

# MODAL ANALYSIS

Acoustic and Vibrations Engineering Services



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**“Far better an approximate answer to the right question, which is often vague, is an exact answer to the wrong question, which can always be made precise.”**

**John W. Tukey**

## **Right questions lead to right answers**

**“I am not bound to swear allegiance to the dogmas of any master.”**

**Horace**

## **The good thing of a problem without an obvious solution is the pleasure in finding it**

**“I support that symbiogenesis is the result of a long time coexistence and that is the main source of evolutionary novelty in all superior non-bacterian organisms.”**

**Lynn Margulis**

## **Fluent communication is the key to progress**

## Objectives

Modal analysis allows the modes and frequencies of a structure or a piece of equipment to be identified.

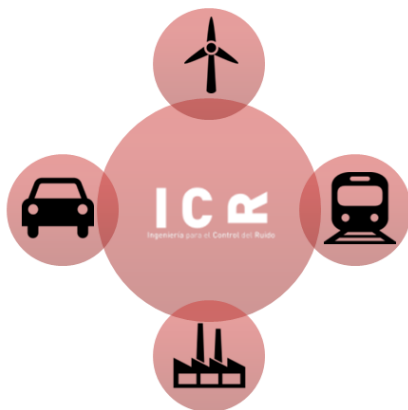
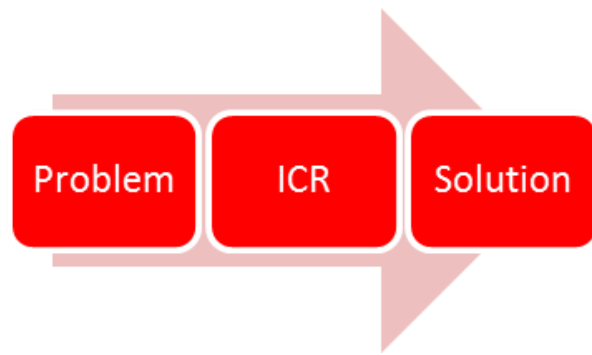
This information is useful because it can be used to determine the adverse effects that could be produced by these modes and frequencies. Structural damage is one of the many negative effects, which is caused due to the excitation of resonance frequencies.

The techniques for modal analysis applied in **ICR**, combined, lead to the prevention of future problems that could be presented by the structures or equipment under study, together with the pinpointing of effective solutions for these problems.

**ICR** is an expert in three techniques of vibration analysis: **EMA**, **OMA** and **ODS**.

## Benefits for the firm

- Detailed knowledge of the dynamics of their products.
- Detection of errors in prototypes and improvement of their design.
- Reduction of the vibrations generated by operating equipment.
- Adjustment of numerical models (FEM) by using their correlation with the results of the modal analysis.



## Applications

**ICR** mainly works for companies in the following sectors/industries:

- Wind power
- Railways industry
- Automotive industry
- Industrial Sector

## Why choose ICR?

**ICR** offers its clients a 360° analysis of the problem, allowing a complete solution to be identified by means of the assessment of the results from de modal analysis.

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*ICR's team of professionals, comprised of engineers, physicists and doctors, has a vast experience in determining the root causes of vibratory problems.*

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**ICR** is an expert in modal analysis and combines various different techniques the latter enables it to adapt to each client's particular problem.



## EMA

When we allude to experimental modal analysis we refer to the process by which the modes and frequencies of an element being excited through controlled external forces can be determined. These “controlled external forces” are applied using a hammer or a “shaker”.

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### Benefits for the firm

- Quick and low cost methods are employed.
- A wide variety of machines and structures are applied.
- Solutions for vibratory and structural problems are determined.
- Reduces production costs.
- Allows the correlation of the results with the numerical models of the firm.

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### Successful Cases

#### WIND POWER SECTOR



**FIRM:** Alstom Wind  
**PROJECT:** Analysis of powertrain, installed inside the nacelle of the wind turbine ECO - 100S1.

Determination of the vibration modes of the structure (in the client's plant) of the converter, the generator, the multiplier and the control cabinet.

#### RAILWAY SECTOR

**FIRM:** CAF, Construcciones y Auxiliar de Ferrocarriles.  
**PROJECT:** Analysis of a powertrain.

Experimental Modal Analysis of the powertrain of NIR (North Ireland Railways) diesel units.



## OMA

Operational Modal Analysis determines the modes and frequencies of a structure when it is operating at its normal functional conditions. That is to say, that the excitation is not controlled, as in EMA, it instead derives from the functioning of the system or from the surrounding environment.

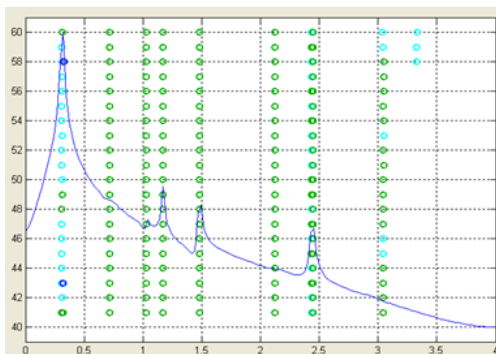
*ICR has developed a specific software whose purpose is to facilitate the vibration characterization infrastructure, even in multiple configurations.*

## Benefits for the firm

- OMA is a method that is adequate for large structures where controlled excitation is difficult to carry out.
- Diagnoses vibratory and structural problems, facilitating their solution.
- Allows the dynamics of the structure or the equipment, depending on the operating conditions, to be considered.

