FIFTH INTERNATIONAL CONGRESS ON SOUND AND VIBRATION
DECEMBER 15-18, 1997
ADELAIDE, SOUTH AUSTRALIA

A NEW TOOL FOR SOUND PROOFING INSPECTION: THE SALSA SYSTEM

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ABSTRACT

Acoustic imaging techniques based on nearfield phased pressure or intensity mapping are now well known and provide a very explicit "view" of the localization of the predominant noise sources ("hot spots") on any kind of surface (machinery casing, car body, engine block, vessel hull, etc.).
However, the constraint of sampling accurately and regularly the acoustic volume around the investigated object requires a very high order of sophistication; in most of the practical situations, it is not even physically feasible because of the presence of obstacles like pipes, ducts, surrounding equipment, insufficient clearance, for example. Normally, the imaging processing can be made only when a regular grid (generally a large rectangle per side of the object) sampled at perfectly constant intervals has been acquired under experimental conditions.
METRAVIB RDS has developed the new SALSA toolbox to overcome this difficulty and provide a much more flexible and user friendly acoustic imaging approach from a small array moved by hand in face of the investigated noise source. From the co-ordinates of two corners of the array for every measurement, a 2-D or 3-D specific spatial interpolation algorithm, together with adequate "extension" formulae provide a completed optimized input to the imaging process for the MALICE software described in a parallel presentation (cf. ref. [1] ICSV'5 paper N°379428).
Examples of applications will be provided such as the diagnosis of acoustic leakage of a car door sound-proofing and gaskets in real industrial conditions. The application potential is by nature unlimited.

1. PRINCIPLES OF ACOUSTIC HOLOGRAPHY

The principles of the nearfield "Acoustic Holography" are presented in detail in the companion paper n° 379428 on MALICE software [1]. Here, we just point out the main purposes and characteristics of such a method.

1.1 Acoustic Holography purposes

Generally speaking, the Acoustic Holography allows from a nearfield acoustic survey the identification of sources responsible for the acoustic pressure radiated by a complex shaped equipment. The method applied in SALSA consists in reconstructing the vibrational components related to the source field from acoustic measurements, in using a back-propagation technique, which removes all the interferential components of the nearfield of extended and (partially) coherent sources. The primary sources, or "hot spots" will then be visualized in image form, ready for interpretation.

The major improvements offered by SALSA are related to the practical collection and eventual re-sampling of the data as facilitating its everyday use.

I.2 Method

The Acoustic Holography is based on the measurement of phased acoustic pressures on a regular plane of sensors located nearby the sources, using one or several references (acoustic and/or vibrational). (cf. figure 1).

In order to keep all the available information (i.e. propagative and non-propagative components), it is necessary to perform measurements in the nearfield of the radiating structure, taking into account the interferential nature of this field.

Indeed, the frequency domain where acoustic holography can be applied is limited by the characteristics of the measurement instrumentation.

The experimental difficulties of acoustic holography are the following ones :

- today, the available methods and software are assuming a systematic and regular sampling of the acoustic nearfield in front of the noise making structure to be imaged, which is not easy to handle in practice when pressuring in situ industrial noise sources,
- the practical use is thus restricted to fully accessible objects (easy for a demonstration set-up, but far from being a general situation in a workshop, under an automotive bonnet or in a naval machinery room),
- in other cases, the truncation of the measurement meshing drastically degrades and restricts the quality and exploitability of the results.

II. THE SALSA SOFTWARE IMPROVEMENTS

Due to the limitations previously explained, METRAVIB RDS has developed SALSA. With this software, METRAVIB RDS is offering a break-through capability to enhance and make easier the acoustical imaging surveys, by combining :

- a robust and field proven palliative to the usual "edge" and "side" arising when the experimental nearfield survey cannot properly "cover" acoustic sources in the periphery,
- a new and totally user friendly "diffuse interpolation" capability to handle any practical sensor location without requiring to the experimentator the usual time consuming "systematic meshing" compliance at the entire scale of the inspected object.

