# A directional aircraft noise measurement system

## the first system that senses aircraft noise like homo sapiens

Measuring aircraft noise accurately is a major problem in the protection of the environment against excessive aircraft noise. Noise from other sources, such as ground traffic, rain and wind hamper these measurements. This is even more the case at greater distances from the airfields. Another aspect are ground reflections, which increase the aircraft noise levels up to 3 dB. In case of strong wind and heavy rain fall noise measurements with conventional systems are even worthless.

Photo 1. Spatial microphone configuration of DINOS

For these reasons a system has been developed which truly distinguishes aircraft noise from other noise sources, like ground traffic, rain and wind induced noise. Also ground reflections, which depend on the environment and weather, are determined.
Photo 1 shows the microphone configuration of such a system. By the spatial configuration the system is able to detect and track aircraft by using the aircraft noise. The strength of the aircraft noise is measured accurately. Up to four aircraft can be handled is this way separately.

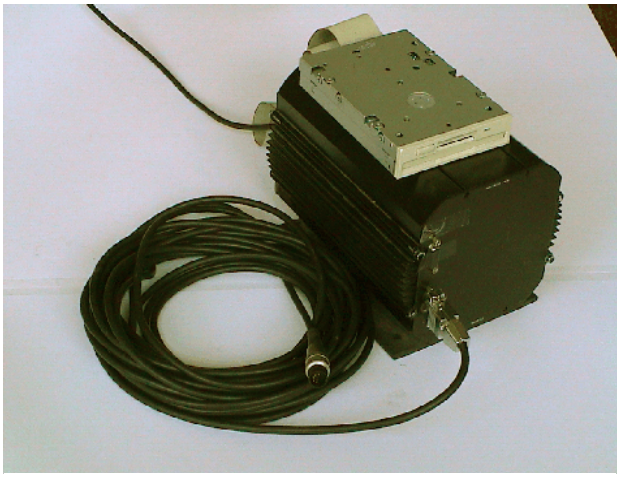

Photo 2. Cabinet with electronics

Due to the optimal method of the signal processing of aircraft noise, the system is cost-effective and the physical dimension of the used off-the-shelf electronics is 10x10x10 $cm^3$.
Photo 2 shows the housing of the electronics.
The method is more or less like homo sapiens recognizes and tracks aircraft by hearing.
An equivalent technique is used for the tracking of underwater objects by sonar, like oil-pipelines in the sea bottom.
The evaluation of the system has been carried out by prof. Dr. Ir. Botteldooren in order of the ministry of Traffic and Waterways of the Dutch government[1].

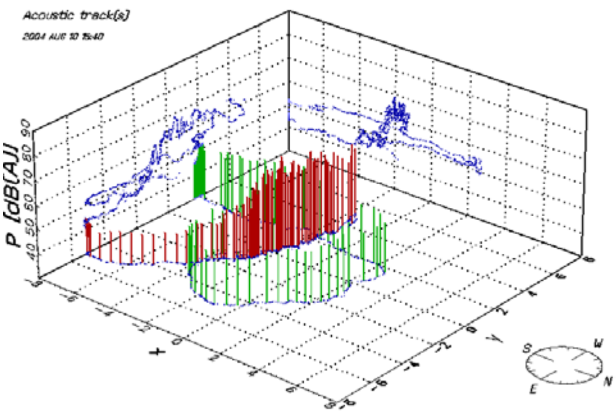


Fig.1. A soundtrack recorded by DINOS on the parking roof of shopping mall Geesterduin in Castricum at 14:42, August 10th 2004; the compass shows the orientation of the figure, see also the text.

The effectiveness of the system is shown by realtime presentation of the acoustic signal processing and of the tracking of aircraft.
Fig. 1 shows the tracking as sound traces.
The horizontal ground plane of the figure is equivalent with the known radar screen. The noise strength is drawn vertically. The scale of the horizontal x- and y-axes is equal to the height difference *h* between the aircraft or vehicle and the center of the microphone configuration.
The aircraft or vehicle position is related to that reference point (0,0). The compass card in the figure shows the world orientation. By coloring these traces originating above resp. below the reference point resp. red green, air and ground traffic are indicated by color.

