ICR

Ingeniería para el Control del Ruido

Projects

ICR, Ingeniería para el Control del Ruido, specialists in vibro-acoustic

Company

Francesc Xavier Magrans

Founder and Director

Degree in Physical Sciences and PhD in Civil Engineering

ICR, Ingeniería para el Control del Ruido, S. L. was founded in Barcelona in 1995 by experts in the field of vibro - acoustics from the automotive sector.

From the beginning it adopted as its motto "The science of silence", understanding acoustics and vibrations as fields of science in full evolution.

ICR, throughout its history, has focused its activity on the development of testing and calculation solutions at the technological frontier, always intending to solve real problems with practical solutions.

Since our inception, we have had the opportunity to participate in numerous projects of great importance and technological scope, both nationally and internationally.

The knowledge gained over the years has been translated into the development of new predictive methods.

As a result of the professional balance between the members of the team, practical knowledge and theoretical knowledge converge perfectly when obtaining and analyzing experimental data of problem.

In recognition of its success, it has signed contracts with multinational companies to transfer its testing and calculation methods to them. Some examples include CSR in China, Hyundai -Rotem in South Korea, Alstom in France, and CAF in Spain.

Mission

We solve complex vibro-acoustic problems by applying advanced technology and analysis methods. These methods allow us to understand each problem perfectly which result in proposing optimal, practical and reliable solutions.

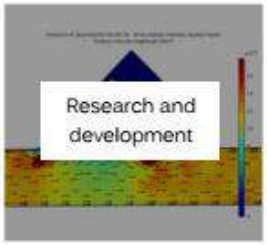
Our philosophy

Research and Innovation as a source of knowledge and technology.

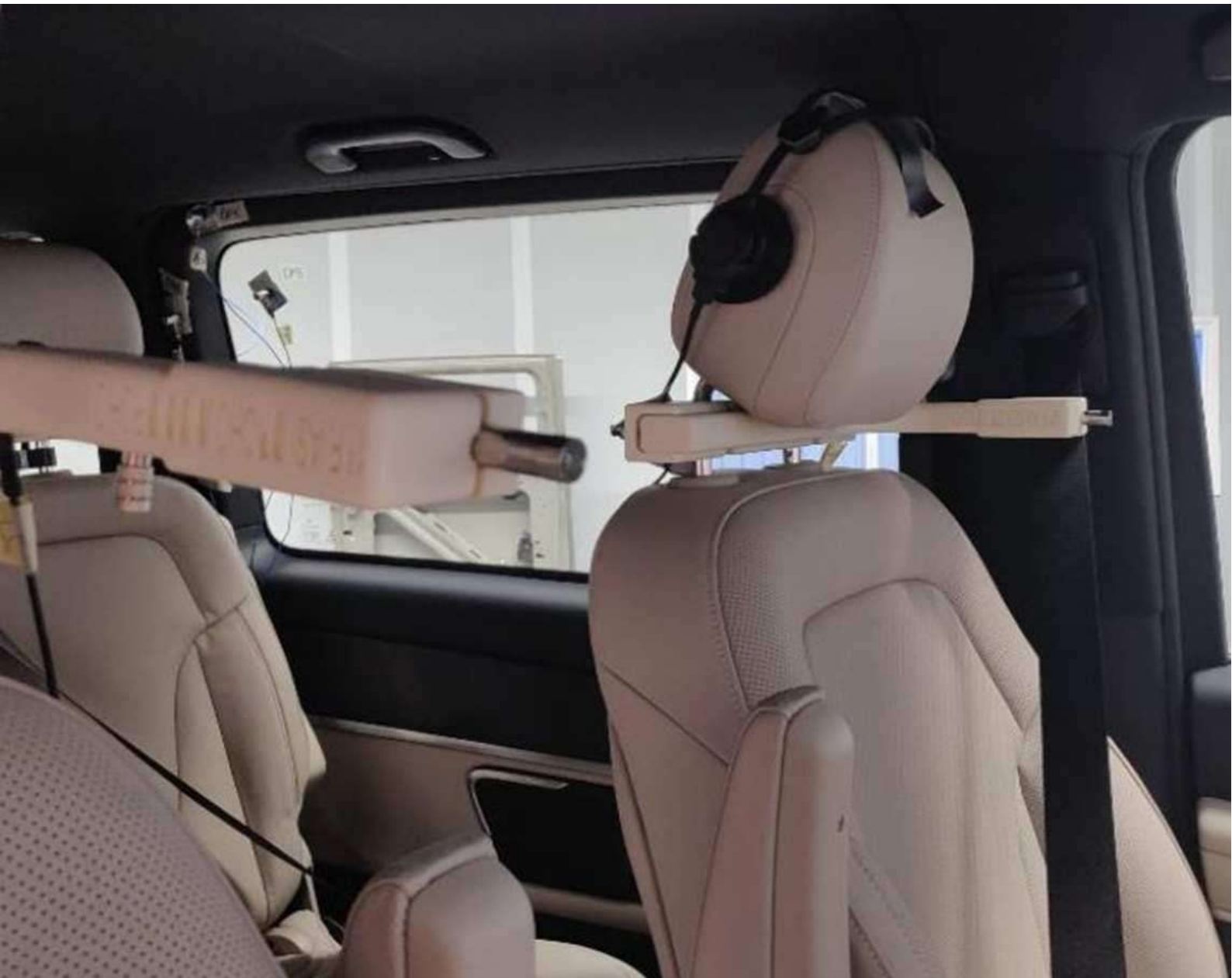
Engineering services for its transformation into tangible value for our customers.

Training to enable smoother interaction and a deeper understanding of our work

Sectors:



Automotive



Study of Squeak and Rattle noise characterization in high-end vans.

Development of a methodology for the study of noise in automobiles together with tailor-made technical training.

In 2017, the company “Mercedes-Benz Vitoria” requested the realization of different trainings to thek Technical Department to address the theoretical and practical problems related to acoustics and acoustic measurements.

The content of these trainings is specially designed for the specific needs of the customer, in this case, in the automotive sector. The training is structured in different sections where the fundamentals of acoustics and vibrations together with the basics of vibro-acoustic measurements are treated. Concepts of acoustics applied to the automotive industry are also taught, breaking down different measurement techniques, analysis, calculation methods and solutions.

All ICR training courses include practical applications using noise and vibration measurement equipment (accelerometers, microphones and multichannel spectrum analysers). In this way, real measurements are carried out and they covered those concepts presented during the course. This encourages the attendees to participate actively throughout the training.

As a result of these trainings, Mercedes-Benz Vitoria once again relies on the experience of ICR to carry out a study of Squeak and Rattle noise characterization in high-end vans. To do this study, three measurement campaigns were performed in the acoustic room of the Mercedes factory in Vitoria.

In the campaigns, several types of measurements were conducted in order to collect as much data as possible for defining a noise identification method later. After analysing different methodologies, it was decided to use the technique based on cross-correlation.

TECHNICAL SPECIFICATIONS:

Customer: Mercedes - Benz
Location: Vitoria (Spain)
Year: 2017-2019
Sector: Automotive, Training
Service: Computational Vibro-acoustics, Noise and vibration control of a product, Acoustic measurements and certification, Courses and training

This technique allowed to consistently detect and identify noises from the pressure signals of the microphones placed near the defects.

Thanks to this project it has been possible to develop a promising and relatively simple to implement technique to detect and identify Squeak and Rattle type noises.