The following example illustrates the SALSO user's benefits in the analysis of a car interior :

- you cannot remove the seats, as you have to really drive in order to tackle all the noise sources (engine, aerodynamics, tire/road contact, ...),
- you hardly get access to the lower corners of the windscreen or to the entire doors periphery, without removing acoustically important parts like dashboard etc...,
- anyway, you expect there significant sources.

Since the software will manage with the sensor locations you have effectively used, and does not ask you for "ideal" but impractical ones, you can use the "ping-pong pad" set up of acoustic arrays offered in the SALSA package, designed to match your practical needs (see Figure 6).

III. SALSA RESULTS EXAMPLES IN THE CONTEXT OF A REAL CAR HABITACLE ANALYSIS

In illustrating purposes, the result from real testing on a car are provided Figures 3 to 5. Subsequent diagnosis of each identified source are the following :

- Figure 3 shows an insufficient sound proofing around the door lock. This is also a very classical phonic bridge for cars. The upper part of this figure is related to a slight defect (moderate acoustic leakage) and the lower part is related to a more severe defect (serious acoustic leakage). Here, acoustic holography allows to visualize the gravity of this defect from one case to another.

- Figure 4 shows the ability of acoustic holography to visualize the effect of modifications induced by correcting in practice a defect detected by applying SALSA as a control procedure (in this case the defect is an acoustic insulation loss close to the rear door lower part). The before/after SALSA display is self-speaking.

- On Figure 5, the identified acoustic defect is related to an acoustic insulation defect on a car window due to an abnormal leakage located on the right near door slide rail (the upper window seal has been intentionally cut on a very small portion). In this case, acoustic holography allows to locate immediately this acoustic defect which would have remained undetected in the standard car manufacturer control procedures, as the resulting loudness is just at the acceptance level. However, by solving it, the comfort impression when driving on a motorway is well improved.

IV. CONCLUSION

Some original improvements in terms of every day practicability of the classical Acoustic Holography have been presented, which are implemented in SALSA, a system developed by METRAVIB RDS. They allow the user to work on a regular virtual sensor distribution by regularizing the initial meshing which takes into account the environmental restrictions. To extend the meshing on the boundaries for better resolving peripheral sources, a use of this software related to an operational situation (passenger car analysis) have been presented : the ability of Acoustic Holography to locate acoustic serial manufacturing defects of any kind, to visualize the time evolution of such defects and to put into evidence the effect of modifications when correcting a defect has been illustrated.

REFERENCES

[1] "MALICE, the Efficient Acoustical Imaging System for Precise Noise Source Localization" – D. VAUCHER, D. WEBSTER, B. GARNIER, F. MOLLIEX – ICSV'5, Adelaide, Australia – December 15-18, 1997

[2] « Nearfield acoustic holography : I. Theory of generalized holography and the development of NAH » - J.D. MAYNARD, EG WILLIAMS and Y. LEE - J. Acoustic Soc. Am. Vol. 78, n° 4

[3] "The acoustic holography: from nice pictures… to effective applications" – B. GARNIER, F. MOLLIEX, D. VAUCHER – ICA 95 – 15th International Congress on Acoustics – Acoustical Society of Norway/ IUPAP – Trondheim (Norway) – 26-30 June 1995 – Vol. 4 – pp. 55-60 – M. Newman Ed.

