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Recognition and quantification of aircraft noise events inside dwellings

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Abstract

To examine the relation between aircraft noise and a certain parameter inside dwellings (e.g. sleep disturbance) it is necessary to determine whether an aircraft passage occurs and to value such an event. Monitoring the sound level is necessary for that purpose. As partner in a large survey our company is responsible for the acoustical aspect for which we monitor the sound level inside a number of dwellings on different locations in the vicinity of Amsterdam Airport Schiphol. In a pilot study, done by another research institute, the recognition and the quantification of the aircraft noise events was done on a real-time basis by which a threshold level had to be exceeded, with minimal duration and a certain exceedance hysteresis. The disadvantage of this method was that in situations with a high background level or noise disturbance (passing cars, snoring, overlapping aircraft events) events were missed or were taken into account incorrectly. Therefore a method has been developed by which the sound level is registered continuously, so afterwards a correct analysis is possible. By linking the noise data to radar observation data from the airport Flight track And Noise Monitoring System (FANOMOS) a good estimate can be made on what moment an aircraft passes. The method is automated in such a way that for every aircraft event maximum and SEL-values are determined. Based on different criteria the event is evaluated whether it has to be taken into account or not. In comparison with the pilot setup the percentage of correctly determined aircraft events is highly increased.

1. Introduction

The purpose of many researches is to determine a relation between cause and effect. Major concern is finding a method by which one can observe and recognize each parameter (and its variation) and to value the parameter and its significant variations.
If the cause is determined completely and correctly, the relation between the effect and the cause can be specified more easily and precisely.
Peutz is cooperating in a large survey that is carried out to examine the relation between aircraft noise and sleep disturbance. We have the responsibility for the acoustical part: we had to develop a decent method for recognizing and quantifying aircraft noise.
For distinguishing aircraft noise events from other noise events it is necessary to obtain information about aircraft passages. Additionally has to be determined to what extend the noise level has been increased due to the aircraft noise.

2. General setup

Research has been done in a number of locations in the vicinity of Amsterdam Airport Schiphol (AAS). On every location sound level meters were installed: one at an outdoor position and about ten inside dwellings.
The noise level inside dwellings is a better parameter in relation to the personal aircraft noise exposure than the outdoor noise level. The monitored level at the outdoor position however provides additional evidence of actual occurrence of aircraft noise at the positions indoors.
The registered data on the sound level monitor is read out by (notebook) computer containing the required software.

3. Pilot setup

In the pilot setup, the sound level was monitored but not continuously registered. The recognition of an aircraft passage was done on a real time basis.
The sound level meters available for this examination have a noise event detection program and an aircraft identification program. These programs were used in the pilot study.
During monitoring a noise event was recognized when the sound level exceeded a certain threshold level. If the level exceeded the threshold for a certain period the event was accepted and registered. An aircraft noise event and an environmental noise event were distinguished by means of a certain exceedance hysteresis.

This noise event detection and aircraft identification program did not function optimally.
The settings of the sound level meter (threshold level etc.) have to be chosen very carefully. Per location and per position these setting can vary to obtain an optimal detection of the events. If the settings are too low, separated events will run over and the number of events will run over the limited memory capacity. If the settings are too high, events will not be detected.
In the pilot study 50 % of the events were missed or otherwise incorrectly detected.

4. New setup

In our new setup the sound level is registered continuously from 22:00 h to 9:00 h. Hereby the total capacity of the sound level meters memory is used. The memory is read out after 5 days. The parameter which is registered is the L_{eq} over 1 second.
The sound level meters are all synchronized by linking each to a Radioclock which perceives the time from an atom clock.

In the developed program the sound level data can be linked to radar observation data from the airport Flight track And Noise Monitoring System (FANOMOS). These FANOMOS-data contain a good estimate on what moment an aircraft passes and what the L_{max} would be during this passage.

