inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 7.1

GROUND NOISE MONITORING SYSTEM AT NARITA AIRPORT AND IDENTIFICATION OF NOISE SOURCES

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Keywords:
JM1TLC, LXU46Y

ABSTRACT
This paper describes a brief outline of a new automatic noise monitoring system, which was installed at Narita Airport last November as a environmental countermeasure. The system monitors noise due to airport ground activities separately from fly-over noise. The system consists of eight remote stations and a central station made of Windows NT data processing & communication server. It has a specific function to identify or classify sound sources of airport ground noises due to engine run-up tests, APU operations, towing car's passing, airport-construction machinery operations and so on.

1 - INTRODUCTION
The New Tokyo International Airport (Narita Airport) is one of the world's major air transportation hubs. Fifty airlines from 38 countries fly into the airport, which sees some 67,000 passengers and 4,400 tones of cargo per day pass through its facilities. Narita Airport has, however, been obliged to operate using a single runway, and it cannot meet the demand of newcomers from 33 countries yet. To solve this congestion, the Narita airport authority (NAA) started the construction of a parallel runway last December. There was a great difficulty before NAA managed to reach an agreement with inhabitants against construction of the parallel runway and relevant city governments. Roundtable Conferences among all the related associations were held 12 times since September 1993 in order to solve various problems resulting from the further airport construction. Finally, the negotiations came to a mutual agreement and they concluded 22 items of agreements. One of the agreements was to make the best efforts towards decreasing noise due to airport ground activities such as engine run-up tests, aircraft towing, APU operations and so on. The noise is called as ground noise in the following.
In response to the agreements, NAA has laid down several rules to regulate airport ground activities such as engine run-up tests and APU operations to reduce ground noise. Besides, since 1995, field measurements of ground noise has been periodically fulfilled $2-4$ times a year at Chiyoda and Sanrizuka regions, where people sometimes make complaints about ground noise, close to the airport (See Figure 1). However, the situation of ground activities changes day to day and the sound propagation over ground is strongly affected by the weather conditions, resulting in a large fluctuation of noise exposure due to ground operation time to time. Therefore, it is difficult to evaluate the effect of ground noise correctly by short- term measurements. Besides, airline companies and NAA has now constructed a new noise reduction hanger for engine run-up tests. It may increase the frequency of run-up noise generation. To cope with these situations, NAA decided to install a new unattended ground- noise monitoring system in order to monitor the noise 24 hours a day. The construction was completed last November and it has come into regular operation from April 1st, 2000.

2 - SYSTEM CONFIGURATION AND ITS FUNCTIONS
The new system consists of eight remote monitoring stations and a central station (Windows NT data processing & communication servers and peripheral devices). They are connected each other using