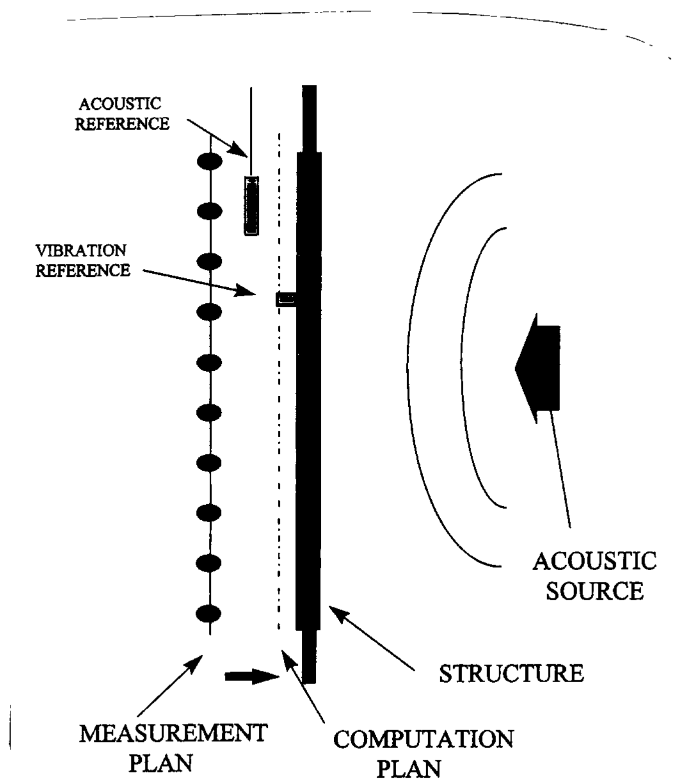

Figure 1: usual measurement configuration for Acoustical Holography

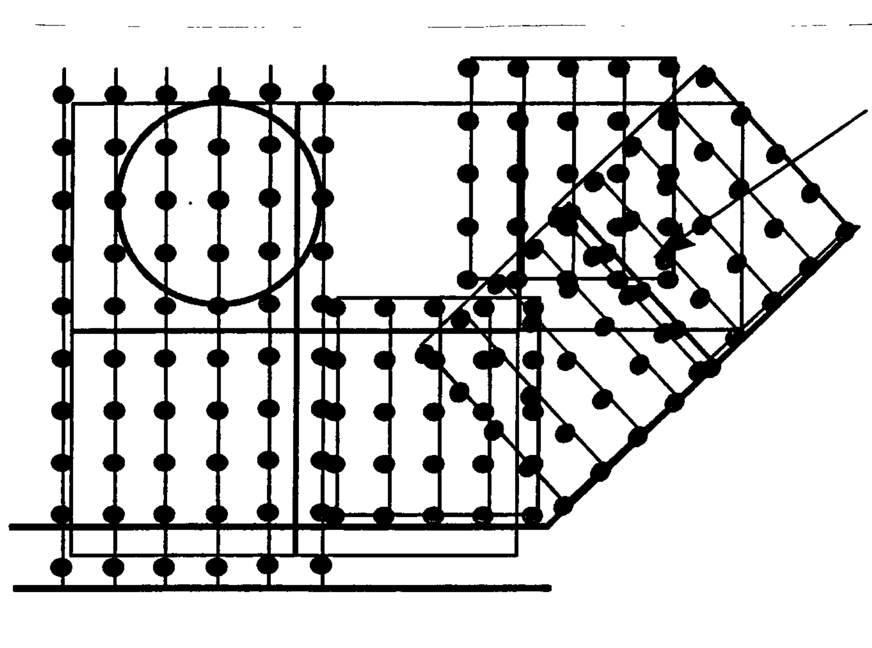

Figure 2: Final measurement meshing

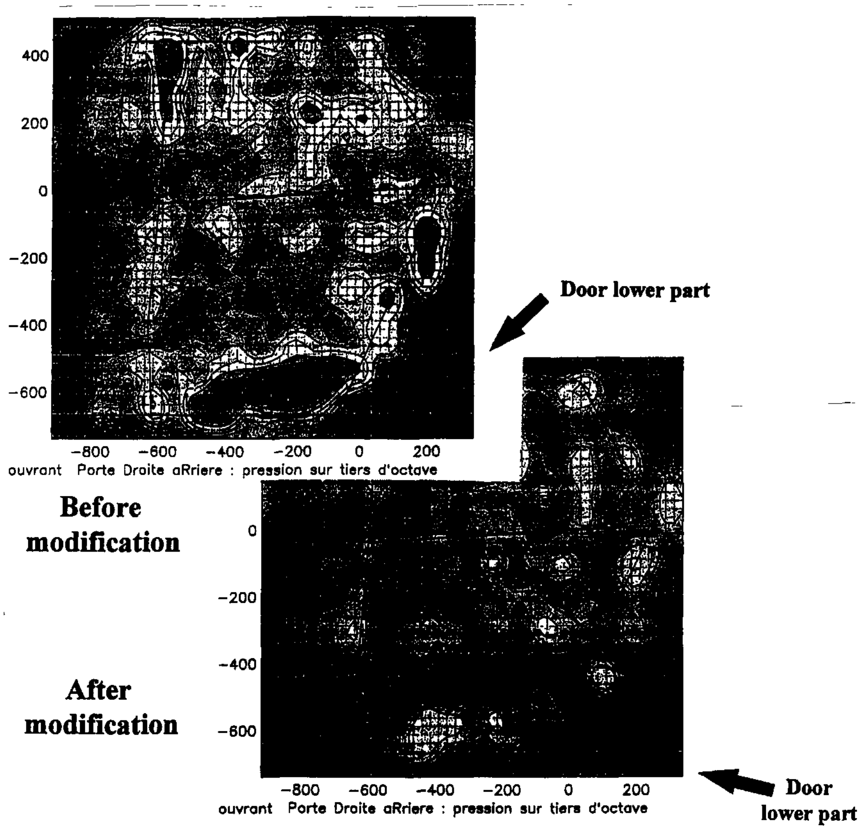