TECHNICAL SPECIFICATIONS:

Customer: Mercedes - Benz
Location: Vitoria (Spain)
Year: 2017-2019
Sector: Automotive, Training
Service: Computational Vibro-acoustics, Noise and vibration control of a product, Acoustic measurements and certification, Courses and training

Research project on the Ferrari 456

Study for the acoustic characterization of the vehicle

The Italian company Ferrari, dedicated to the manufacture of racing cars and high performance sports cars, funded a private research project called: "Cabin noise reconstruction at the mid-high frequency range", to apply it to its new car model, the Ferrari 456.

The objective of the project was to define the acoustic characterization of the vehicle by calculating the acoustic power of all the interior panels of the car, in the medium and high frequency range, by applying Model Inversion technology.

The purpose of the Model Inversion methodology is the identification of the acoustic characterization of each interior surfaces (sound sources) and to determine their contribution to each point of the sound field of the room. The Model Inversion method is a non-intrusive technique that allows a minimum interference in the object of study, in a very reasonable lapse of time.

ICR's proposal allowed Ferrari to reduce the process time of obtaining the acoustic power of the interior surfaces of the passenger compartment from 30 days to 2-3 days.

ICR has been developing its own computational tools for the study of the inverse problem for 25 years, including optimization techniques, resampling and stability analysis to ensure the validity of the solutions obtained.

TECHNICAL SPECIFICATIONS:

Client: Ferrari
Location: Barcelona (Spain)
Year: 1998
Sector: Automotive, R+D+i
Service: Vibro -acoustics computational

As a result of this research study applied to the automotive sector, a paper was published at the European Congress Euronoise' '98, entitled: "An Innovative approach for the noise reconstruction and analysis at the medium-high frequencies".

O. Guasch, F.X. Magrans, P.V. Rodriguez & G. Manacorda, Proceedings of Euro-Noise, Munich, Germany, October, Vol. I, pp.503-509 (1998).

TECHNICAL SPECIFICATIONS:

Client: Ferrari
Location: Barcelona (Spain)
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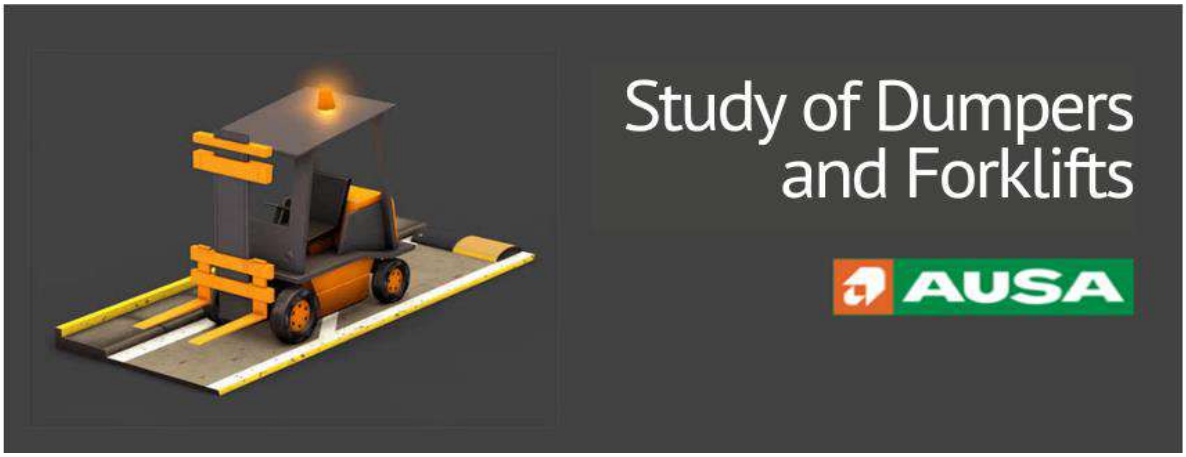
Service: Vibro -acoustics computational



Acoustic characterization of two heavy Industrial vehicles

Study of a forklift and a dump truck

The company AUSA, a manufacturer of compact industrial vehicles for material handling and road maintenance, which operates in the global market, contacted ICR several years ago to conduct several acoustic characterization studies for two of its vehicles: a forklift truck model C150H and a D350AHG dump truck model.

Between the studies carried out were the analysis of noise and vibration transmission paths of the vehicle, which was applied to both vehicle models, and the vibratory characterization of the engine and the design of an acoustic silencer for the exhaust pipe, studies applied only to the C150H model.

The technology used for the analysis of vibro-acoustic transmission paths was the ATPA method, developed by ICR. This method made it possible to determine the different contributions, both airborne and structural borne, of the noise received at the driver's position and other points around the vehicle. The application of this method allowed to know how much noise directly came from the vibration of the various elements of the bodywork and how much received by air. The objective of this study was both to reduce the sound pressure level at the defined points and to determine the necessary modifications to be made to the vehicle to achieve the expected reduction.

The method of mobilities and the source descriptor were applied to define the vibration characterization of the engine. The application of the mobilities method made it possible to know the vibratory power transmitted by the engine to the vehicle, through the points where the engine attaches to the body. On the other hand, the method called source descriptor, allowed to study how the power transmitted by the engine to the bodywork was modified to through the spring mounts when the spring mounts were modified.

TECHNICAL SPECIFICATIONS:

Client: AUSA
Location: Spain
Year: 2000-2001
Sector: Automotive
Service: Computational Vibro-Acoustics, Advanced Transfer Path Analysis (ATPA).

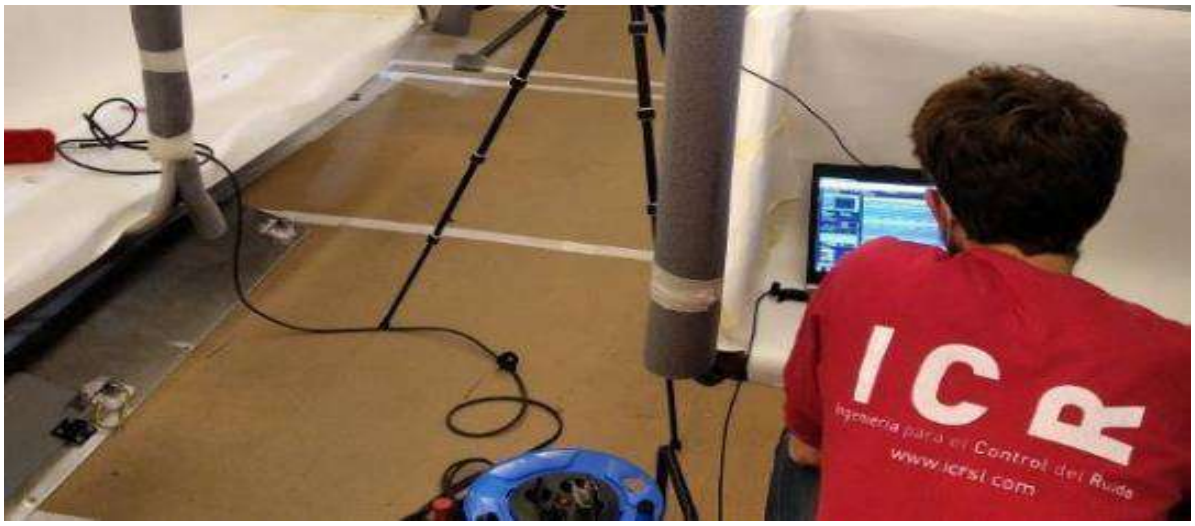
The study also provided the ability to predict how the vibrational power would be transmitted from the engine (together with the spring mounts) to a different receiver, i.e. in a different body. The study was carried out on a C150H vehicle. The vehicle experienced excessive vibration when idling. It was due to the operation of hydraulic pump that moves the forks. The pump's operation caused a reduction of the engine revolutions, resulting in an increase of the vibration of the bodywork. Applying the method of the Mobilities and the Source Descriptor, it was possible to find a solution to reduce these vibration levels.

