, it becomes possible to correctly interpret the various evaluation values for noise pollution, with a view towards preventive measures such as noise preventative land use planning.


Figure 2: Location of four monitoring devices installed at Noi Bai International Airport.

### 3.2. Data acquisition and processing methods

The technology to be disseminated through this project is measurement technology for monitoring aircraft noise for environmental protection around the airport. It is necessary to identify the sound source and determine whether the measured noise is due to aircraft or other facilities such as roads in the vicinity of the airport. Furthermore, aircraft noise changes depending on runway usage, season, and wind direction. Therefore, year-round noise monitoring or multiple short-term measurements should be performed, and noise evaluation is necessary. As described above, aircraft noise measurement systems are designed for continuous noise measurement while identifying the sound source. The equipment itself operates unattended, but the various tasks required for operation, including setup and data processing, require specialized knowledge and expertise.

It is also common to include an aircraft identification function that allows the determination of the type of aircraft, thereby proving that the measured noise is, in fact, aircraft noise. For this purpose, it is common to identify the aircraft by receiving radio signals emitted from it, but such signals are only transmitted by ordinary passenger aircraft. Some aircraft do not transmit radio signals that allow the identification or only transmit encrypted signals, so they cannot be identified by model identification devices that receive radio waves.

In addition, equipment for continuous monitoring of the sound incidence direction enables tracking of the sound source position and movement. Thanks to these features, identification is also possible for the aircraft without relying on radio information. Like in other developing countries, many aircraft types are used at the same airport in Vietnam. The system enables the identification of both types of aircraft. Vietnam has higher humidity than Japan; the system is equipped with a heater to minimize the effect of moisture. By contrast, measuring devices from other companies do not come with such a heater. This feature reflects ingenuity and know-how unique to Japan, a country with high humidity. In addition, a remote microphone sensitivity checking function is provided to confirm that the measuring equipment is operating normally and that the microphone's sensitivity, which serves as a sensor, has not changed.

## 4. ILLUSTRATION OF DATA ANALYSIS OF MONITORING DATA AT NIA

More than two years have passed since NIA's aircraft monitoring equipment was installed. Many monitoring data have been accumulated. This part presents the aggregation of the data in two years, 2019-2021, to confirm the effectiveness and demonstrate the usefulness of monitoring data.

### 4.1. Analysis of runway use and flight operations

Below are analysis results of flight tracking and noise levels observed by the monitoring system set up for NIA from January 2019 to August 2021.

Figure 3 shows the number of flights of take-offs and landings every hour obtained by analyzing all the observed noise events. Figure 4 shows the total hourly number of noise event at the VOR/DME station. It can be seen that although there are fewer flights from 2 to 5 am, aircraft are operated all day, including midnight and early morning. The air traffic control office can provide such information, but it can also be obtained from the installed noise monitoring system.

