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INFLIGHT NOISE ENVIRONMENT IN HELICOPTERS

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1 - INTRODUCTION

Acoustical imaging techniques are providing today new powerful ways to investigate in detail relatively complex fields. METRAVIB R.D.S. has acquired a broad theoretical and practical experience of.

The main application of these techniques is to classify major noise sources in order to apply significant and efficient noise reducing techniques.

In this paper a systematic procedure of analysis and field description is presented ; this method allows quick and accurate evaluation of the efficiency of various modifications in an helicopter (acoustic and damping materials).

This procedure relies on the use of energetic and spatial criteria to analyse acoustic fields by means of nearfield multi sensor acoustic arrays.

2 - PROBLEM DESCRIPTION

Helicopters structures and cockpit are submitted to very high vibration levels, typically 2 to 3 times higher than in a conventionnal aircraft. This situation leads to high noise levels in a very broad frequency range.

Excitation sources are numerous : main and rear rotors, engines, gearbox and other prime movers.

If one is looking for dBA levels reduction, the most significant effects can be reached by working on the 500 - 3 000 Hz range as most of the noise in this frequency domain is associated with discrete frequency peaks. Furthermore, payload restrictions on helicopter lead necessarily to drastic optimisation of any acoustic lining.

To achieve this optimisation the acoustic field must be determined in an accurate yet simple way. This paper describes two methods used in conjunction : intensitymetry and phase acoustical arrays.

3 - INTENSITY ANALYSIS

Noise intensity measurements are becoming widely used nowadays, specially for acoustic power measurements : in this case the total energy flow on a closed surface adds up to the total radiated power.

For internal problems, on the contrary, the overall energy balance on a closed surface is null. In this case, the analysis is limited to identification of areas letting in most acoustic energy flow within the cabin.

Typically, acoustic intensity is measured from p and v evaluation (Fig. 1)

$$P = (P_1+P_2)/2 \quad \text{and} \quad V = -1/\rho \int (P_1-P_2)/\Delta x \, . \, dt$$

$$I(\nu) = \text{Re}\,\{\overline{p}(\nu).\overline{v}(\nu)\}$$

This operation is done using the multiple intensity probes system of METRAVIB, SALSS.

4 - PHASE WAVE ANALYSIS

This second technique is only applied to major acoustically efficient areas as found with the intensity measurements. The procedure uses spatially preformed arrays to filter out specific wave forms. The array is made of two plane sensors layers : this set up identifies the acoustic field into plane wave clusters comming in the solid angle Ω (Fig.2). It is then possible to single out any local phenomenon.

Both techniques have been used on an helicopter in stabilised flight (straight and level) at a speed of 135 Kts.Helicopter structure is sketched on Fig.3.

In these early stages of the research, all existing linings in the helicopter have been removed.

All data were recorded on a 14 track recorder, later to be processed. All measurements refered to in this paper have been performed within 90 minutes.

5 - INTENSITY MEASUREMENTS

Noise intensity measurements have been carried out in the two one octave bands 1 and 2 kHz (707 to 2 828 Hz). Acoustic energy balance covers all internal cabin surface.

Fig.4 gives a relative internal noise spectra in the cabin.
Fig.5 shows intensity array positionning on the right hard side.
Table 1 presents intensity results.

6 - CONCLUSION ON INTENSITY MEASUREMENTS

This energy levels classification is easy to perform and gives an interesting first order description of the acoustic field.

Intensity data processing lead to identification of areas where the radiated power density is important. Among these areas, the rear ceiling appears to be dominating.

In order to investigate the actual type of acoustic field responsible for these high levels, a more accurate method is needed : phased array analysis.

7 - PHASED ARRAY ANALYSIS

The measurements were performed on the rear ceiling in the same frequency band.
The method structure is the following :
Compute the P_{12} wave going from surface 1 towards surface 2
(data : p_1 and p_2 and P_{12}, P_{21} interferences on both surfaces).

Fig.7 and Fig.8 show theoretical and experimental positions.