The design of a new acoustic muffler for the vehicle's exhaust pipe also contributed to the reduction of the emitted noise.

TECHNICAL SPECIFICATIONS:

Client: AUSA
Location: Spain
Year: 2000-2001
Sector: Automotive
Service: Computational Vibro-Acoustics, Advanced Transfer Path Analysis (ATPA).

Railway



Study of the location of noise sources inside a passenger cabin of a train

Analysis carried out on a Brussels metro unit using the “Scan&Paint” technique

The Spanish railway company CAF (Construcciones y Auxiliar de Ferrocarriles), based in the Basque Country, asked ICR to carry out a noise source location study on a metro unit in Brussels.

This acoustic study aims to evaluate, identify the origin and propose a solution to reduce the noise inside the car deck and cabin. ICR proposes this study in two phases of analysis: the first phase of diagnosis and the second phase of acoustic solutions.

In the first phase the problem is diagnosed by experimental methods allowing to establish a classification of the different parts involved in the problem. ICR uses the "Scan & Paint" digitizing technique to obtain direct visualization of sound pressure, acoustic velocity and sound intensity fields.

The method is based on moving a probe that measures the pressure and velocity of the particles over the surface under study, while recording the image. With this, a detailed description of the spatial distribution of sound and the identification of the main problem areas is obtained, as well as the spectral characteristics of the noise.

Once the results have been analysed and the tonal noise that generates discomfort has been identified, ICR designs a proposal for its reduction, within phase two of the study. The solution is a Helmholtz resonator with a dimensions and acoustic characteristics. CAF makes a prototype of this ICR resonator design and checks the efficiency in situ. Thus, the client obtains a solution to his problem and can check the results of the proposed solutions offered by ICR.

TECHNICAL SPECIFICATIONS:

Client: CAF (Construcciones y Auxiliar de Ferrocarriles)
Location: Beasáin (Basque Country)
Year: 2020
Sector: Railway
Service: Computational Vibro-acoustics, Engineering-Consultancy acoustics

Prediction of the interior noise level of the AVRIL prototype train, after modifications in the interior design

Study on the prediction of the noise level inside the passenger vehicle of the AVRIL train prototype.

Within the framework of the acoustic consultancy that ICR carries out jointly with the Spanish company Talgo, a study has been carried out on the prediction of the noise level inside the passenger vehicle of the AVRIL train prototype. This study aims to quantify the improvement in the insulation of the prototype floor as a result of the design modification, through metamaterials.

What are metamaterials?

Metamaterials are structured artificial materials, in which the presence of resonances gives rise to properties not found naturally in materials. Metamaterials make it possible to control propagation and achieve absorption and insulation physical properties that are impossible to achieve with conventional materials.

The noise inside the passenger vehicle has been studied, depending on the generating noise sources: interior noise due to rolling, aeroacoustics excitation (at 320 kph) and auxiliary equipment have been analysed.

These calculations have been made for different train speeds (160 kph and 320 kph).

TECHNICAL SPECIFICATIONS:

Client: Talgo
Location: Spain
Year: 2021
Sector: Railway
Service: Computational vibro-acoustics

Antwerp Tramway Study

Analysis and characterisation of the track and terrain

A technical team travelled to Antwerp to carry out a series of tests on a local tram unit. All the measurements were carried out at the Ambers Deune Tram Dépot with the aim of generating a numerical calculation model. The results obtained from these measurements, allows to determine the force that a tram unit transmits to the ground during its passage.

Different types of measurements have been carried out on the Dépot test ring, such as track characterisation through roughness and mobility tests, terrain characterisation through vibration transfer function measurements and finally measurements of the dynamic passage of the tram.

Roughness measurements defined the irregularity of the track on which the tramway travels. This measurement makes it possible to assess the influence of the roughness of the track on the level of vibration in the tram. On the other hand, the characterization of the ground allows to define the vibration levels that are transmitted by the ground in the passage of the tram.

Together with these measurements, a characterisation of the tram unit Client: CAF was carried out by means of a mobility test on the wheels of the trailer bogie (Construcciones y and the motor bogie. These tests were carried out inside the Dépot, in the Railway Auxiliary) maintenance area, allowing the technicians to access the lower part of the tram.

TECHNICAL SPECIFICATIONS:

Client: CAF (Construcciones y Auxiliar de Ferrocarriles)
Location: Antwerp (Brussels)
Year: 2018
Sector: Railway
Service: Measurements acoustics and certification

Vibro-acoustic characterization for a new high speed train

AVRIL train modelling

The interior acoustic comfort of any vehicle is becoming an element of essential value for companies in the railway sector. For this reason, carrying out an exhaustive study of the interior noise level of the new high-speed trains has become a differentiating element for the Spanish company Talgo.

For this project, a complete characterisation of the passenger carriages and driver's cab of the AVRIL train prototype has been carried out in order to export it to the new F070 high-speed train. Based on the design of the AVRIL train, the necessary measurements will be taken, which will later be used to validate the medium-high frequency models as well as to obtain the data that cannot be obtained by means of modelling.

Listed below are all the works carried out for the complete study of the AVRIL train:

• Characterization of sources of airborne and structure-borne noise.

• Development of an acoustic FEM model of the car interior and cabin for low frequencies.

• Prediction of parietal noise levels around the train.

• Characterization of the insulation (TL) of the train panels.

• Development of a numerical model of interior noise, for high frequencies, using the Sound Particle Tracing method.

• Extensive measurement campaign on the AVRIL prototype.

TECHNICAL SPECIFICATIONS:

Client: Talgo
Location: Spain
Year: 2017
Sector: Railway
Service: Advanced Transfer Path Analysis (ATPA), Computational Vibro-Acoustics, Engineering - Acoustic Consulting.

Once all the calculations and measurements have been carried out, and with the results obtained, ICR has proposed viable solutions to minimize the interior noise of the train, and thus improve the acoustic comfort of the passengers.

TECHNICAL SPECIFICATIONS:

Client: Talgo
Location: Spain
Year: 2017
Sector: Railway
Service: Advanced Transfer Path Analysis (ATPA), Computational Vibro-Acoustics, Engineering - Acoustic Consulting.

Technology transfer of the ATPA transmission path calculation method

Demonstration application in the metro KORAIL 31795

For more than 15 years, ICR has been developing the ATPA (Advanced Transfer Path Analysis) transmission path calculation method. This method, created entirely at ICR, makes it possible to separate and quantify the transmission paths between a vibro-acoustic source and a receiver, and also to know the noise contribution of each element involved in a mechanical system. The information obtained from the analysis makes it possible to detect which elements contribute most to the problem and to prioritize interventions on specific components in order to reduce the noise emission of the critical components identified.

In this project, the South Korean company Hyundai-Rotem needs to differentiate and separate the contribution of airborne noise from the structural borne noise inside a train carriage to obtain the different contributions and be able to apply specific solutions.

For this reason, ICR offers Hyundai-Rotem a technology transfers of the ATPA method. The technology transfer allows the company to learn how the method works both at a theoretical and practical level and to have the software at its disposal, so that it can apply it directly in its daily activities. This transfer consists of:

• Theoretical training on the ATPA method.

• Experimental training on how to apply the method to real train measurements.

• Sub-delivery of the ATPA calculation software adapted to the customer's instrumentation equipment.

TECHNICAL SPECIFICATIONS:

Client: Hyundai-Rotem
Location: South Korea
Year: 2016
Sector: Railway
Service: Technology transfer, Advanced Transfer Path Analysis (ATPA), Custom software development, Courses and training

• Training on the use of the ATPA calculation software to analyse the results obtained in real measurements.