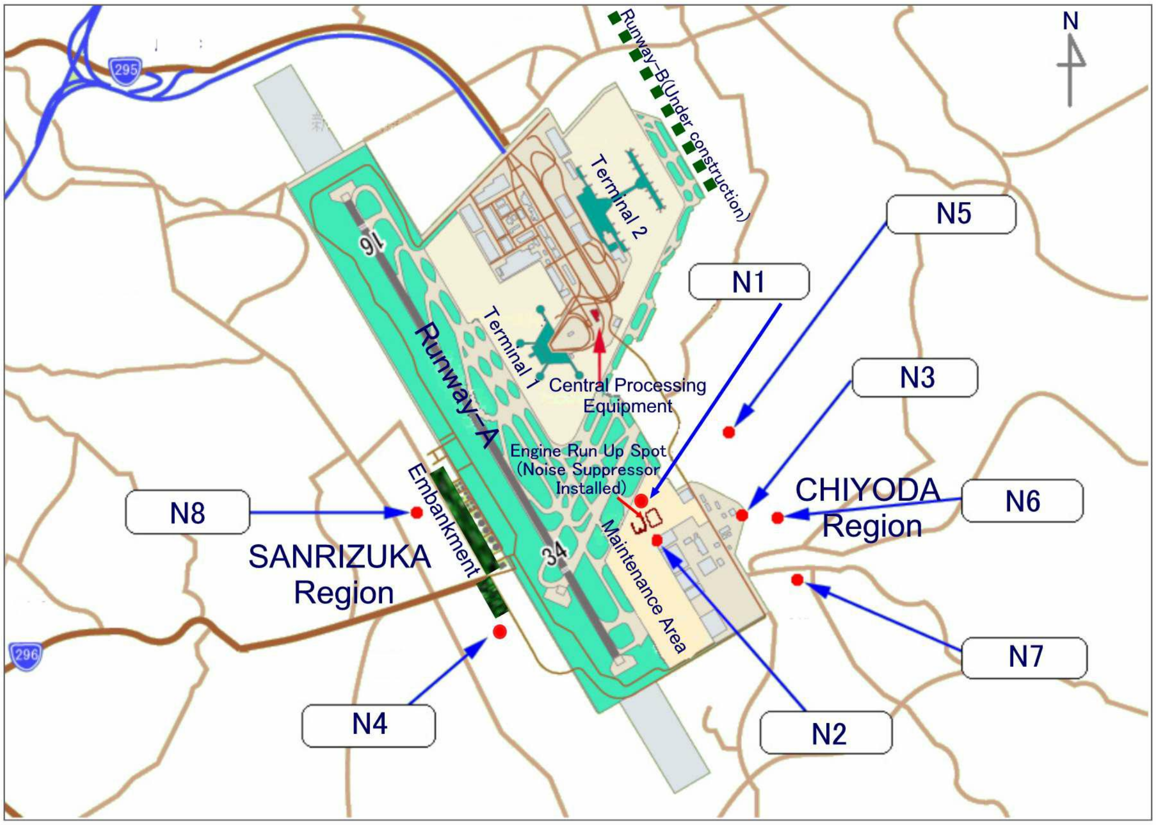

Figure 1: Site location of eight remote monitoring stations, the central station.

TCP/IP protocol, 64 KBPS via an exclusive telephone line. Figure 1 shows a geographical site location of the central station, eight remote stations and engine run-up test facilities.

2.1 - Remote monitoring stations

The number of remote stations was limited to the minimum due to the cost for installation and maintenance. The eight remote stations N1 − N8 were set up inside, outside and near the boundary of the airport. First, N1 is located close to the engine run-up spot to identify the execution of engine run-up operations and to estimate sound power correctly near the noise source. N2 was installed on the corner of the rooftop of an airline hanger to discriminate noise events due to APU and towing operations around the apron. N5 − N7 are stations for monitoring ground noise exposure at locations representing Chiyoda residential area, while N8 represent Sanrizuka. We decided to set up a station in Sanrizuka because of a dense population, although soundproofing embankments screen airport ground noise. Finally, N3 and N4 were placed near the boundary of airport. Observation at these stations is expected to be a reference for evaluation of noise propagation to the surrounding residential areas.

2.2 - Setup of remote monitoring station

Every station has a main microphone of a sound level meter for noise level measurement and three extra paired microphones for the detection of instantaneous 3-dimensional sound arrival direction [1], together with various devices such as a main processing unit, a noise identification unit and so on. From the output of the sound level meter, short-term average sound level every one second ($L_{Aeq,1s}$) and the maximum sound level during the one second ($L_{Asmax,1s}$) are calculated for the evaluation of ground noise, after the sound signal is sampled at every 20.8 microsecond. On the other hand, the sound data observed using the three paired microphones are processed every 0.2 s in the aircraft noise identifying unit, in order to calculate instantaneous sound arrival direction as angles of elevation and azimuth.

2.3 - Functions of a remote station

The main processing unit stores both the data synchronously for further data reduction and it carries out various data reduction. It estimates short-duration noise events ('noise peak') such as aircraft fly-over and long-lasting intermittent noise ('intermittent event') like engine run-up noise, by applying the following procedure using the noise floor information every 1 s [2]. A 95 % percentile level $L_{95,10min}$

during 10 minutes calculated every instant is used as noise floor for the detection of 'noise peak', while a 95 % percentile level $L_{95,1h}$ during one hour as the noise floor for 'intermittent event' evaluation. Noise events are identified using certain threshold values on maximum sound level and sound duration above noise floor. Information recorded for a 'noise peak' is L_{Asmax}, L_{AE}, sound duration, time of occurrence and a result of aircraft identification. Information for a 'intermittent event' is a distribution of sound arrival direction during the event and a result of sound source identification in addition to the same information for a 'noise peak'. The remote station preserves data of sound pressure signals as a ten-second long WAVE file or transmits it to the central processing equipment when the sound level goes over a certain threshold determined in advance. It also calculates and stores so called LEQ metrics $L_{Aeq,24h}$, $L_{Aeq-air,24h}$, $L_{Aeq,daytime}$ and $L_{Aeq,nighttime}$ everyday. Note, although the height of microphones was basically set to 4 m above the floor, the floor height was forced to change place to place from about 4 to 40 meters above ground due to the limited options for site selection. However, because of this, we could set up devices for meteorological observation at three stations N3, N5 and N7 to obtain weather information. The height is 2 m, 20 m and 40 m above the ground. The weather information is available for prediction of sound propagation to residential areas.

