SYSTEM SUMMARY

Noise Source Identification During Flyover of Passenger Aircraft

Uses

- Noise source identification during flyover testing during R&D and at the certification stage of a project
- Noise source identification on subsonic transport aircraft on undercarriage, slats and flaps, and engines
- Useful for flyover altitudes of between 30 m and 300 m

Features

- Records all signals during measurements
- Transient tracked analysis using flight track information via IRIG-B time coded signal
- Deconvolution algorithms used to improve spatial resolution relative to classical beamforming
- Post-processing of data
- Photographic validation of position of aircraft for on-the-spot synchronisation with acoustical data (optional)
- Fast validation on site of beamforming calculations (optional)

Method

The aircraft position during a flyover is measured with an onboard GPS system, and synchronisation with array data is achieved through recording of an IRIG-B signal together with the array data and the GPS data on the aircraft. The Beamforming calculation is performed with a standard tracking time-domain Delay And Sum (DAS) algorithm [1], with the capability of Diagonal Removal to suppress wind noise.

For each focus point in the moving system, FFT and averaging in short time intervals is then performed to obtain spectral noise source maps representing the aircraft positions at the middle of the intervals. With sufficiently short averaging intervals, the array beam pattern remains almost constant during the corresponding sweep of each focus point. This means that a Deconvolution calculation can be performed for each FFT frequency and for each averaging interval in order to enhance resolution, suppress sidelobes and scale the maps.

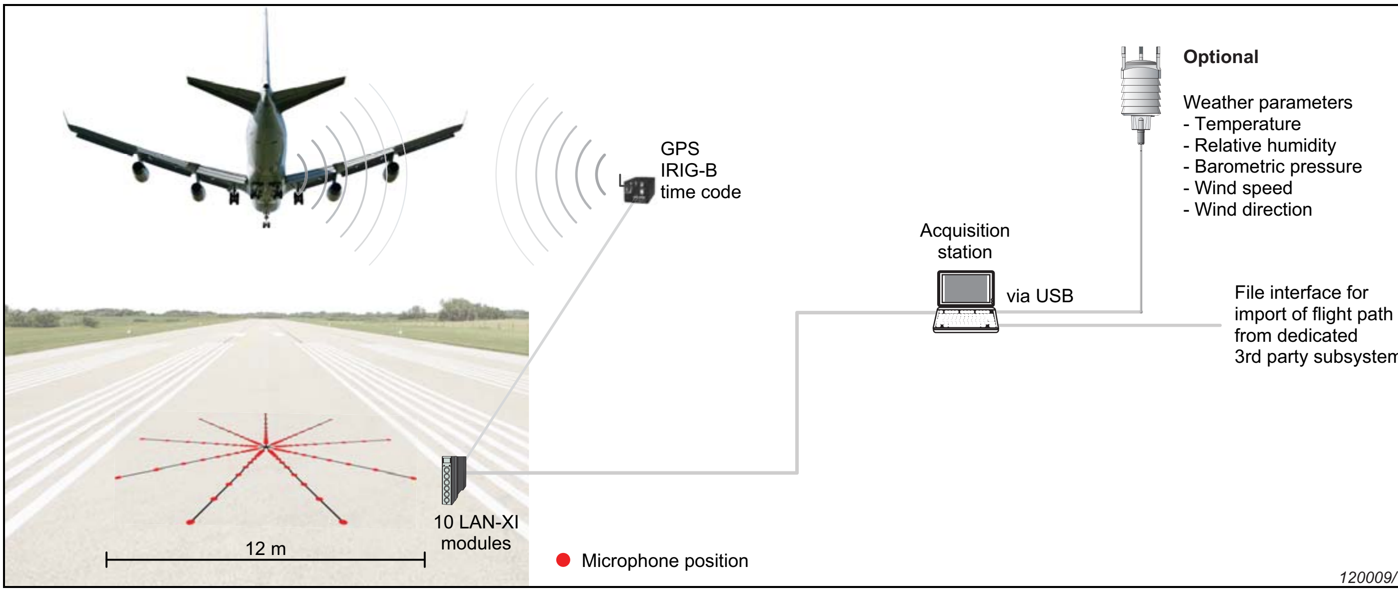
In relation to the Deconvolution, it is important to take into account the frequency shift of the sidelobes in the calculation of the Point Spread Function (PSF) [2]. The requirement for compensation can, however, in many cases be avoided by the use of a carefully selected FFT record length. For the Deconvolution, a FFT-NNLS algorithm is used [3].