Two expert technicians from ICR travel to the customer's facilities in South Korea for a period of 15 days to give the theoretical course and proceed with the practical training for the application of the technology in a real case. In this case, the customer requests to carry out the training tests in a KORAIL 31795 metro unit.

TECHNICAL SPECIFICATIONS:

Client: Hyundai-Rotem
Location: South Korea
Year: 2016
Sector: Railway
Service: Technology transfer, Advanced Transfer Path Analysis (ATPA), Custom software development, Courses and training

Caledonian Sleepers train interior acoustic comfort improvement design

Noise study carried out according to the client's protocols

Caledonian Sleeper is the collective name for night train services between London and Scotland in the United Kingdom. This train has different types of carriages for passengers: carriages for passengers in armchairs and sleeper carriages for passengers can rest in their own room with beds.

The study carried out on this train aims to ensure compliance with the client's specifications for the improvement of interior acoustic comfort. To this end, the interior sound pressure level (SPL) has been analysed and both the sound insulation index of the carriage and the interior noise level due to the air conditioning and ventilation system have been studied. At the same time, the interior linings have been studied to take into consideration the effect of the interior acoustic treatment that affects the reverberation time in the final result.

For the calculation of the insulation of the panels and the characterization of the ventilation system, the dBKAisla and dBKDuct calculation programs, developed entirely by ICR, are used. Once the results are obtained, a 3D numerical model of the train is elaborated where all the geometry is modelled, analysing all the materials used for the construction of the vehicle. Thanks to the results of the calculation, the interior of the vehicles is redesigned to ensure that they meet the acoustic comfort requirements set by the client. ICR has advised the client on the modifications to be made to obtain these improvements.

TECHNICAL SPECIFICATIONS:

Client: CAF (Construcciones y Auxiliar de Ferrocarriles)
Location: Spain
Year: 2015
Sector: Railway
Service: Computational Vibro- acoustics, Acoustic Consulting

Evaluation of the acoustic quality inside a train

Civity Bari train speech intelligibility analysis

In order to evaluate the interior acoustic quality of the Civity Bari train, as far as the messages played through the public address system are concerned, a speech intelligibility study has been carried out. There are different procedures to determine this acoustic parameter.

In this study the RaSTI index (Rapid Speech Transmission Index) has been applied, the value of which can vary between 0 and 1, with 0 being poor intelligibility and 1 being excellent intelligibility.

The measurements took place inside the Civity Bari ETR452 train. To carry out the measurements, several measurement points have been selected in each of the 4 vehicles that make up the train, applying the IEC 60268 - 16:2011 standard, together with the TSI PRM 2008/164/EU, which define the minimum requirements allowed, as well as the technical specifications of the measurement procedure in European trains.

TECHNICAL SPECIFICATIONS:

Client: CAF, Contrucciones y Auxiliar de Ferrocarril
Location: Bari (Italy)
Year: 2015
Sector: Railway
Service: Acoustic measurements and certification.

Acoustic consultancy for the development of a new tramway

Mexico-Toluca Interurban Train

This project has studied the internal and external noise level of the new intercity electric train in Toluca, Mexico.

For this study, a numerical model of the complete train has been made to predict the internal and external noise levels. For the modelling of the new train, the acoustic characteristics of the materials and equipment to be installed, which were defined by the client, have been used. The methodology used for this calculation has been SPPS (Sound Particle Propagation Simulation) which allows to make an acoustic prediction within the domains of propagation of complex shapes, in three dimensions.

Numerical acoustic models allow the client to know the level of interior and exterior noise, the insulation of the materials installed, as well as the noise that a train will generate, in this case, as it passes over a viaduct or through the interior of a tunnel. By carrying out this type of study prior to the construction of the train, the client can modify the design in order to closer to the desired vibro-acoustic conditions.

For the calculation of the Toluca train, a three-dimensional numerical model has been generated with the geometry of the train inside a tunnel. A study of the acoustic insulation of the constituent elements of the train has also been carried out. The commercial software dBKAisla, developed by ICR, has been used.

Once the results of the modelling have been obtained, acoustic advice is offered to improve the interior and exterior noise levels of the new train..

TECHNICAL SPECIFICATIONS:

Client: CAF (Construcciones y Auxiliar de Ferrocarriles)
Location: Spain
Year: 2015
Sector: Railway
Service: Vibro-acoustics computational, Acoustic Consulting

Interior and exterior noise analysis for the characterization of a tramway.

Stockholm tram study

The company CAF, supplier of Urbos trams for Storstockholms Lokaltrafik (SL AB), the company responsible for the transport network of the city of Stockholm, needs to carry out a study to determine the interior and exterior noise on a Stockholm Tram unit.

Due to the extreme weather conditions in the Nordic country, it was necessary to carry out a complete study of the acoustic comfort of the train. The acoustic tests were carried out at the Valenciennes Railway Test Centre in France.

The aim of the tests is to determine the noise inside the vehicle, as well as the noise emitted towards the outside, both when the train is stationary and when it is running. Together with the relevant noise measurements, the following parameters have been analysed:

• RASTI word intelligibility rating

• Reverberation time of the passenger lounge and the driver's cab

• Track roughness according to EN 1561 standard

• Track Attenuation Ratio (TDR), which quantifies the attenuation of rail vibration as a function of distance along the track.

The results obtained have made it possible to verify whether the tram complies with the requirements specified in the client's specifications.

TECHNICAL SPECIFICATIONS

Client: CAF (Construcciones y Auxiliar de Ferrocarriles)
Location: Valenciennes (France)
Year: 2013
Sector: Railway
Service: Measurements acoustics and certification

Vibro-acoustic analysis of diesel-engine trains

Noise and vibration study

The Basque company CAF (Construcciones y Auxiliar de Ferrocarriles), with headquarters in Beasáin, has been relying on ICR for technical collaborations in noise and vibration for more than 20 years.

One of the most relevant projects that ICR has carried out together with CAF started in 2004 and lasted until 2007. In this project, Northern Ireland Railways (NIR) s/3000 type trains were studied, together with Renfe's ADR S/598 trains.

The project consisted of the analysis of the noise and vibrations generated in the different types of trains mentioned above (S/3000 and ADR S/598) studying mainly the diesel engine system.

The carried out measurements allowed to analyse the dynamic behaviour of the engines by simultaneously performing noise and vibration tests at different points of the train.

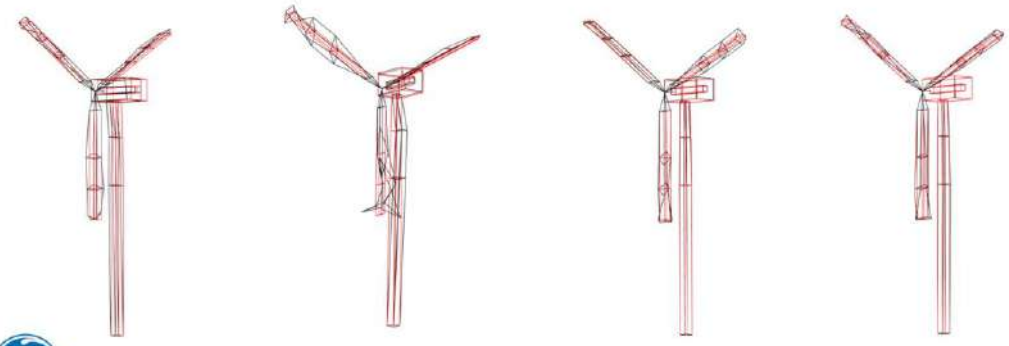
Experimental techniques such as EMA (Experimental Modal Analysis) and ODS (Operational Deflection Shape) were applied and the free forces of the engine were quantified using ICR methods.