The green sound trace in Fig. 1 shows a car driving onto the parking roof of a shopping mall, rounding the microphones and coming to a stop. Seconds later a Boeing 747, its sound shown by the red trace, appears in the west, flies over and disappears in the southeastern direction. By drawing once a second a vertical line in the sound trace the motions of the vehicles are shown. As expected the sound intensities are the highest at the shortest distance between the microphones and the aircraft.
The flight height or path can be determined in a number of ways. Even with a single monitoring system the height can be determined, but with a large error due to wind and other error sources.

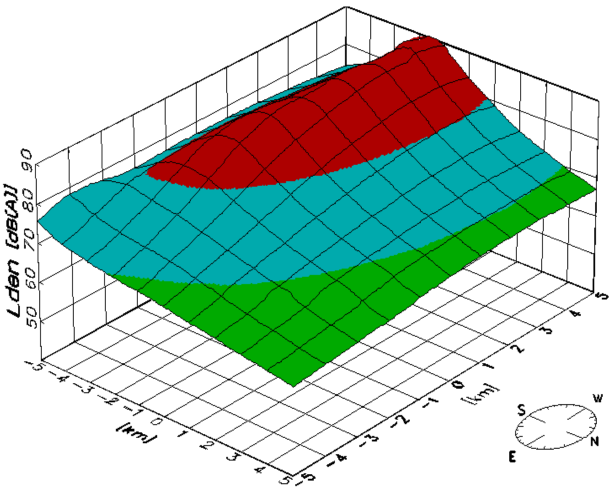


Fig. 2. A sound landscape created from aircraft noise shown in Fig. 1.

An elegant way is by combining the data of two or more monitoring systems, making the system fully independent of other systems for determining the flight path with high accuracy. By extrapolation of the measured sound data, the sound intensities of the whole area between the monitoring systems and even outside that area are determined accurately and a so-called sound landscape is obtained. Even with one system a landscape is obtained, but with greater error. Fig. is an example of the latter.
The more distant from the monitoring system the greater the error of extrapolation will be.
In case of the Dutch town Castricum the generation of a fully accurate aircraft noise landscape would require three such systems[2].

Busy aircraft traffic is not without nuisance. The resulting complaints about the nuisance can be related to the aircraft noise traces. These complaints will have a statistical distribution around the flight path, which will correspond with the NaX characteristics, like in the Wyle report[3]. These NaX characteristics are more or less equivalent with ROC characteristics or false alarm and detection probabilities used in the sonar and radar technology[4]. With these measurements better predictions of nuisance will be obtained than by calculating the aircraft noise from type, load, maneuvering and path of the aircraft and then interpreting.

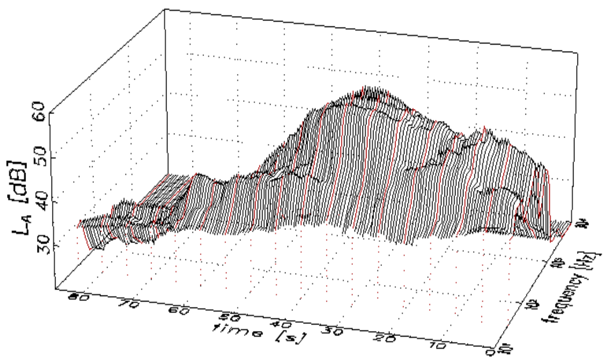


Fig. 3. A presentation of A-weighted spectra of an aircraft passing by in 1/3 octaves re. 20µP / √Hz, with reduced directional sensitivity.

Also other parameters can be extracted directly from these measurements. Fig. 3 for example shows spectra of an aircraft passing by. These spectra, needed for the calculation of sound landscapes, make it too possible to relate noise complaints to noise types, like whistle sound, which depend also on the aircraft maneuvers

Conclusion: a wealth of accurate information about aircraft noise is possible with a system based on discriminating noise sources and using the flight path from the acoustic measurements by new signal processing techniques.

1. D. Botteldooren, “Evalutieverslag Directief monitoring systeem vliegtuiglawaai”, Vakgroep Informatietechnologie, Groep Akoestiek, Universiteit van Gent, Belgium, 2000
2. Gezamenlijke Bewonersplatformen rondom Schiphol, ‘Als een goed instrument, een discussiestuk’, juni 2004.
3. B. Albee,en X. Jessurun, Wyle Report, ‘Nighttime noise criteria and land-use guidelines for the city of High Point, februari 2003
4. R.J. Urick, Principles of Underwater Sound for Engineers, (Mac Graw-Hill, New York)