8 - CONCLUSION ON PHASED ARRAY MEASUREMENTS

In addition to the intensity analysis data, phased array measurements have given:
- The acoustic field reverberation index,
- The separation between incident and reflected energy.

Fig.9, 10, 11.

Two main facts can be outlined :

a) In low frequencies, up to 1 600 Hz, the ceiling is rather singular, with well defined high level zones :

- A local effect towards the left near of ceiling for 787 Hz, doubled with a distributed area, resulting from two plane waves interferences.
- An area near the left side of ceiling along the whole length. This frequency at 1012 Hz is that of the rear rotor.
- Two well defined local sources at 1095 Hz possibly linked with the two oil tanks, fixed on the ceiling. This source is very characteristic as they vibrate in opposite phase.

b) In high frequencies, overall sources above 1600 Hz.

It must be pointed out that the high stationary wave index (bare surfaces) has probably made it more difficult to identify some other phenomena.

10 - GENERAL CONCLUSION

A new systematic procedure to analyse noise in helicopters is presented. The method is simple and quick to use and can be described in its two major components

- One set of noise intensity measurements to identify quickly major radiating areas.
- One set of phased array measurements applied to the major radiating area. This second set of measurements has provided detailed information on the acoustic sources natures.

The overall method appears to be well suited for very confined acoustic measurements while remaining very simple and flexible.

FIGURES

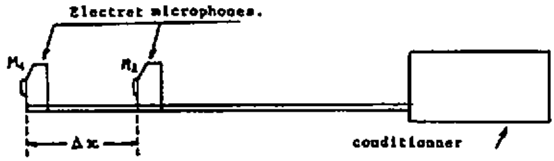


Fig.1 : Intensity Probe

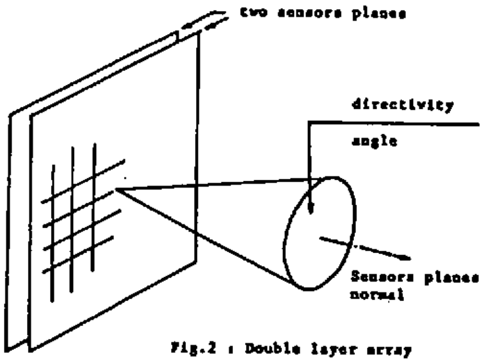


Fig.2 : Double layer array

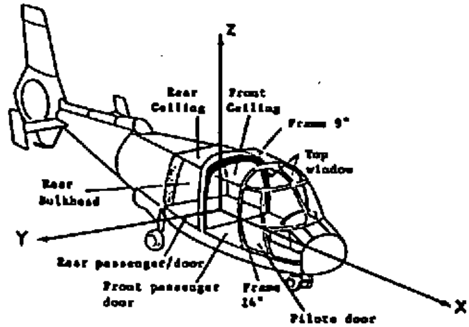
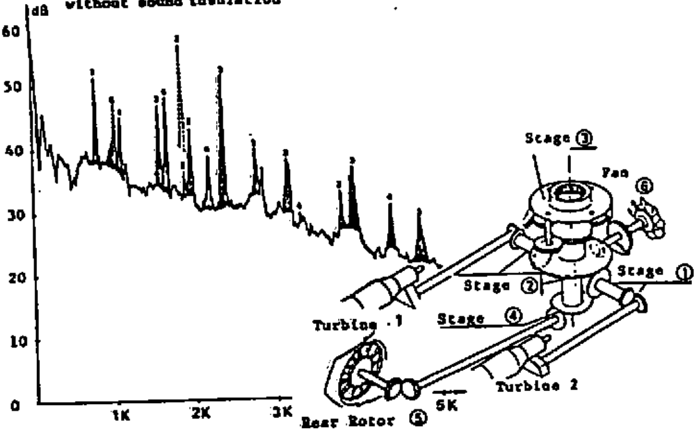