From these measurements, a numerical model was generated that allowed to deeply study the vibro-acoustic behaviour of the train and its components, which reduce to have access to the train.

TECHNICAL SPECIFICATIONS:

Client: CAF (Construcciones y Auxiliar de Ferrocarriles)
Location: Beasaín (Spain)
Year: 2004-2007
Sector: Railway
Service: Modal Analysis

Wind Energy



General Electric

Operational Modal Analysis (OMA) of wind turbine model Hal-X

Identification of the frequency and damping of tower and blade modes under operating conditions

In order to monitor wind turbines, know their vibration behaviour, and detect possible faults, both towers and blades are equipped with sensors. General Electric (GE) has installed this measuring equipment in its wind turbines and stores the data provided by the sensors.

From these data, it is possible to characterize the operating vibration modes of the wind turbine structure, both in shutdown and as well as in operation. Thus, using the software "Invent", which was developed by ICR to perform an operational modal analysis (OMA), the vibration modes of the wind turbine are identified from the information of the acceleration and deformation sensors provided by the company.

The aim of the project is to analyse 5 operating conditions at different wind speeds and to identify the wind turbine vibration modes in order to extract the relevant information containing the vibration frequency of each mode as a function of wind speed.

The first step of the applied methodology consists of filtering all the data provided by the sensors, which are organized in time series. Those series that show stability in the operating parameters and that have correspondence with the nominal curves of the wind turbine are chosen.

From the data extracted from the accelerometers and the gauges, the operational modal analysis (OMA) of the wind turbine is carried out, as follows has already been specified above using the self-developed program "Invent".

TECHNICAL SPECIFICATIONS:

Customer: General Electric (GE)
Location: Barcelona (Spain)
Year: 2021
Sector: Wind Energy
Service: Modal Analysis

This analysis consists of measuring the response of the structure to machine operation and wind impact, comparing the sensors with each other to obtain the frequency and damping of the natural vibration modes of the structure under operating conditions.

To improve the identification of the modes, the movement of the wind turbine is animated, which facilitates the classification of the vibration modes.

TECHNICAL SPECIFICATIONS:

Customer: General Electric (GE)
Location: Barcelona
Year: 2021
Sector: Wind Energy
Service: Modal Analysis

Study of the structural damping of a wind turbine

Use of the Operational Modal Analysis (OMA) Method

ICR performs an exhaustive study on the damping characteristics of a wind turbine related to the first two bending modes of its tower by means of statistical procedures in a database of several thousands of operational modal identifications.

The wind turbine integrates a mass damper tuned to the natural frequency of these first two modes.

The base structural damping of the system, the additional contribution to the damping introduced by the tuned damper and the aerodynamic damping experienced by the system under production conditions are determined. By these identifications a correlation is made with environmental operating parameters such as wind speed, yaw angle and main directions of vibration.

The study is based on a campaign of more than 2000 cases of identification by means of operational modal analysis, processing more than 350 hours of signals acquired in the field.

A new statistical analysis methodology is implemented based on probability distributions and statistical identification of independent events.

TECHNICAL SPECIFICATIONS:

Customer: General Electric (GE)
Location: Barcelona (Spain)
Year: 2020
Sector: Wind Energy
Service: Modal Analysis

Industry

Vibration study during the construction phase of a desalination plant in Oman

Vibration level prediction from a semi-empirical Barkan model

Through APPLUS+, a leading company in the inspection, testing and certification sector worldwide, ICR carried out a study to predict the vibrations caused during the construction works of a power and desalination plant AL Ghubrah III, located on the seafront of the city of Muscat in Oman.

The study has focused on the prediction of transmitted vibrations from two areas of the construction site to adjacent buildings during excavation, as well as their evaluation.

Firstly, the current regulations of local and international have been defined in order to determine the indicators and admissible limit values, in terms of vibrations, for the development of the study

Secondly, for the prediction of the vibration level caused by the construction works, a vibration model based on a Barkan model has been carried out.

What is a Barkan numerical model?

This is a semi-empirical model., which characterizes the propagation of vibrations through the ground, and its parameters are usually adjusted on the basis of experimental measurements.

This type of model makes it possible to determine the influence of frequency on the attenuation process during the propagation of vibrations through the ground.

TECHNICAL SPECIFICATIONS:

Client: APPLUS
Location: Sultanate of Oman
Year: 2021
Sector: Industry, Environment, Infrastructures
Service: Industrial noise and vibration control (outdoor), Environmental acoustics

For this particular project, first of all, the vibration source has been characterized, based on international scientific literature and previous experience.

Subsequently, a Barkan model has been generated at each site, to propagate the vibrations through the ground, and finally, insertion curves have been applied to the model, based on international standards, to quantify the vibration received in the most affected sensitive receptors, both in the residential area and in the office buildings area.

Finally, the last step was to evaluate the vibration levels obtained according to the selected standards and the proposed limit values.

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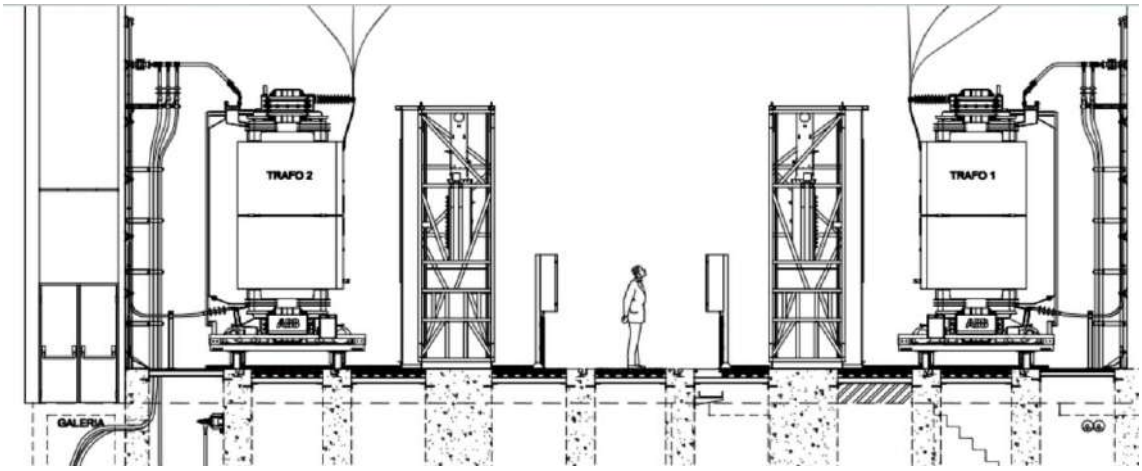


Vibro-acoustic study in an electric power transformer substation in Seville.

Analysis, diagnosis and proposed solutions for a problem of noise transmission to a residential building adjacent to the substation.

The company ELECNOR, S.A. contacted Ingeniería para el Control del Ruido, S.L., with the aim of carrying out a vibro-acoustic study to diagnose and propose corrective measures for a problem of noise transmission to one of the rooms of a house next to the electrical energy transformer substation SE-Osorio in Seville, Spain.

The inhabitants of the adjoining house report the perception of a disturbing noise, which could correspond to the normal operation of the transformer substation.

The methodology of the study begins with a vibro-acoustic measurement campaign on the transformer station and the adjacent house, in order to determine the characteristics of airborne sound insulation, the characteristics of structural transmission between the substation and the house, as well as the determination of the vibro-acoustic levels of the system.

This study is evaluated according to the regulations set out in the Official Gazette of the Province of Seville. "Ordinance for the protection of the environment with regard to noise and vibrations".

