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EXPERIENCES WITH AN INTELLIGENT MEASUREMENT SYSTEM FOR MONITORING AIRCRAFT NOISE WITHOUT RADAR ASSISTANCE

Rein C. Muchall
OMEGAM, Environmental Research Institute of Amsterdam
P.O. Box 94685
1090 GR Amsterdam, Netherlands
R.Muchall@omegam.nl

Abstract

As the city of Amsterdam had some doubts about the reliability of the Dutch aircraft noise level calculations, they decided to directly measure the noise level at two locations. A stand-alone noise monitoring system was then developed, consisting of a standard noise level meter, a wind speed meter, a radio scanner and a PC. The software controls the measuring process, guards the measuring conditions, performs the aircraft noise recognition and calculates the various noise climates. The first unit was operational in 1991, in 1992,1997 and 1998; more units were installed in the cities of Amstelveen, Beverwijk and Zaanstad at a distance of 10 to 20 km from Schiphol airport. The results over a 10-year period from 1991 -2001 showed a 2 dB(A) significant difference between the Dutch noise calculations and measured noise levels.

1. Introduction

At the end of the eighties, the City of Amsterdam was confronted with a great number of calculated noise maps of the Amsterdam Airport Schiphol and its surroundings. There were considerable differences between these noise maps, which caused doubts about the reliability of the Dutch calculation method (using the FAA aircraft noise database). Therefore the decision was made to directly measure the actual yearly average noise level.

2. Hardware

Because of budget limitations it was necessary to use standard, non-specialized equipment as much as possible. The hardware of the monitoring systems consists of:

1) **A noise level meter** type 1, with A-weighting, slow integration time and DC output. No frequency filtering or L_{Aeq} facility is required.
2) **An outdoor microphone**. For this, the standard microphone of the meter was used. A heating element was wrapped around the pre-amplifier to prevent condensation on the connectors and microphone. We have used different types of wind covers. The acoustic properties of these wind-rain cover combinations had to be measured.

3) **A wind speed meter with DC output**.
4) **A radio scanner**. Following Okuda,[1] in 1997 one unit was extended with a radio scanner for the 1090 MHz frequency band. This frequency is used by the transponder of the aircraft. For the measurements, only the strength of the signal was relevant.
5) **A radio antenna** for the 1090 MHz frequency band with directivity characteristics, which depend on the unit's location with respect to the average flight path.
6) **A computer**. Here, a standard PC was used. It was extended with a 16-port AD-converter to which the analog output of the noise level meter, the wind speed meter and the scanner were connected.
7) **A radio clock**, working on the European time signal from Frankfurt. This was necessary for good synchronization with other monitoring units because the internal clock of the PC is not sufficiently accurate.
8) **A telephone modem** with a fixed line or a GSM mobile telephone. Some units had no means of communications at all. In that case, the data were transferred to diskette. This was done once a month together with the inspection and calibration.

Because of the use of standard equipment, the hardware costs of this type monitor unit are less than 30 % of the cost of the noise monitoring units, which are normally used around airports with specialized outdoor sound level meters. This is apart from the costs of radar support.