Fig.3 : Structure definition of SA 365 N

Fig.4 : Internal Noise Spectrum (Passenger Seat) without sound insulation



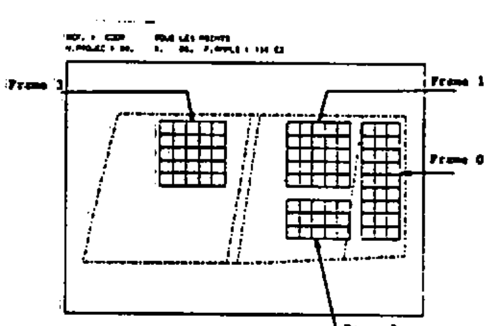


Fig.5 : Right Side

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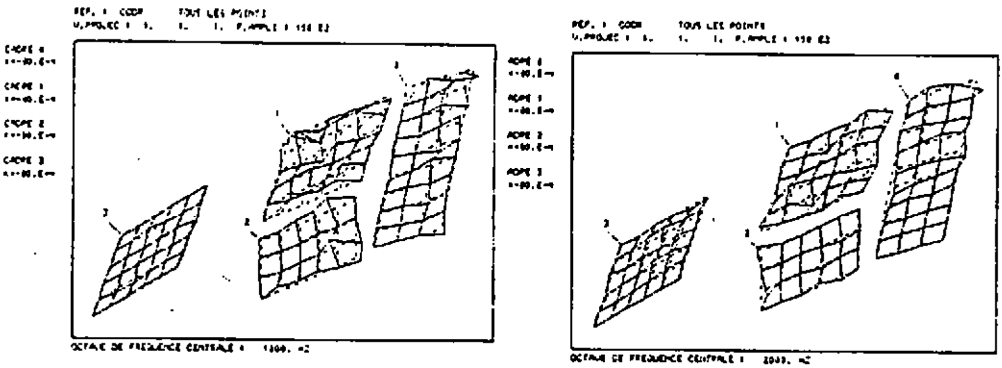
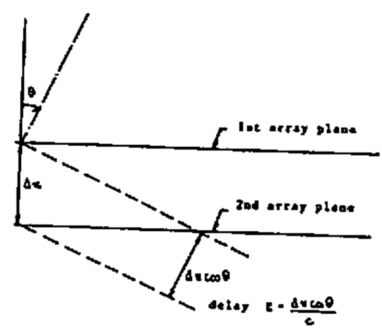
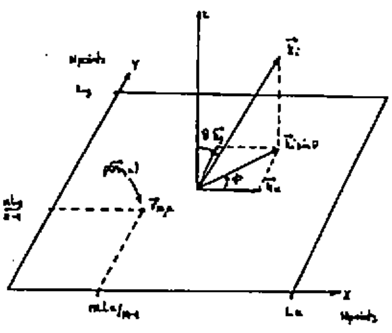
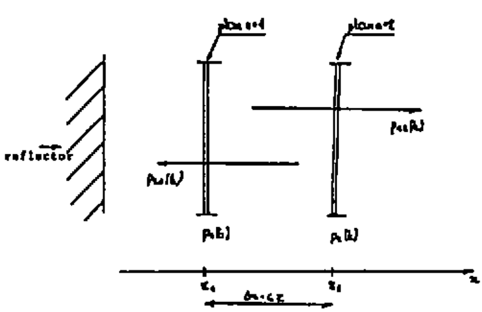