Once the results of the measurement campaign have been obtained, a series of vibro-acoustic solutions are proposed for application in the following areas different points of the substation, in order to minimize the noise impact and thus comply with current regulations.

TECHNICAL SPECIFICATIONS:

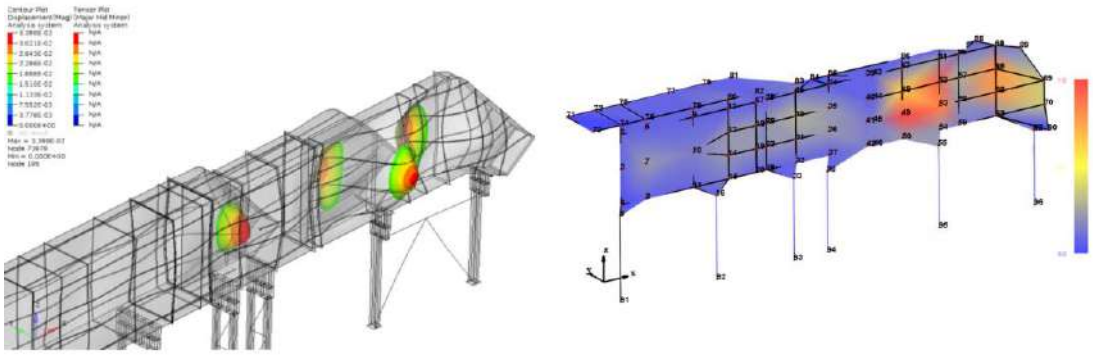
Client: Elecnor
Location: Seville (Spain)
Year: 2018-2020
Sector: Industry
Service: Industrial noise and vibration control (indoor and outdoor), Acoustic measurements and certification, Engineering - Consultancy acoustics

Due to the complexity of the application of these solutions, a follow-up of the installation of the corrective measures is carried out, in addition to another measurement campaign to monitor the noise received in the adjoining residential building for three weeks. This monitoring allowed us to record whether the solutions applied are working correctly.

Finally, thanks to all the technical contributions offered by ICR to the client, as well as constant advice, Elecnor has been able to deal with the serious noise and vibration problem they had in this substation in Seville.

TECHNICAL SPECIFICATIONS:

Client: Elecnor
Location: Seville (Spain)
Year: 2018-2020
Sector: Industry
Service: Industrial noise and vibration control (indoor and outdoor), Acoustic measurements and certification, Engineering - Consultancy acoustics



Analysis of a gas scrubbing system at a petrochemical plant in Saudi Arabia

Identification of vibration response, numerical modelling and proposed solutions to reduce vibration levels.

INTECSA Industrial, a company dedicated to the design and execution of industrial installations worldwide, contacted ICR to carry out a study of the dynamic behaviour of two gas purification systems. The proposed study has been carried out on a duct installation with fans in a petrochemical plant in Ras Al-Khair, Saudi Arabia.

The system to be monitored consists of a duct system with fans, which experiences cracking in the outer stiffeners of the ductwork due to the operational vibration environment of the system

The study includes an initial analysis of the client's vibration problems, a vibration measurement campaign with subsequent analysis, the development of a mathematical model created with the finite element method (FEM) together with a proposal for countermeasures based on the model generated.

In the first phase of the study, an experimental vibration measurement campaign is carried out in the duct of interest in order to obtain the vibration response of the system at a series of points that allow to describe with sufficient precision the vibration deformations of the system in operation.

Through an analysis of the results obtained by using the ODS (Operational Deflection Shape) method.

TECHNICAL SPECIFICATIONS:

Client: INTECSA Industrial
Location: Ras Al-Khair (Saudi Arabia)
Year: 2017
Sector: Industry
Service: Computational Vibro-acoustics, Modal Analysis, Acoustic Measurements and Certification, Engineering-Acoustic Consultancy

It is determined which regions of the bandwidth are more excited and how the structure is deformed, and highlighting the modes that respond to the operational excitation. In addition, the acquisitions made at each point of the structure allow to determine the global level of vibration in each of them.

Next, a finite element model (FEM) of two duct systems is elaborated, obtaining the dynamic response of the system including the set of three fans, ducts and support. This model is performed as a qualitative validation of the hypothesized excitation mechanism from the visual inspection of the plant.

Once the results of both models (ODS and FEM) are obtained, a simple validation of the excitation mechanism is carried out to define if the cause of the operational excitation in the duct walls is the turbulence generated inside the duct due to the change of section. A simulation was carried out by implementing a simple Boltzmann particle fluid model in a 2D mesh.

Finally, thanks to the results obtained from the whole study, different corrective measures are proposed throughout the system to improve vibration levels and avoid cracking.

TECHNICAL SPECIFICATIONS:

Client: INTECSA Industrial
Location: Ras Al-Khair (Saudi Arabia)
Year: 2017
Sector: Industry
Service: Computational Vibro-acoustics, Modal Analysis, Acoustic Measurements and Certification, Engineering-Acoustic Consultancy

Vibration study for the ALBA synchrotron

Test and verification measurements of the defined solutions

Do you know what a Synchrotron is?

A Synchrotron is a scientific infrastructure that uses electromagnetic fields to accelerate electrons to high speeds very close to the speed of light and thus produce synchrotron light. This light makes it possible to visualize the internal structure of materials and study their properties.

ICR participated with several studies in the design of the ALBA Synchrotron, the most important circular particle accelerator in the Mediterranean area, located in Cerdanyola del Vallés (Barcelona).

The first work was carried out in 2005, before the construction of the ALBA Synchrotron. The physical dynamic parameters of the terrain that would house the ALBA synchrotron were obtained experimentally, in order to generate a finite element model with which to model the propagation of surface vibration waves in the critical area.

For this purpose, both the SASW (Spectral Analysis of Surface Waves) method was applied to determine the dynamic parameters of the terrain and the Nakamura method to determine the depth to the rock surface.

Once these parameters were determined, a numerical model was generated to design a massive concrete slab system to isolate the critical area of the synchrotron from vibrations coming from outside (nearby industry, road traffic, auxiliary equipment of the Synchrotron complex buildings, etc.).

A prediction of the noise levels inside the critical area, due to the noise produced by the different auxiliary equipment, was also carried out.

TECHNICAL SPECIFICATIONS:

Client: CELLS - Master de Ingeniería, S.A.
Location: Cerdanyola del Vallés (Barcelona)
Year: 2005-2010
Sector: Industry, Environment
Service: Industrial noise and vibration control (exterior and interior), Computational Vibro-acoustics

The calculation was carried out using the ray tracing method based on a three-dimensional acoustic model of the space. From the results obtained and following the acoustic design criteria previously marked, a series of solutions were proposed to meet each and every one of the design objectives.