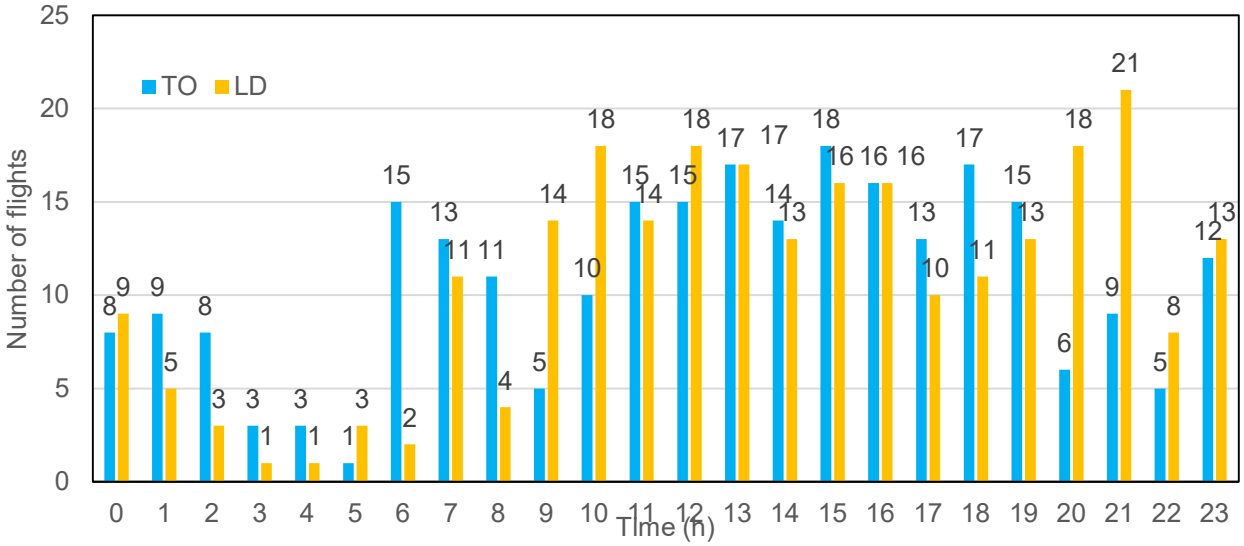


Figure 3: Hourly take-off (TO) and landing (LD) status

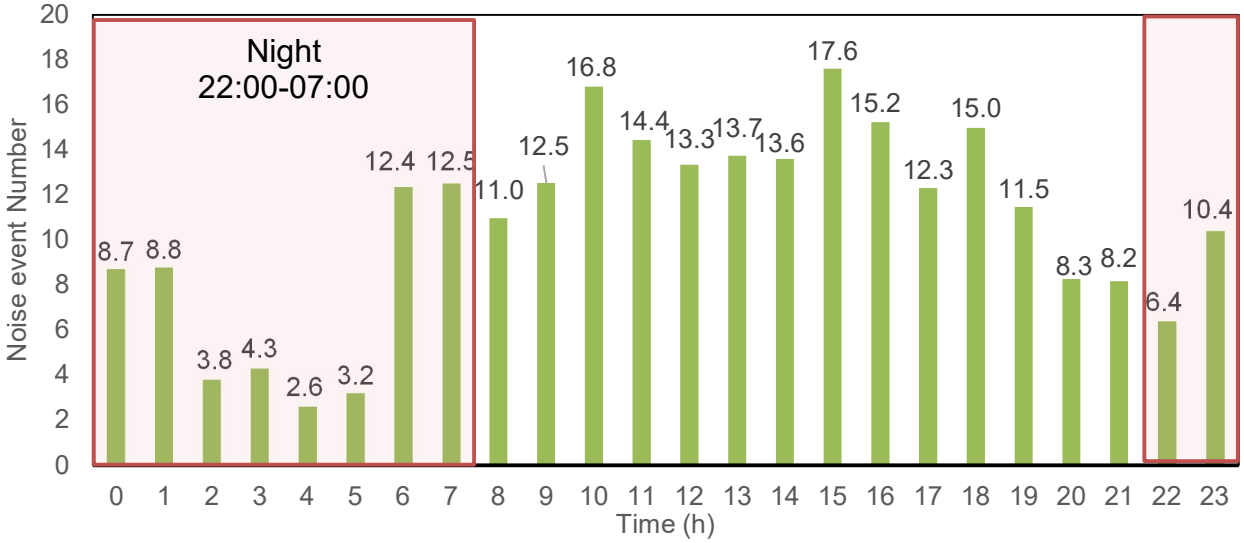


Figure 4: The hourly total number of noise events at the VOR/DME station

Figure 5 shows the distribution of the maximum noise level by aircraft type and take-off weight observed at the VOR/DME station. The aircraft types most used at NIA are circled in red. They are A320, A321, A359, and B789. These aircraft types also contribute the majority of noise exposure. This information suggests what types of aircraft are helping to reduce noise levels. For example, the A359 is one of the lowest noise level aircraft of similar maximum take-off weight. Preferential treatment for such low-noise aircraft should be considered in future aviation environmental policies.