Figure 3: Fault correction on the rear door of a passenger car

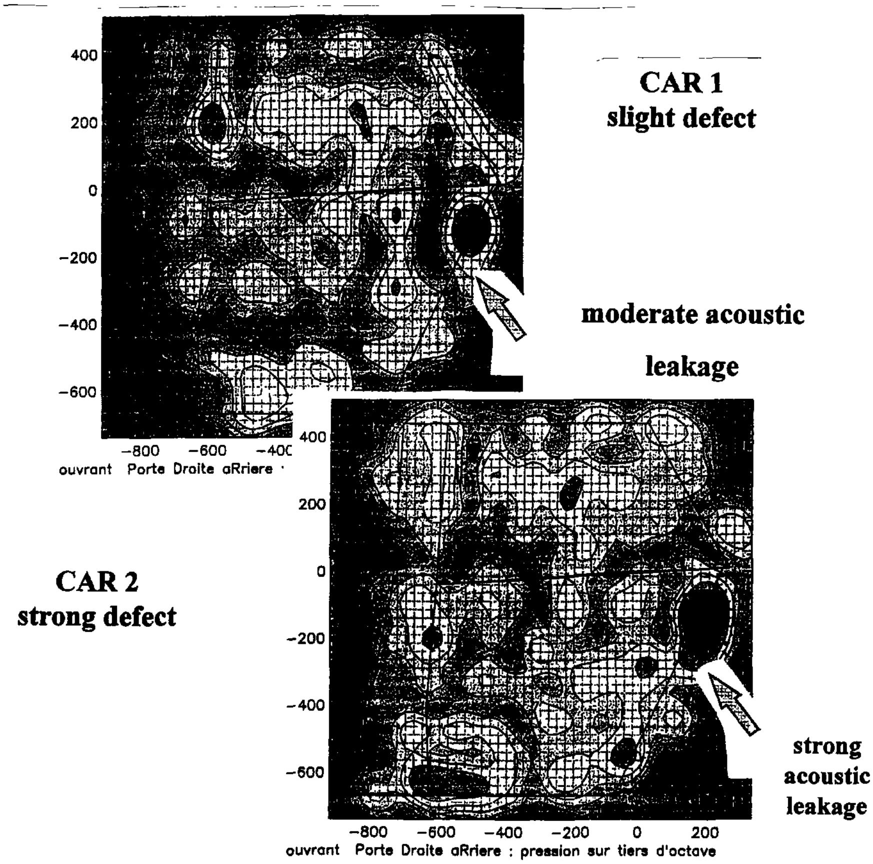

Figure 4: Improvement of door lock acoustic insulation

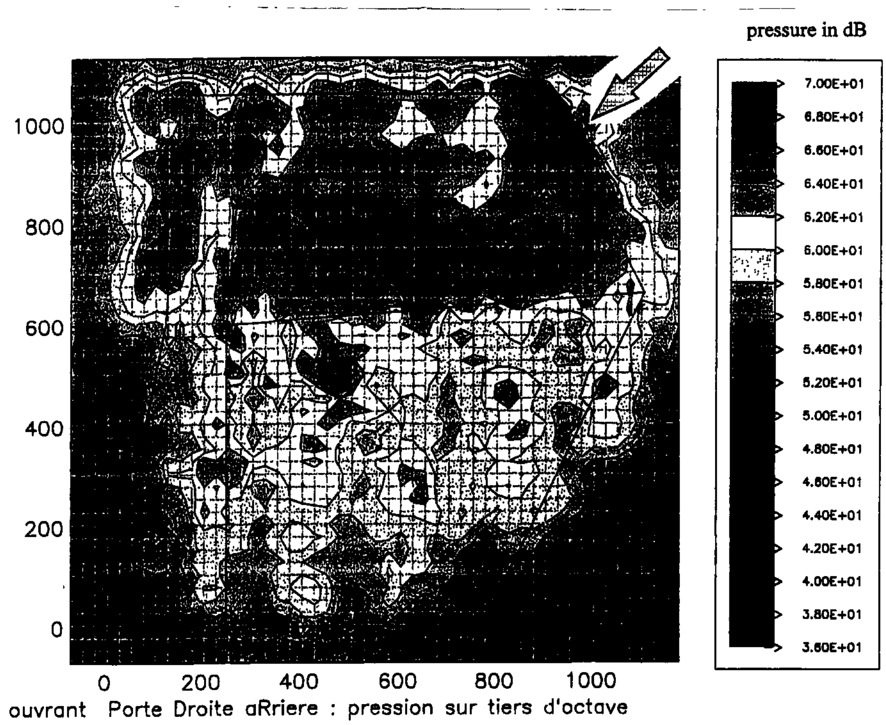