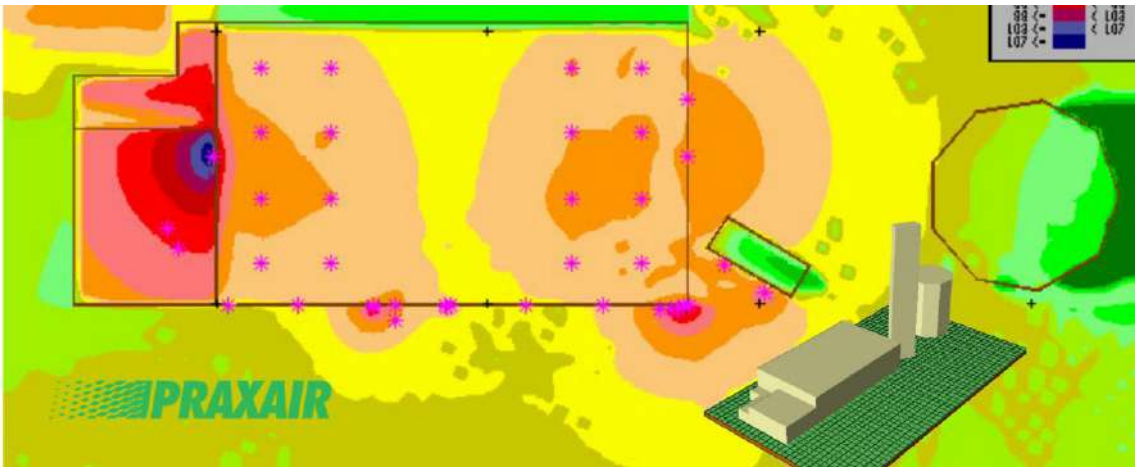
Once the entire ALBA Synchrotron infrastructure was under construction, ICR performed measurements to check and verify the correct assembly and operation of the designed slab. These works were carried out in 2008.

Finally, between 2009 and 2010, the noise and vibration levels of the auxiliary equipment installed in the Synchrotron were studied. Likewise, different anti-vibration solutions were designed and the work was monitored for their correct installation.

Today, after its tenth anniversary, the ALBA Particle Synchrotron is still working at full capacity.

TECHNICAL SPECIFICATIONS:

Client: CELLS - Master de Ingeniería, S.A.
Location: Cerdanyola del Vallés (Barcelona)
Year: 2005-2010
Sector: Industry, Environment
Service: Industrial noise and vibration control (exterior and interior), Computational Vibro-acoustics



Model Inversion Method in a gas factory

In 1998, the French company PZ (Phillippe Zuliani) contacted ICR to carry out an acoustic study of the AGA PRAXAIR gas production plant in Toulouse (Portet sur Garonne), one of the world's largest distributors of industrial gases. In this study acoustic solutions were proposed, once the results are known, for compliance with current legislation on noise and vibration.

Previously, the French company SCP Acoustique was responsible for an environmental study that evaluated the initial noise levels produced by the industry, resulting in noise levels above the permitted levels.

ICR began work to reduce the noise generated by the industry facilities, so that it was possible to selectively treat the noisiest elements of its facilities, in order to reduce the overall noise level and to achieve desired levels at the receptor points. To achieve this, the Model Inversion methodology was applied to obtain the acoustic power of the sources from sound pressure measurements of each noise source involved in the problem.

The adaptation of the method to this type of problems allows to determine the acoustic power of each noise source present in an industry, as well as to know its contribution at any point of the resulting sound field, even keeping all the sources working simultaneously at full performance, in a record measurement time.

From the knowledge of the acoustic power of each source it was possible to calculate its contribution to the overall noise level received. In this way, it was possible to create an ordered list of sound sources, from most to least important. Thanks to this ranking, it was possible to prioritize and determine which sources were the most important.

TECHNICAL SPECIFICATIONS:

Client: AGA Praxair
Location: Toulouse (France)
Year: 1998
Sector: Industry
Service: Vibro acoustics computational, Model Inversion Methods

The knowledge acquired in this project, served for the publication of an article in the scientific journal Applied Acoustics: O. Guasch, F.X. Magrans & P.V. Rodriguez. An inversion modelling method to obtain the acoustic power of the noise sources in a large factory. Applied Acoustics 63, pp.401-417 (2002).

TECHNICAL SPECIFICATIONS:

Client: AGA Praxair
Location: Toulouse (France)
Year: 1998
Sector: Industry
Service: Vibro acoustics computational, Model Inversion Methods

Noise analysis on large format printers

Study and acoustic consultancy for plotters at HP

Have you ever thought about the noise that a printer makes? Maybe you noticed it when it was running, or maybe when it was idle. Often when it is turned off that we notice that something was bothering us.

Sometimes we are not aware of the noise generated by the equipment around us, but companies in the industrial sectors are careful to generate as little noise as possible to avoid disturbing its users.

This is the case of HP, a company dedicated to the small and large format printing sector. HP's European research centre based in Sant Cugat del Vallés, have relied for over 25 years in ICR to advise them on vibro acoustics in reference to their large format plotters

The first noise and vibration study that ICR carried out for HP was in 1996, where the noise generated by the prototype printer that they were about to launch on the market was analysed. In this initial study, the noise generated by this prototype was analysed, and different silencers were designed to minimize the noise emitted.

From this point on, different projects were carried out where noise reduction in different prototypes was dealt with. Analysis techniques such as ATPA (Advanced Transfer Path Analysis), ODS (Operational Deflection Shape) methodology or acoustic photography for sound source localization were applied, among other experimental methods developed by ICR.

ICR worked on more than 10 projects of noise analysis of HP plotters, between 1996 and nowadays. In these projects apart from the acoustic study, different solutions have been designed and implemented to minimize the emitted sound levels.

TECHNICAL SPECIFICATIONS:

Client: HP
Location: Sant Cugat del Vallés (Barcelona, Spain)
Year: 1996-2021
Sector: Industry
Service: Noise and vibration monitoring of a product, Advanced Transfer Path Analysis (ATPA), Modal Analysis, Vibro-acoustics computational.

In 2002, as a result of one of the study projects, ICR patented one of the solutions offered to HP. This patent was named "Holddown Device for Hardcopy Apparatus", with the number US 2002/0097311 A1, and published on July 25, 2002.

The HP case is extensible to any other industry pursuing acoustic improvement of their products, such as automobiles, trains, consumer electronics or other industrial products.

TECHNICAL SPECIFICATIONS:

Client: HP
Location: Sant Cugat del Vallés (Barcelona, Spain)
Year: 1996-2021
Sector: Industry
Service: Noise and vibration monitoring of a product, Advanced Transfer Path Analysis (ATPA), Modal Analysis, Vibro-acoustics computational.

Acoustic advice and consultancy for the reduction of the noise immission level of a luxury yacht shipyard

Noise measurements, evaluation of the shipyard works together with proposals for improvement solutions.

Noise measurements, evaluation of the shipyard works together with proposals for improvement solutions.

ICR has trained its employees in the theoretical knowledge of acoustics (noise and vibrations) in order to implant in the company's DNA the importance and awareness of noise and vibration generation during the work carried out on the yachts.

But the most important work that ICR has been doing together with MB92 has been that of acoustic advice and consultancy. This advice has gone through different phases and ranges during all these years:

• Predictive advice: Different numerical calculation models have been carried out to predict the feasibility of different works to be carried out. Different types of solutions have also been simulated at numerical level and finally different predictive scenarios have been calculated for different areas of the shipyard to determine the impact of these work areas on the affected neighbours.

• On-site consultancy: ICR has a special service called ICR+ that allows companies to have an acoustic engineer specialized in the company's facilities exclusively for the time determined by the client. Marina Barcelona 92 has had for 4 seasons a specialized engineer for daily and continuous advice in all the works that were carried out in the work area closest to the neighbours.