From the FANOMOS-data time values are processed at which an aircraft can be expected to pass. In a period of 20 seconds before and 20 seconds after this time value, the actual time value is determined at which the maximum value (L_{max}) of the registered L_{eq}'s in that period is found.
Starting from this time value the time values are determined at which the sound level was -5, -10 , -15 and -20 dB.

For the periods of time between the -5, -10 , -15 and -20 dB-time values the SEL-values are determined. These are the SEL(5), SEL(10), SEL(15) and SEL(20). It is not necessary to find all these SEL-values for every event, SEL(10) is the mostly used parameter in the further examination in finding a relationship with sleep disturbance. The SEL(10) or SEL(15)-value are the most preferable to determine. The SEL(5) is very sensitive to small fluctuations and other disturbing noise not related to aircraft noise. SEL(20) is mostly not determined because of the limited dynamics of the measured data.

The program produces raw SEL-data. With a post processing step the program determines which data are correct. The final output of the program is a list of all determined values per event per position, with the incorrect values marked. Another list is provided of the best available correct values per event per position.
Some selection criteria are defined to determine whether the values of an event are correct or not.
If a SEL-value has been determined over a larger period than 60 seconds before and/or 60 seconds after the determined time value at the L_{max} the value will be rejected. The event level has not exceeded the background level clearly, so the event can not be recognized.
If the 60-second period is achieved only before or after the moment at which L_{max} takes place, the determination of the time value at L_{max} appears to be not correct; the corresponding SEL-value must also be rejected.
Another important criterion (empirically determined) is:

$$L_{max} + 7\,dB < SEL \leq L_{max} + 13\,dB \quad (1)$$

If not complying to the left side of the criterion the level variation during the event is too low in relation to the L_{max} to recognize it as an event. If not complying to the right side of the criterion there is too much noise that disturbs the event.
If for an event, after checking at the already mentioned criteria, the SEL(5)-value is the only value which is not rejected, then the period in which this value has been determined must be larger than 15 seconds. If not, the dynamics of the event can be considered too low to be a recognizable event. These criteria can be optimized for every location. By selecting the clearly observable events on the outdoor monitor the specific features of the aircraft events for that location can be determined.

Major difference in relation with the pilot setup is that the most important data (sound level) is registered. The processing of the data is done in a automated way. This method can always be expanded, so linking to different parameters is still possible.

5. Results

Every aircraft noise event inside dwellings is detected and quantified by the program unless this is not possible (background level exceeds event level).
All data are visualized in the program window. As an example a part of the program window is displayed in figure 1. This is done for an arbitrary location for a period between 3:30 a.m. and 3.40 a.m.. For every position the sound level is displayed as function of time. The upper sound level curve is the one for the outdoor sound level monitor. The others are for positions inside dwellings. The events specified by FANOMOS are represented with auxiliary lines and a triangle in the outdoor position curve. The events are recognizable and the determined maximum level and the SEL's are represented with auxiliary lines of different colors.

As can be seen there is much noise disturbance at some positions. At position 3 the peaky curve can be declared by snoring of the person sleeping in the monitored room. At position 5 the disturbance is very high, an aircraft noise event is hardly recognizable. The disturbance is not well declarable.

The figure shows that with this method it is directly visible on basis of which criteria the event will be accepted or rejected.