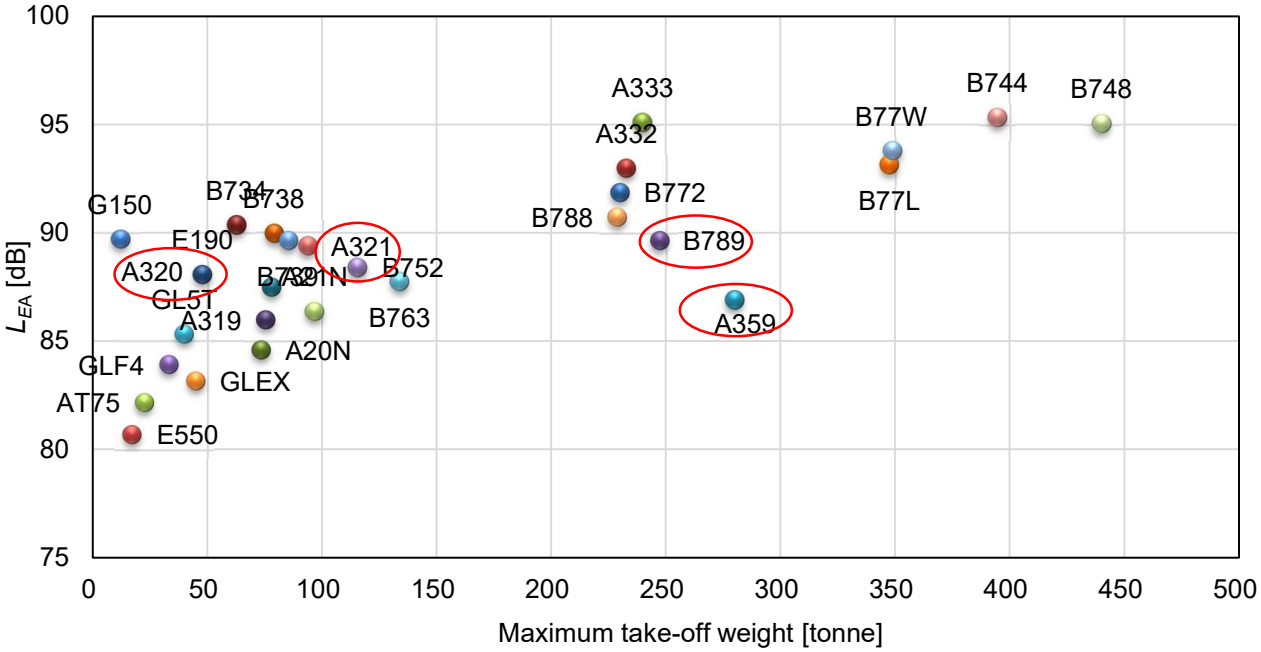


Figure 5: Noise levels observed at the VOR/DME station and maximum take-off weight of take-offs by aircraft type

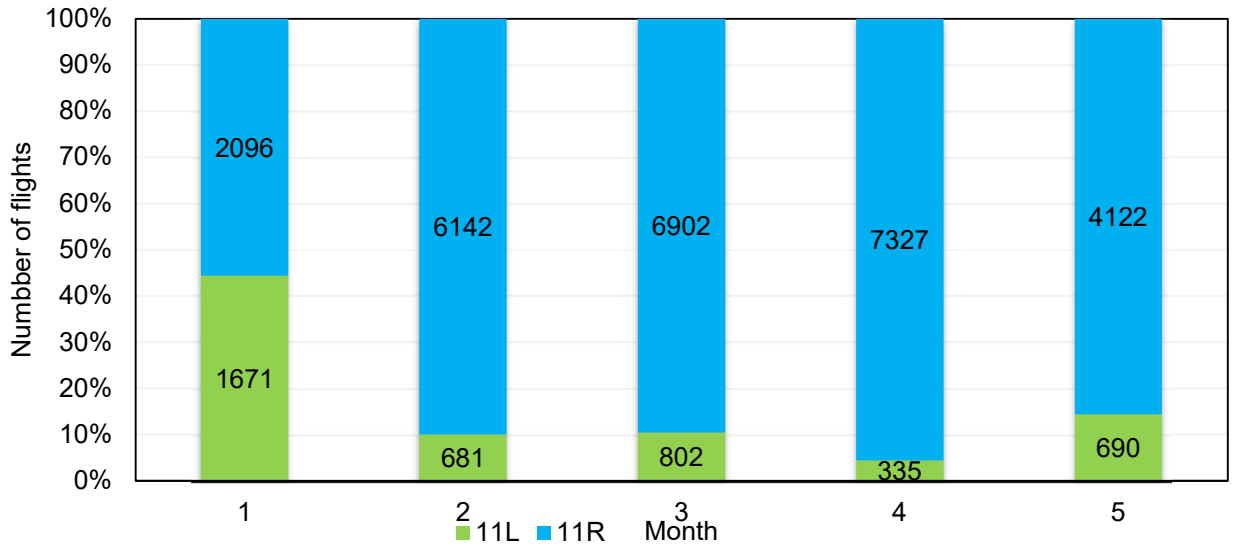


Figure 6: The ratio of the runway use of eastward take-off aircraft used based on data obtained from VOR/DME station

Figure 6 shows an analysis result of the ratio of runway use by eastward take-off aircraft based on monthly observation data obtained from VOR/DME station. It can be seen that both runways were used in January, but after February it can be seen that the 11R was mainly used as the departure runway.