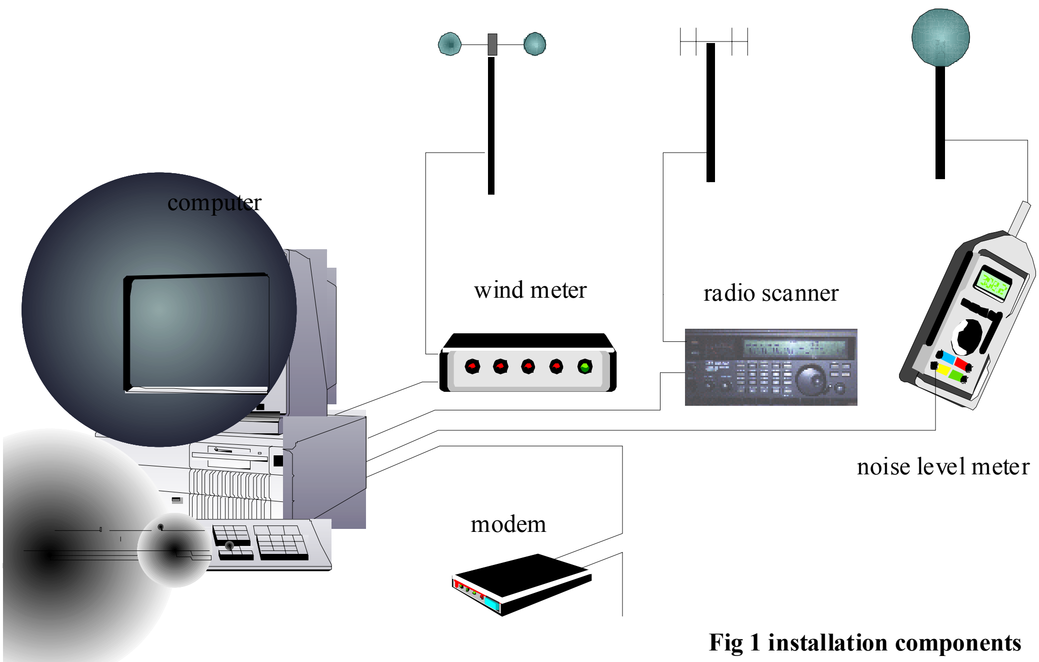

Fig 1 installation components

3. System intelligence

The local PC in the monitoring unit controls the in-situ data processing. It continuously samples the noise level, wind speed and radio level with a sampling frequency of 1 Hz. From these samples, it calculates the L95 level of the last 15 minutes. All recorded parameters are connected with a noise event. The start of an event is defined at the moment that a sample exceeds the L95 level by more than 5 dB(A) for longer than 10 sec. The noise event is completed when the noise level drops below the trigger level longer than several seconds.

This is done because of the non-constant level of the aircraft noise. Then, a calculation process begins to generate a number of parameters:

1 Date and Time of the L_{max} in sec
2 L_{max} , L_{Aeq} and L_{95} noise level
3 Duration T_{trig} measured at the trigger level and T_{10} measured 10 dB below the L_{max}
4 Maximum rise time $dLdT_{max}$ of the noise level during the noise event
5 Maximum wind velocity V_{max} at the time of L_{max}
5 LR_{max} and LR_{95} radio level

