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NOISE SOURCES IDENTIFICATION SYSTEMS
GENERAL DESCRIPTION AND PROBLEMS

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INTRODUCTION

Source identification and localisation has been a major challenge to physicists for a great part of the human history. In its most general form, it is the ultimate step in the complete understanding of a complex real situation. As most physical phenomena are treated on the causal principle, a physical system is truly and fully understood when both the source and "propagation" path are positively identified. In this general trend constant work has been done to improve both the sensitivity and accuracy of methods and systems used.

In passive systems of sources identification, this has been the case for :

- Radioastronomy
- Underwater acoustics
- Optical detection

Progress in these various methods has been achieved by :

- Basic transducers improvements
- Data processing developments

As far as noise sources are concerned, the most widely used methods of identification are based on passive systems.

In these systems, we can see two main types of approach to the problem :

1 - Interferometry (energetic)
2 - Additive synthesis (time signals)

SYSTEMS CHARACTERISTICS

These two methods are quite different in principle and in their applications.

1- Interferometric treatment of multiple microphones information is done by investigation of propagation time difference processing of the acoustic waves.

2 - Additive synthesis gives the time dependent acoustic signal associated with waves coming in the main directivity axis of the array.

In general terms, these two kinds of methods will give descriptions of the noise field, and consequently of noise sources, which are quite different in their applications.

Interferometry	Additive Synthesis
⇓	⇓
Energetic Description	Time Information
⇓	⇓
Bright acoustic spots	Acoustic field wave Structure
⇓	⇓
Point Sources	Vibrating surface trace of acoustic waves

SYSTEMS APPLICATIONS

INTERFEROMETRY is used to study large industrial areas from a distant point, where noise pollution is experienced, all existing noise sources contributing to the acoustic environment at that point. Sources angular position and frequency spectrum together with energy contribution ordering are possible with this technique. Difficultes in the use of this technique come from :

- existence of sources very close to each other at the same frequency.
- Singularities in the propagation space between sources and array (loss of coherence).

On the other hand, an interferometric array of span D has the directivity of a 2D span additive array.

ADDITIVE SYNTHESIS ARRAYS : these systems gives the acoustic time signal in its main direction. As such, this information can be used :

- to check coherence of various sources.
- to trace the elementary radiation process involved in a given acoustic field.

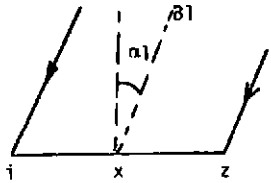
In this case, the acoustic field can be represented by a set of acoustic plase waves. Acoustic data of this type are much richer in information for the acoustician and the designer. These systems give a description of noise field structure which is physically related to the radiating structure, by continuity.

SYSTEMS OPERATING PRINCIPLES

I - INTERFEROMETRIC ARRAYS

Starting from the crosscorrelation fonction between two transducers

$$\Gamma_{12}(\tau,x) = \Gamma_{B1}(\tau - xa_1)$$



by two consecutive Fourier transforms

1 - one from τ to ν .

2 - one from x - νa, one gets for M sources

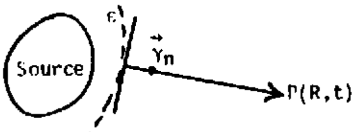
$$I(\nu,a) = \sum_{l=i}^{M} g(\nu(al - a)).(\gamma_{Bl} * f)\nu$$

thus the maximum valus of $I(\nu,a)$ related to noise source k are in the section $a = ak$ of $(\gamma_{Bk} * f)\nu$. The surface $I(\nu,a)$ gives an image of the angular and spectral distribution of the received mean acoustic power.

II - ADDITIVE ARRAYS

The Helmoltz-Huygens integration gives the acoustic Pressure in far field of acoustic radiation on a surface surrounding the source.

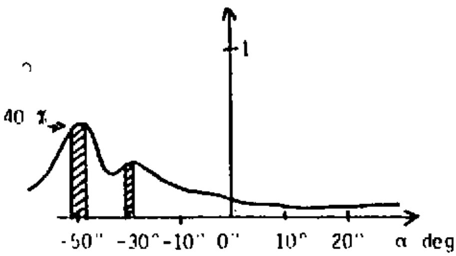
$$P(R,t) = \frac{1}{4\pi R} \int_{\varepsilon} p_0 \ \gamma_n + \frac{1}{c} \frac{\partial p}{\partial t} \cos\theta \ (t - \frac{R}{c}) \ dS$$

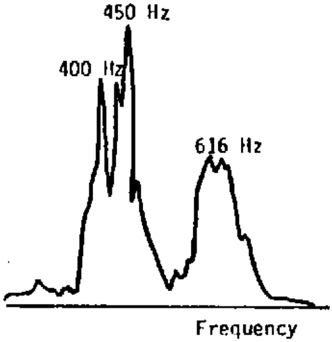


One gets $P(R,t)$ from the measurement of γ_n and $\frac{\partial p}{\partial t}$.

I - INTERFEROMETRIC ARRAY

Analysis of flare noise
Octave Band 500 Hz

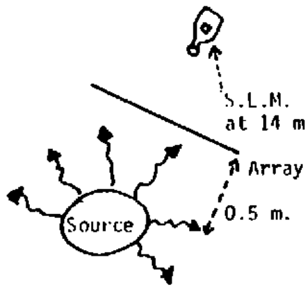


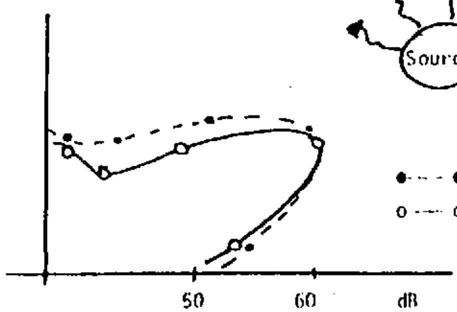


Contribution rate of flare is 40 %
noise level in 500 Hz octave band
is 46 dBL

Frequency spectrum in -52° direction

II - ADDITIVE ARRAY





●- - - ● with a sound level meter
o —— o with additive array (SAAP 811)

Example of comarison between a near-fiels measurement with additive array and a far field measurement with a sound level meter in free field