2.4 - Setup of the central station

The central station consists of several Windows NT data processing & communication servers and their peripheral devices. It automatically controls and receives data from the eight remote stations. At the same time it shows the current noise situation at every remote station and weather conditions in real time operation. It also communicates with other systems such as a aircraft fly-over noise monitoring system to get information about flight operations. The central station process the data obtained and make up figures and tables for reports after re-check analysis of source classification by hand. It is possible not only to listen to the real sound at the eight stations, but also to listen to the recorded sound of 'noise peak' that satisfied the prescribed threshold condition. The central station has been installed in an integrated airport-environment monitor room, NAA central office building. In the room are concentrated three other central stations for monitoring aircraft fly-over noise, air pollution and water drainage from the airport facilities, but at present each system operates independently.

3 - METHOD OF IDENTIFICATION OF NOISE SOURCES

As is stated above, temporal change in sound arrival direction is used as the basis of the method of sound source identification [1, 2]. Each remote station observes noise events as short-duration noise peaks and long-lasting intermittent events at the same time. So, the same portion of a noise level recording may be identified as a noise peak and intermittent event at the same time. In general, noise due to aircraft fly-over (take-off & landing) and towing is to be identified as a noise peak, while noise of engine run-up and APU operation as an intermittent event. Aircraft fly-over noise is automatically excluded using flight information obtained from the other system. Ground noise such as engine test and APU can be identified using data of observed at remote stations N1 and N2, that is, L_{Asmax}, sound duration, time of occurrence and the distribution of sound arrival direction. For example, an intermittent event observed at N1 or N2 is identified to be engine run-up noise if the event satisfies a predetermined threshold condition on level and sound duration and if a certain part of instantaneous sound of the event comes from the direction of an engine run-up spot. We can also distinguish a towing sound, because the sound direction changes as the source moves on the ground. An intermittent event may include sound from two or more sound sources such as engine run-up and aircraft fly-over. It is also possible to be distinguished using the sound arrival direction. The sound sources of intermittent events at stations N3 − N8 distant from the maintenance area in the airport can be identified using the result of N1 & N2.

Figures 2 and 3 show examples of data observation being used for the sound source identification stated above. Fig. 2 shows temporal change in sound level and sound arrival direction (elevation and azimuth) at station N1 and N2 (respectively, upper and lower figures) during a certain time zone at night. In the upper figure, we identify several noise peaks due to take-off and an intermittent event due to engine test, while in the lower figure APU operation is also identified.

Moreover, Fig. 4 shows the distribution of sound arrival direction obtained from every 1 sec data in 24 hours. The left figure, in case of all environ- mental noises, shows that this system identified the arrival direction of take-off / landing aircraft noises at 10 degrees. The right figure, in case of airport ground noise, shows that this system identified the arrival direction of engine run-up noise at 55 degrees and APU noise at 90 degrees. And, we can improve the accuracy in identification by playing back preserved data of sound pressure signals.

As stated above, this system identifies airport ground noises precisely, but we must study how to regulate these noises.