## Successful Cases

### WIND POWER SECTOR



**FIRM:** Projecte de recerca InVent - Alstom Wind

**PROJECT:** Performing a software application adapted for wind.

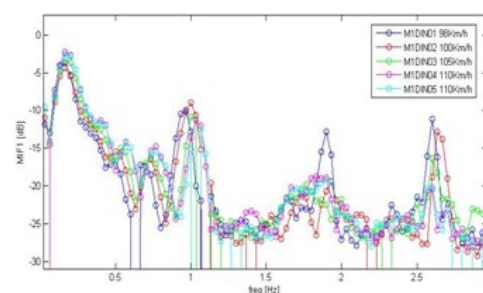
Determination of the modes of wind turbine, in an automated manner, starting from previous measurements taken whilst the wind turbine was operating .

### RAILWAY SECTOR

**FIRM:** TIFSA

**PROJECT:** Measurement of the vibrations of a railway bridge (old viaduct) of the AVE in Contreras, Spain .

Analysis of the vibrations of the bridge at real operating conditions, by means of the technique of OMA.





## ODS

The ODS analysis of a machine or structure allows its vibratory behaviour to be visualised whilst it is operating. This analysis consists of the carrying out of a simultaneous measurement of the vibrations at different points of the structure or the machine. With the results, the obtained data is linked to a geometric model that allows the machine/structure's movement to be observed at every frequency.

### Benefits for the firm

- It is the fastest method to apply.
- Studies the behaviour of the object whilst operating.
- Analyses the element's problems when it has already been implanted.
- Solves both structural and vibratory problems.
- Treats the structural problem in a direct manner, thanks to the possibility of visualising it.

### Successful Cases

#### INDUSTRIAL SECTOR



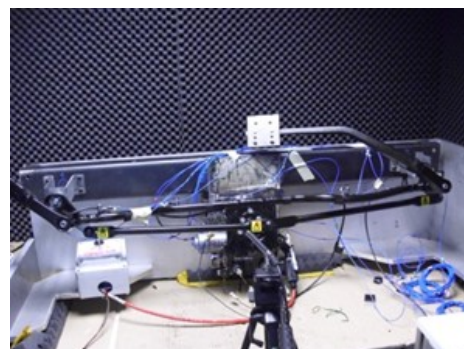
**FIRM:** KAO Corporation S.A.  
**PROJECT:** Analysis of the vibratory behaviour of the factory's machines.

Determining behavior vibratory machines obtaining an optimal operating mode.

#### AUTOMOTIVE SECTOR

**FIRM:** Lyon Renault Trucks, Doga S.A.  
**PROJECT:** Acoustic counselling for the design of a wipers.

ODS analysis of the installment of a wipers, along with that of the motor's nodes.





## Projects involving Modal Analysis

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**ICR** counts with a vast experience in applying the previously mentioned methods of Modal Analysis to solve vibratory problems. The upcoming list shows some examples of projects conducted during the last few years, which are related to the three kinds of modal analysis.

### **EXPERIMENTAL MODAL ANALYSIS (EMA)**

- Experimental modal analysis of the power train of ADR diesel units. CAF, Construcciones y Auxiliar de Ferrocarriles.
- Experimental Modal Analysis of the drive train of an ECO-100 Alstom Wind wind turbine. Measurements were taken in the client's factory situated in Buñuel. Alstom Wind.
- Development of an EMA of the structure of a nacelle of an ECO-80 wind turbine. Alstom Wind.
- The carrying out of an in situ Experimental Modal Analysis of the multiplier of a wind turbine to measure its vibration modes. Alstom Wind.
- Acoustic study of the nacelle of an ECO-80 wind turbine through the use of an Experimental Modal Analysis. Alstom-Ecotecnia
- Experimental Modal Analysis of the structure of the gondola of a real size prototype of an ECO-100 wind turbine. Alstom Wind.

### **OPERATIONAL MODAL ANALYSIS (OMA)**

- Operational Modal Analysis of the vibrations of Contreras's railway viaduct for the passing of the AVE. Ineco Tifsa.
- Determination of a methodology and the development of a piece of software for the OMA of wind turbines. Alstom Wind.
- Development of an OMA method for Alstom-Ecotecnia's project on wind turbines, called InVent.
- OMA for the field study of a machine in order to obtain the buffer of its (vibration) modes. Alstom Wind.
- Study of the sound produced by a converter, applying OMA, and the designing of a solution to reduce the sound in excess. Trainelec.

### **OPERATION DEFLECTION SHAPE (ODS)**

- The carrying out of an ODS to analyze the movement of a multiplier of an ECO-100 wind turbine, whilst it was operating. Alstom-Ecotecnia
- Analysis of the vibratory behaviour of the factory's machines, applying an ODS. KAO Corporation S.A.
- ODS of a converter to determine the spatial distribution of the resonances and their contribution (to overall noise). The study was performed whilst the body was operating. Trainelec.



Ingeniería para el Control del Ruido

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