### 4.2. Comparison of situations before and after the pandemic occurred

The monitoring device installed at NIA is for trial use and makes it possible to observe all flight events continuously for an extended period. This analysis helps assess flight operation and the noise situation during the operation period. The travel restrictions due to the COVID-19 pandemic since early 2020 worldwide have caused many changes in all aspects of life, especially in the acoustic environment. At the end of March 2020, all international flights were closed due to the pandemic, causing an unprecedented change to the acoustic environment around NIA. Figure 7 shows the flight number and noise levels observed based on the continuous observation for two years of 2019-2021 in the context of reduced operation due to the pandemic at NIA.

It can be seen from Figure 7 that the number of flights at NIA dropped sharply four times, corresponding to the times when the government ordered travel restrictions to prevent the disease from spreading. Overall, the noise levels around NIA were found to decrease after the epidemic outbreak with the four significant drops. This analysis allows an understanding of the degree of the environmental change in the vicinity of the airport. The other function is to provide the information required to create a noise prediction map (Figure 8). By understanding the operation status and noise status by time zone, the authorities can estimate the magnitude of noise impact, especially the concern about the night operation of aircraft, which can cause sleep effects.

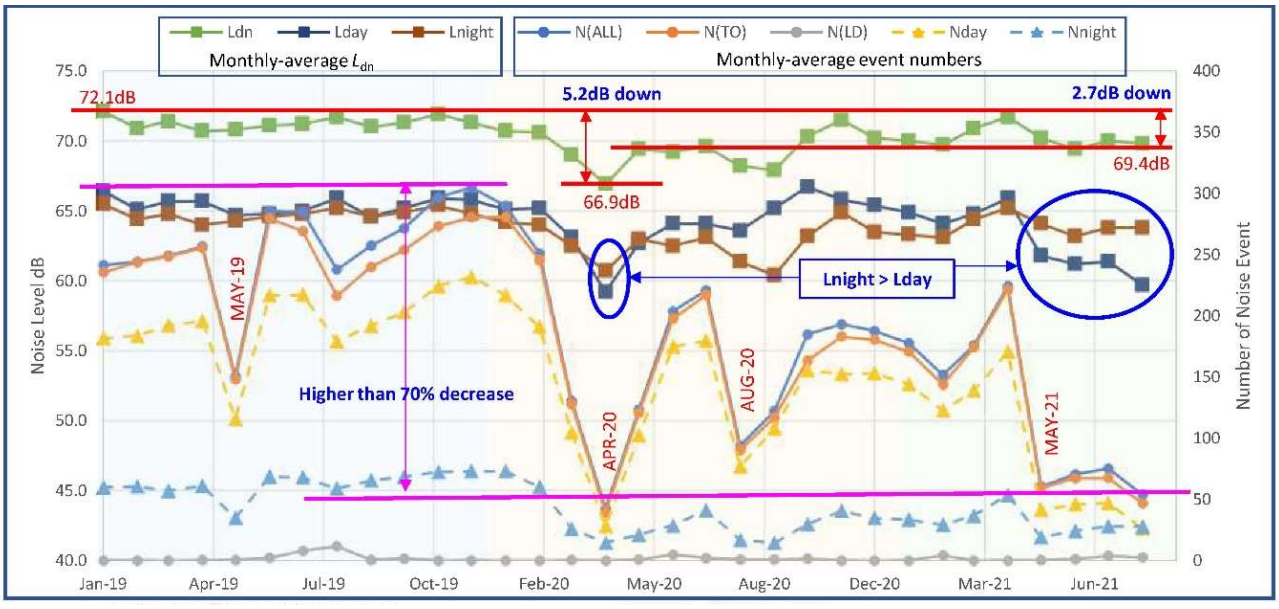


Figure 7: The flight number and noise levels observed in two years of 2019-2021 at NIA