The array design and the use of a frequency-dependent smooth array-shading function are inspired by Sijtsma and Stoker [1]. However, to support quick and precise deployment on the runway, a star-shaped array geometry is used as illustrated in Fig. 1. The full array consists of 9 identical line-arrays which are joined together on a centre plate and with equal angular spacing controlled by aluminium arcs. The 12 microphones on one 6 m line array are clicked into an aluminium tube, rotated in such a way around its axis that the ¼″ microphones touch the runway.

Due to the turbulence-induced loss of coherence over distance, a smooth shading function is used that focuses on a central sub-array, the radius of which is inversely proportional to the frequency [1]. At high frequencies only a small central part of the array is therefore used, which must then have small microphone spacing. To counteract the resolution loss at low-to-medium frequencies resulting from the high microphone density at the centre, an additional weighting factor is applied to ensure constant effective weight per unit area over the active part of the array.

The effective frequency-dependent shading to be applied to each microphone signal is implemented as a FIR filter, which is applied to the signal before the Beamforming calculation. An important benefit of using only a circular central sub-array at each frequency (over which microphone signal coherence is not lost) is that loss of coherence need not be modelled in the PSF used for Deconvolution.

Fig. 1 *Schematic diagram showing a typical customised system for Noise Source Identification during flyover of passenger aircraft – measurement and data acquisition*

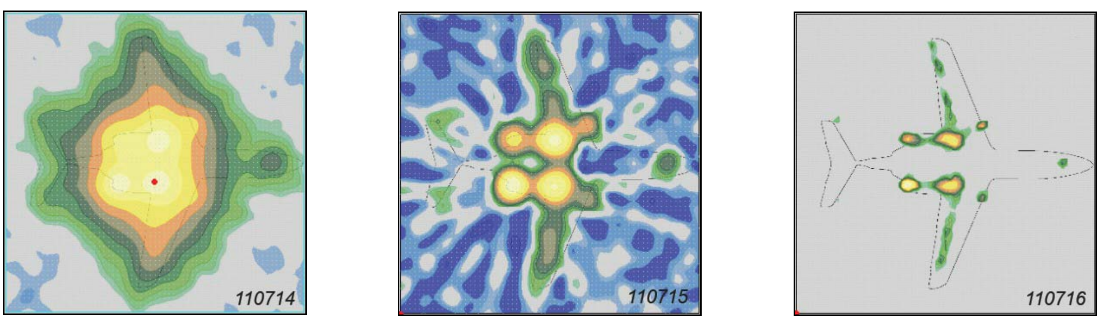


Typical System

For a frequency range of 500 Hz to 6 kHz, use a 12 m diameter ground based circular array, which includes 9 spokes, each containing 12 microphones (and a total of 108 channels) [4].

For improved low frequency resolution (200 Hz to 6 kHz), an array with a diameter of 30 m, and 9 spokes each containing 18 microphones is recommended.

Fig. 2 *Results for the 2 kHz octave band when the nose of the aircraft is exactly over the array centre (x=0) under the following conditions: Landing configuration, Level flight, Engine idle, Altitude 59 m, Speed 57 m/s. Left: DAS; Centre: DAS + Shading; Right: DAS + Shading + Deconvolution (Measurement data obtained during joint research work between JAXA (Japan Aerospace Exploration Agency) and Brüel & Kjær)*



References

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[2] Guérin, S. and Siller, H., "*A Hybrid Time-Frequency Approach for the Noise Localization Analysis of Aircraft Fly-overs*", 14th AIAA/CEAS Aeroacoustics Conference, Vancouver (Canada), 5-7 May 2008, AIAA Paper 2008-2955.

[3] Ehrenfried, K. and Koop, L., "*A comparison of iterative deconvolution algorithms for the mapping of acoustic sources*", 12th AIAA/CEAS Aeroacoustics Conference, Cambridge, Massachusetts (USA), 8-10 May 2006, AIAA Paper 2006-2711.

[4] Jørgen Hald, Yutaka Ishii, Tatsuya Ishii, Hideshi Oinuma, Kenichiro Nagai, Yuzuru Yokokawa and Kazuomi Yamamoto, "*High-resolution Fly-over Beamforming Using a Small Practical Array*", AIAA/CEAS Aeroacoustics Conference, Colorado Springs (USA), 4-6 June 2012, AIAA Paper 2012-2229.

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