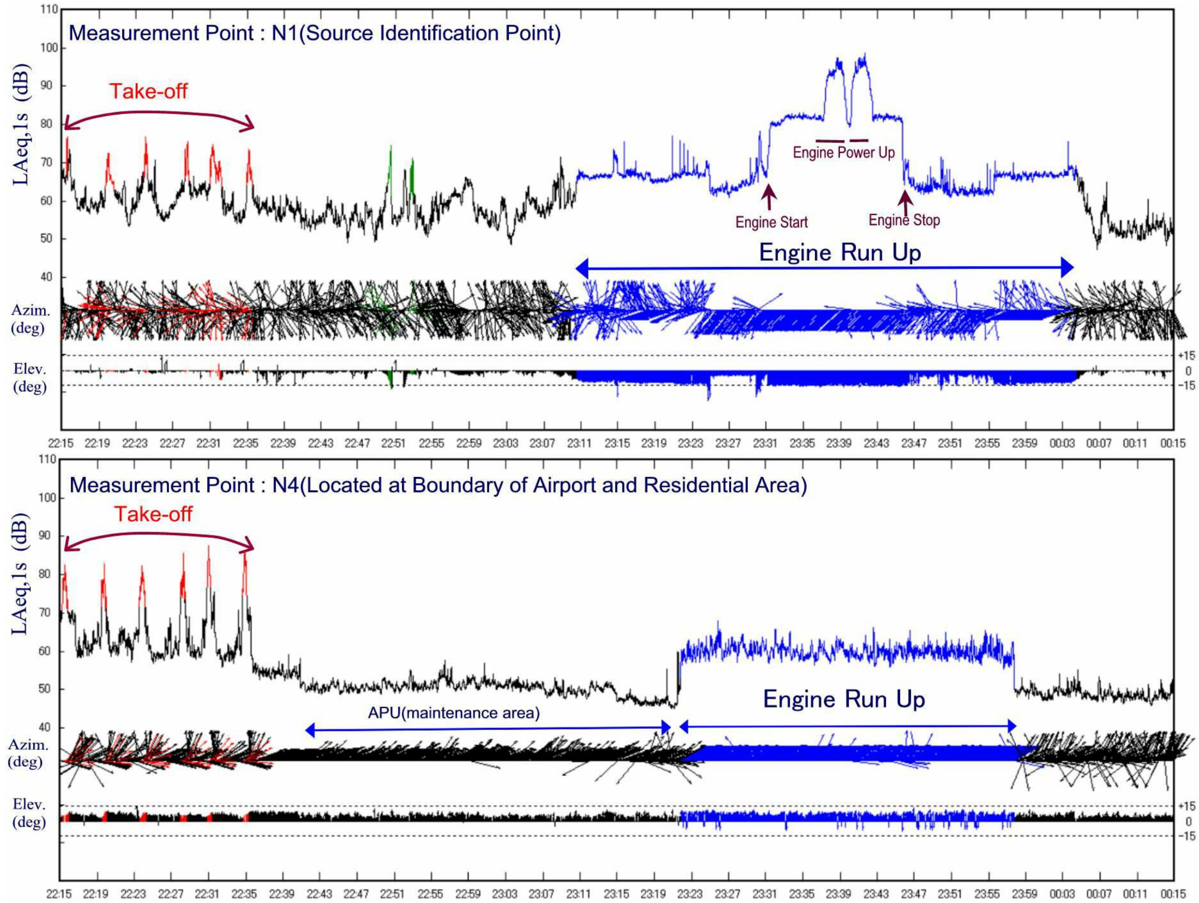

Figure 2: Examples of take-off and engine run-up noise of aircraft during 2 hours from 22 o'clock at two points; these figures show the histories of $L_{Aeq,1s}$ and arrival direction (azimuth, elevation).

4 - CONCLUDING REMARKS

The system has come into regular operation from April 1st, 2000. The function to identify sound sources of ground noise events seems to almost work well, although data accumulation has just now started. However, it is necessary to examine the performance improvement of the sound source identification and the noise regulation.

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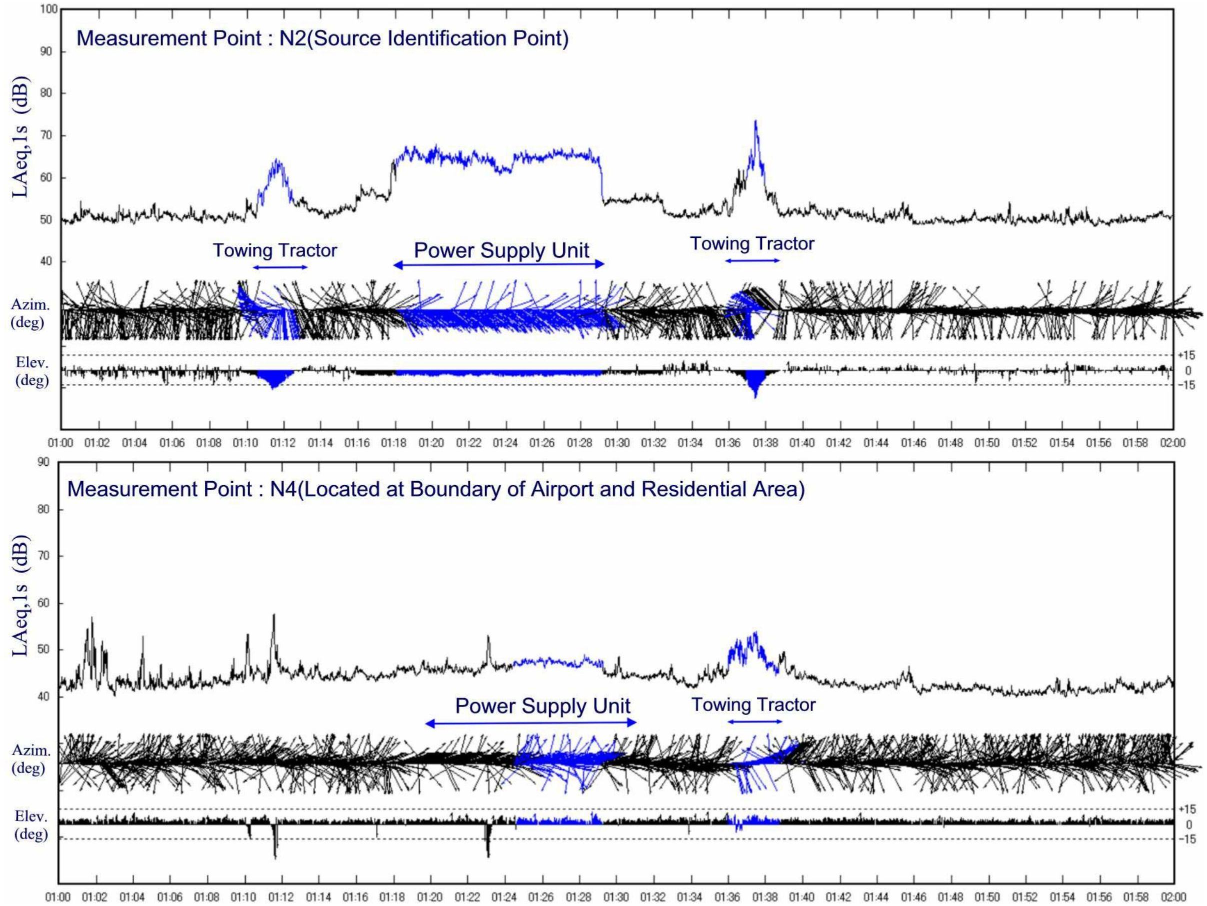