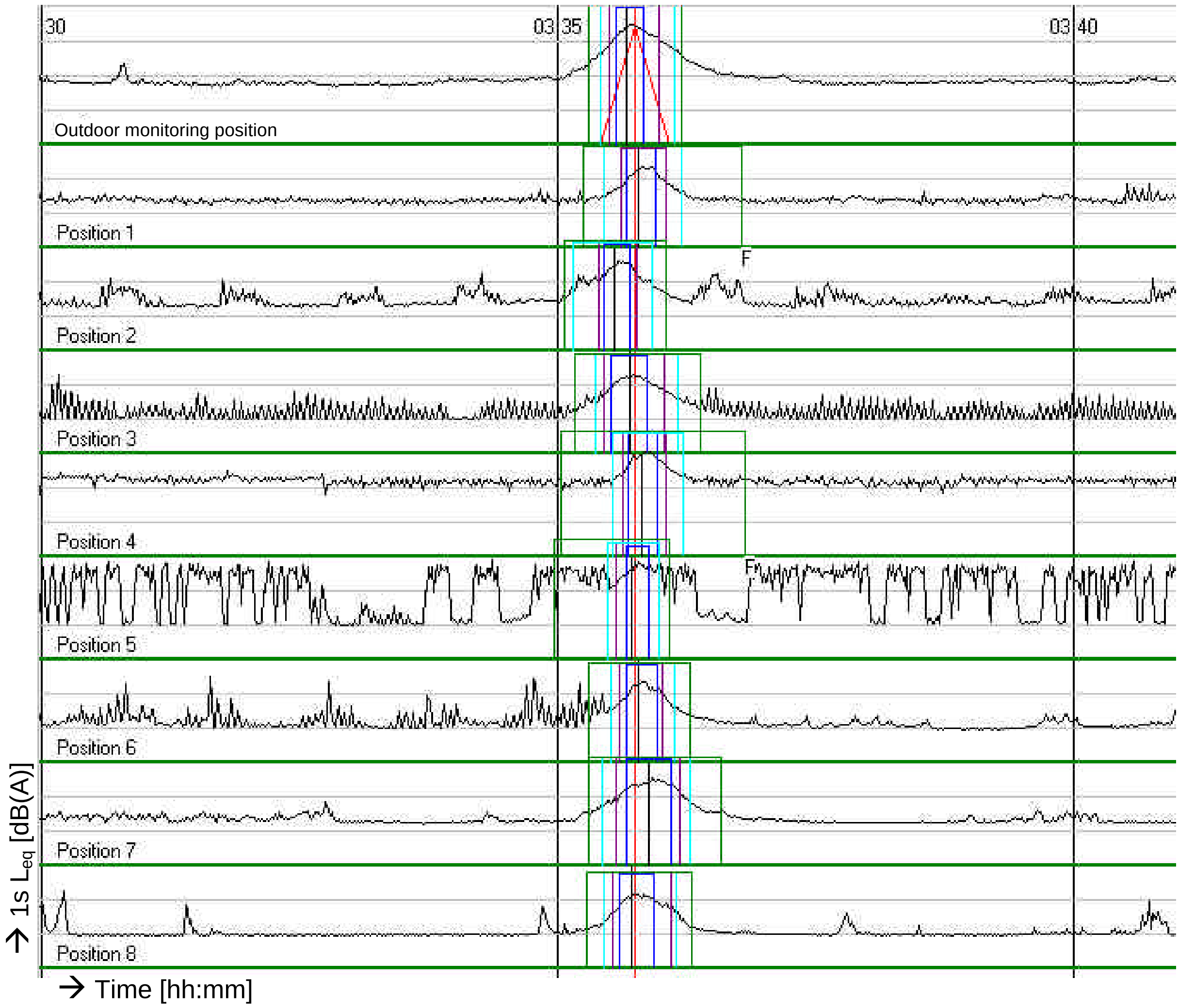

Figure 1: The program display: for a period of 10 minutes the registered 1s L_{eq} in dB(A) is displayed. The event is marked at the time value given by FANOMOS. The determined L_{max} and the SEL-values are also visualized by means of auxiliary lines in different colors.

Conclusions

An adequate method for recognizing and quantifying aircraft noise is developed. The 1s L_{eq} of the sound level is registered continuously. In an automated way these data are further processed. They are linked to radar observation data which estimate the moment on which a aircraft passes. For every aircraft event the L_{max} and SEL-values are determined. These values are checked at certain defined criteria. With this method it is possible to detect all well recognizable aircraft events. A dose effect relation can by means of this method accurately be determined.