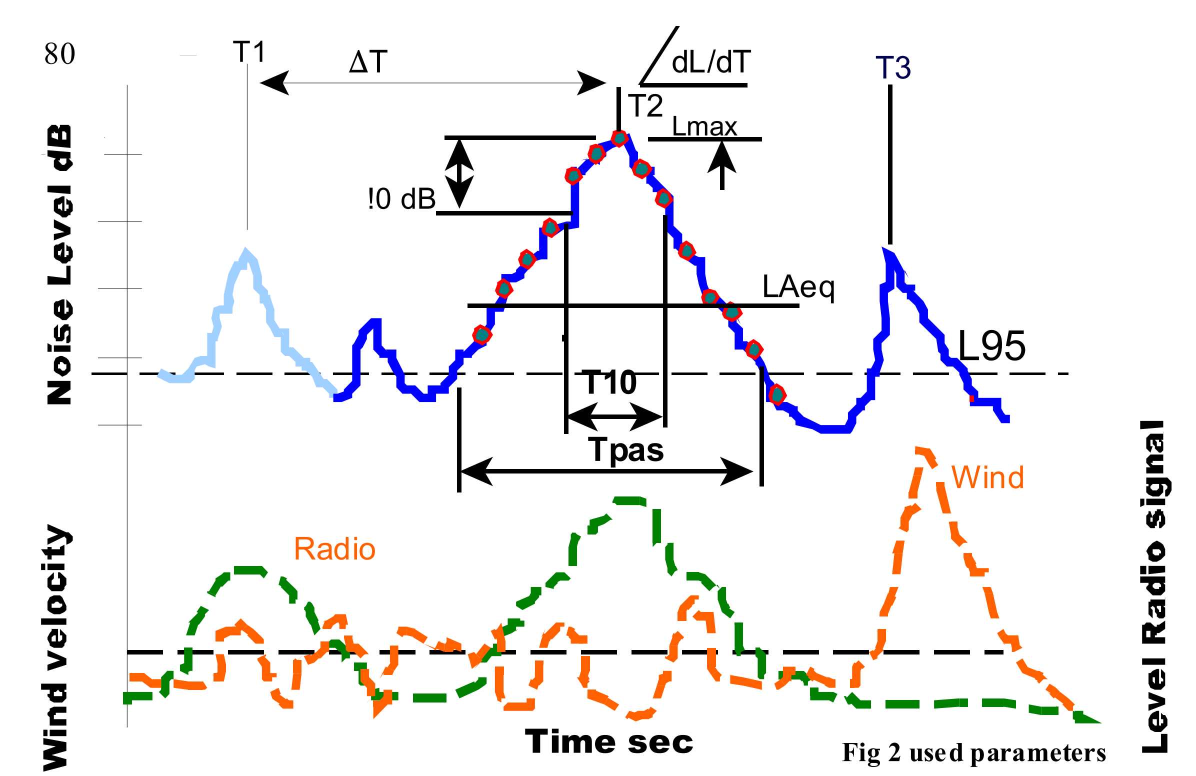

Fig 2 used parameters

The last action is the storing of the measurement data on the hard disk. The advantage of this preprocessing is the data reduction compared to systems, that store all samples, and therefore have an enormous data storing capacity or require an open communication line.

4. Final correction and selection

The second data processing stage is performed at the office. It consists of calibration correction and the validation of the noise events by means of a software filter. From a number of parameters, the deviation from a regression line is calculated and divided by the standard deviation. That is a measure of the probability that a noise event is really an aircraft noise event. The weighting factor of this probability factor is also determined because not every equation has the same discrimination capability. In the end, all probability points are

totalized. To validate a particular event as an aircraft noise event, a minimum probability value is required. The result of this stage is a file with validated measurements.
The next step is to calculate the equivalent noise level L_{Aeq} per hour. Here, the noise energy per aircraft (SEL) noise event is added and divided by the valid measurement time, that is the time during which the measurements do fulfill all the required conditions. In practice a monitoring installation is never in operation all the time. It can be out of service because of maintenance or repairs. Sometimes the weather conditions are bad or there is some disturbing noise. To calculate the average noise level, the real valid measurement time is required. The OMEGAM system has a built-in measurement time registration. In practice about 10 % of the time is non valid because of bad weather conditions which cause wind noise peaks of more than 65 dB(A).

From the L_{Aeq} per hour a number of noise climates can be calculated, such as the L_{Aeq} per night, evening, day, 24 hrs, Ldn and so on. Finally, the L_{Aeq} per month and year are determined.

5.testing and reliability

To develop all these equations and to determine the reliability, a reference file is required with for instance visual observations, noise level recordings, sound tape recordings or radar recordings.

Several tests were carried out. The results of a test in 1995 showed that 702 out of 710 aircraft noise events detected by Schiphol with radar assistance were correctly recognized. This is 3 % difference in number of events or 0.13 dB(A) difference in average noise level. Another validation test was performed in 1996. The results showed a 4 % standard deviation in the number of Aircraft Noise Events during this period. The absolute accuracy is limited to +/- 1 dB(A) by the systematic errors and calibration possibilities of the system.

6.Measurement results

The measurement results of two monitoring stations in the Amsterdam area over the years 1992, 1995 and 1996 showed, on average, a 2.0 dB(A) higher yearly equivalent noise level than was calculated. The unit in Beverwijk showed noise levels, which were about 2.5 dB(A) higher.

7.References

1 Okuda T, et al. Noise monitoring by local self-governing bodies around new Tokyo International Airport. Inter-noise 96: 1931-6.