Figure 3: Examples of towing and power supply unit of aircraft during 1 hour from 0 a.m. at two points; these figures show the histories of $L_{Aeq,1s}$ and arrival direction (azimuth, elevation).

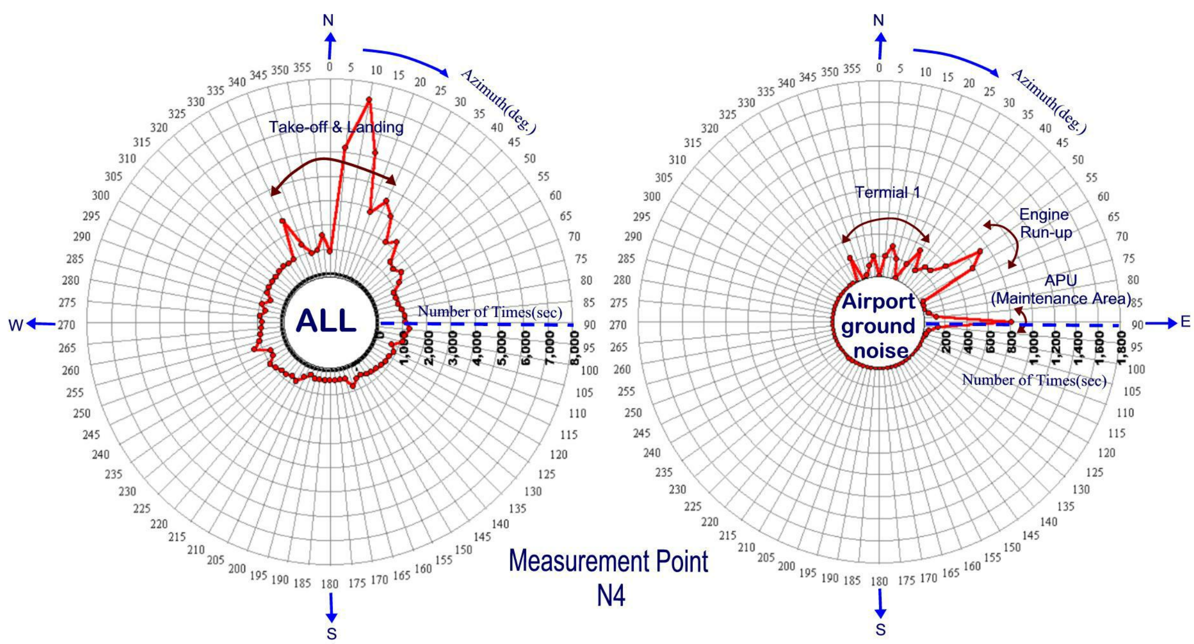

Figure 4: The distribution of sound arrival direction at station N5; the left figure shows all environmental noises and the right figure shows the ground noise.