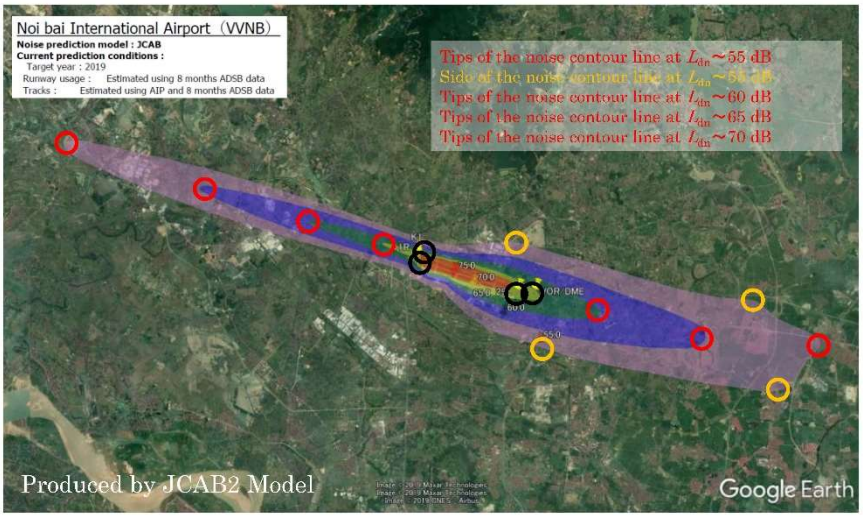


Figure 8: The noise prediction map of NIA produced by the JCAB2 model

## 5. SUMMARY

Through this project, measurement technology and equipment and guidance manuals necessary for monitoring and measurement were introduced. It should be aware that environmental policy planning and the acquisition of noise prediction technology are essential for the sustainable development of the aviation industry in Vietnam. At the same time, the noise monitoring work can contribute to conserving and improving the quality of the living environment in Vietnam. The manual was composed in detail so that CAAV and related authorities can apply it in measurement and continuous monitoring works.

RION and JICA supported CAAV in preparing a manual for codifying the measurement methods and evaluation of aircraft noise, starting from the basic plan for the system. CAAV is also supported in basic investigations and contributes to establishing indices and guidelines for noise evaluation. As a result, specifications, scale, arrangement, and operation planning of monitoring equipment have been confirmed [4]. This paper presented the monitoring results of data compilation extracted from the installed system. The situation during the operation period, such as the usage status of the runway, information regarding the operation status, and noise status by time zone, raised consideration regarding aircraft operation that considers possible sleep effects. It has been proved that formulating an aircraft noise evaluation system promotes understanding of aircraft noise problems.

## 6. FURTHER WORKS

The Japanese government and the Japan International Cooperation Agency (JICA) have been supporting the transportation sector in Vietnam, with airports playing an important role. Vietnam aims to welcome 25 million visitors abroad by 2025 and 100 million by 2030. In preparation for this development, a second terminal (Terminal 2 for international flights) was built at NIA and has come into operation since December 2014. Other investments in constructing new airports for mountainous and island areas like Dien Bien, Con Dao, Sapa, and Pleiku, construction, and expansion to meet transportation needs and ensure defense and security. Until 2025, a construction project of Long Thanh International Airport, which can accommodate 25 million passengers annually, is the government's priority. Next, the construction of the T3 terminal at Tan Son Nhat International Airport to accommodate 20 million passengers annually, the expansion of the T2 terminal to accommodate

15 million passengers annually, and the new Runway 3 and Terminal T3 to the south of NIA will be the government's next moves.

The environmental impacts as the consequence of the above development need continuously observing. The aviation authorities should keep monitoring the noise situation throughout the year rather than only for a limited period to appropriately manage noise issues around the airport. Therefore, a long-term monitoring system that allows understanding changes from year to year is necessary. Adding more noise monitoring locations is essential to continuously grasp the flight status and the secular variation of the noise exposure status. Moreover, creating a noise prediction map and setting up monitoring stations at appropriate locations to confirm the validity of the noise map is essential for managing and reducing the affected area of aircraft noise. After the installation, it is necessary to set up a continuous maintenance system for the equipment. In addition, a working system that can synthesize and provide the required information by analyzing monitoring results, creating diagrams, and collecting reports, promptly also needs to be established and maintained operating for a long term.

## 7. ACKNOWLEDGEMENTS

This work was performed within the framework of a technical collaboration and cooperation program toward establishing monitoring and measuring technology of aircraft noise in Vietnam between JICA, RION Co., Ltd., and the CAAV.

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