Fig.6 : Right Side



Analysis surface meshing





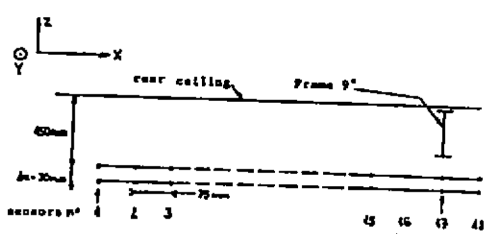


Fig.7 : Separation of incident and reflected waves

Fig.8 : Array positioning near rear ceiling and planes positions

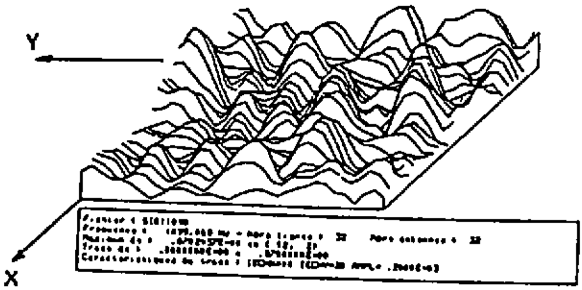
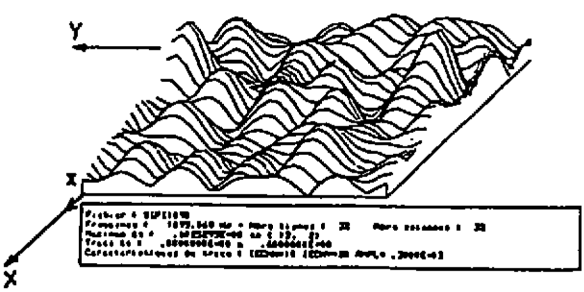
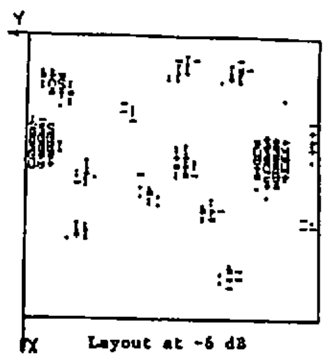


Fig. 9 : Overall pressure field on plane n°1





Layout at -6 dB

Fig.10 : Pressure field radiated by the ceiling

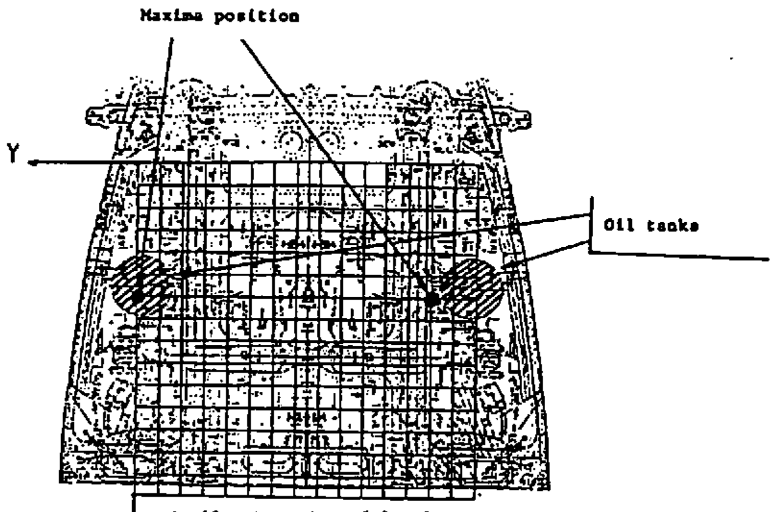


Fig.11 : Position of local sources near ceiling

ENERGY LEVELS

POSITION	FRAMES	SURFACE(m^2)	POWER (mW)	POWER DENSITY (Wm^{-2})
Rear bulkhead	0+1+2	1,76	-1,02	- 0,58
Right hand side	0	0,80	0,39	0,49
	1	0,36	- 0,04	- 0,11
	2	0,24	- 0,20	- 0,83
	3	0,36	- 0,10	- 0,26
Left hand side	0	0,80	0,64	0,80
	1	0,36	- 0,63	- 1,75
	2	0,24	- 0,80	- 3,33
	3	0,36	0,17	0,47
Right front ceiling	0+1+2	1,20	- 0,48	- 0,40
Left front ceiling	3+4+5	1,20	- 1,43	- 1,19
Right rear ceiling	0	0,36	32,70	90,80
	1	0,45	32,40	72,00
Left rear ceiling	0	0,36	36,50	101,40
	1	0,45	36,50	81,10
Frame 9°	0	0,650	3,70	5,70
	1	0,156	- 2,90	-18,60
	2	0,156	- 7,20	-46,10
	3	0,650	1,90	2,92

TABLE 1. : Noise Sources classification