Figure 5: SALSA : acoustic insulation loss on a car window

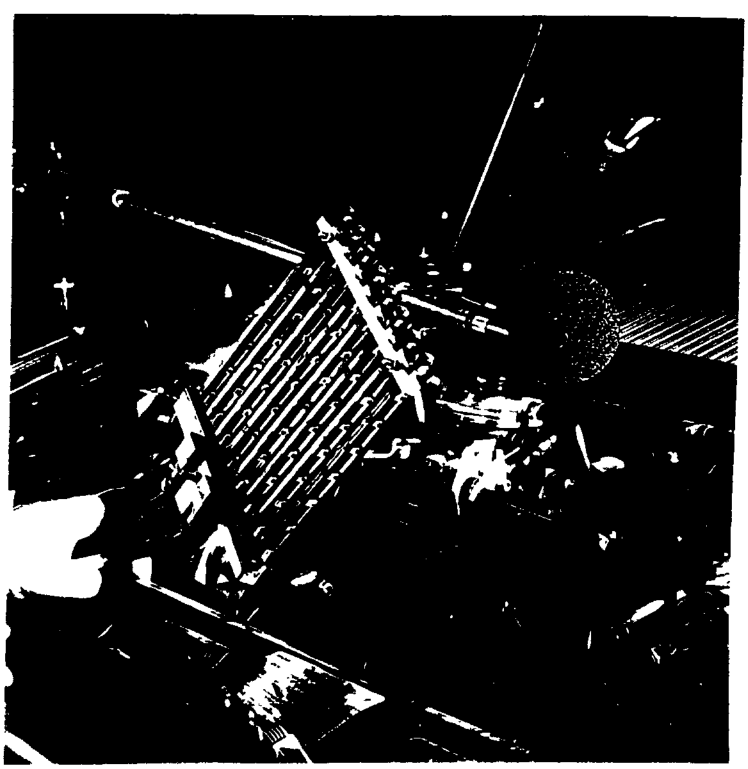

Figure 6: Typical measurement configuration with SALSA – setting the adequate array in the source nearfield