TECHNICAL SPECIFICATIONS:

Client: Marina Barcelona 92
Location: Barcelona (Spain)
Year: 2020
Sector: Naval, Industry
Service: Engineering - Acoustic Consulting
Courses and training
Acoustic measurements and certification

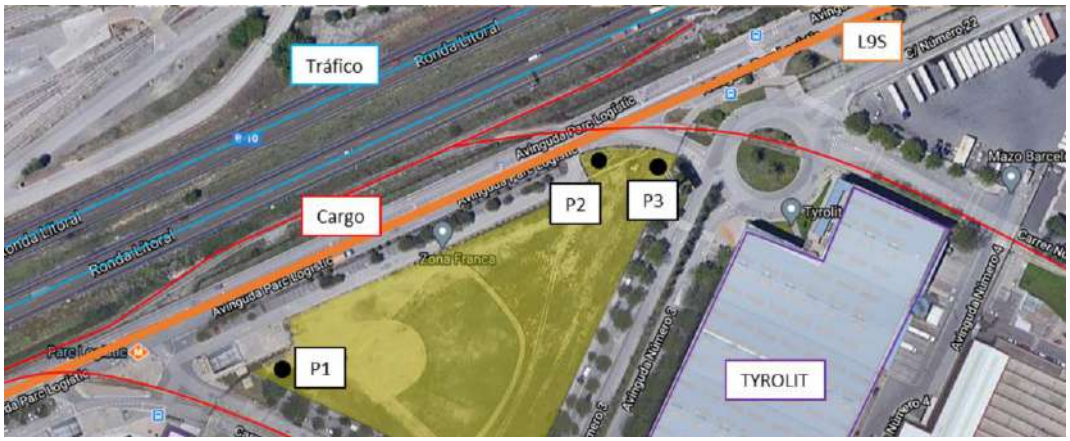
• Resolute consulting: in this phase of consulting, ICR is designing, analyzing and testing the application of new unique solutions for each of the noise jobs performed in the shipyard. These solutions are uniquely and exclusively defined for each job and for each customer.

Thanks to the continuous advice, ICR, can offer its customers a total knowledge of the work or needs of each company, thus achieving better rates of results and satisfaction at the end of each project. Our multidisciplinary team and the constant training of all employees also contributes to achieve a deeper customization in all fields.

TECHNICAL SPECIFICATIONS:

Client: Marina Barcelona 92
Location: Barcelona (Spain)
Year: 2020
Sector: Naval, Industry
Service: Engineering - Acoustic Consulting
Courses and training
Acoustic measurements and certification

Building and Infrastructures



Affectation of different railway and road infrastructures and industrial activities on a building in the project phase.

Measurement, prediction and evaluation of vibrations induced by rail traffic, road traffic and industry in an office building in the Free Trade Zone.

During the development and implementation phase of a new building, many factors may influence the final procedure of the building. In recent years, the interior acoustic and vibration comfort of the building are also being prioritized.

It is for this reason that projects in which many infrastructures coexist, bringing different types of vibrations to the studio, are always a challenge.

In this case, the study was carried out on a site in the Zona Franca (Barcelona) where the origin of the vibrations perceived in the study came from:

• Underground railway infrastructure corresponding to the Transports Metropolitans de Barcelona (TMB) metro line 9 Sud (L9S), in the vicinity of the "Parc Logístic" station.

• Surface railway infrastructure corresponding to the incoming and outgoing material lines, specifically between lanes 24 (T4) and 25 (T3).

• Road infrastructure (road traffic) corresponding to Avenida Parc Logistic and Ronda Litoral.

• Activity of the industries near the site under study (SEAT and TYROLIT).

TECHNICAL SPECIFICATIONS:

Client: PGI Engineering
Location: Barcelona
Year: 2021
Sector: Building, Infrastructures
Service: Vibration measurement, prediction and evaluation of future affectation

The vibration study was carried out based on in-situ vibration measurements. For the evaluation of vibrations inside a house, the procedure described in the Annexes of the Law 16/2002, modified according to the Decree 176/2009, specifically Annex 7 "Immissió de les vibracions als interiors dels edificis" is used.

Once the results of the measurements taken on the site have been obtained, the vibration values from each of the aforementioned infrastructures are extracted and classified. From the vibration levels obtained, the vibration levels in the future building are estimated, taking into account the attenuation due to the coupling of the ground with the building, and the amplification due to resonance of the structural elements.

At ICR, our commitment to the client always goes further, and in vibration study projects for news buildings we always include a risk prediction analysis to illustrate in a qualitative way the impacts of each part of the project in terms of vibration. In this way, the client can assess the importance and severity of the expected vibration levels in a generic way.

TECHNICAL SPECIFICATIONS:

Client: PGI Engineering
Location: Barcelona
Year: 2021
Sector: Building, Infrastructures
Service: Vibration measurement, prediction and evaluation of future affectation

Study of vibrations caused by road infrastructure on the Via Augusta in Barcelona

Future construction of a 6-storey building near the Ronda de Dalt tunnel

The company "Edificio Can Valls S.L.", through the architectural firm A12, requested ICR to carry out a study to determine the road traffic vibration impacts on the new building project located on a site of the Via Augusta in Barcelona.

Thanks to more than 20 years of experience in carrying out acoustic studies, vibration measurements and studies of the effects on buildings due to vibrations generated by infrastructures, at ICR we have a wide knowledge to answer the needs of our clients.

In this case, the structure of the future 6-storey building reached a depth of 15 metres below the surface and was supported on micro piles. The depth of the building coincides with the same substrate layer where the foundations of the Ronda de Dalt branch tunnel are also supported.

Due to this ICR proposed a predictive vibration study, which required vibration measurements at the current ground level and at the planned structure of micro piles. In addition to that, a vibration control during the operation was conducted to have the possibility to accurately study a predictive finite element model. The study was evaluated according to the current regulations on vibrations (Barcelona Environmental Ordinance, OMA 2014).

TECHNICAL SPECIFICATIONS:

Client: A12 Arquitectes
Location: Barcelona (Spain)
Year: 2020
Sector: Building, Infrastructures
Service: Vibration effects of railway infrastructure

The measurement campaign allowed to measure the existing vibration level on the ground and on the planned structure of the new building, proposes to carry out two micro piles in order to record the value of the vibrations at two points of the structure.

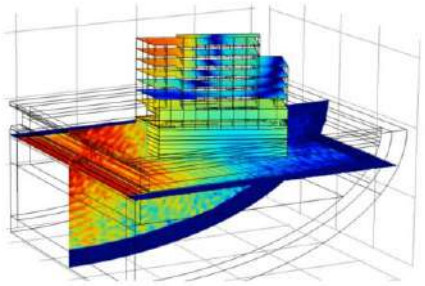
For the predictive study it is necessary to know the type of foundation of the building, as well as some general information about the terrain.

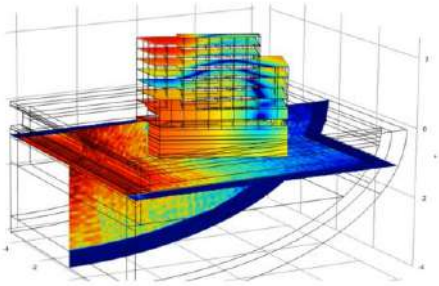
Due to the constructive characteristics of the future building, as well as the proximity to the Ronda de Dalt tunnel, ICR offered the client the possibility of carrying out a predictive study based on a finite element simulation. This type of study is very practical for the client because in the case that in the preliminary study the vibration levels are very close to the limits set by the regulations are obtained, the finite element simulation can model the vibration values of future building more accurately.

This simulation generates a 3D finite element model (FEM) that includes all the sources to take into account, in this case the would be: the geometry of the tunnel and road infrastructure, a representative stratification of the geotechnics of the area and the careful geometry of the construction project by means of solid elements, plates and beams that will allow to obtain the provisional levels of vibrations at different levels at building locations.

TECHNICAL SPECIFICATIONS:

Client: A12 Arquitectes
Location: Barcelona (Spain)
Year: 2020
Sector: Building, Infrastructures
Service: Vibration effects of railway infrastructure





Impact of an FGC tunnel on a hotel in the project phase.

Measurement, prediction and evaluation of vibrations induced by railway traffic on a hotel

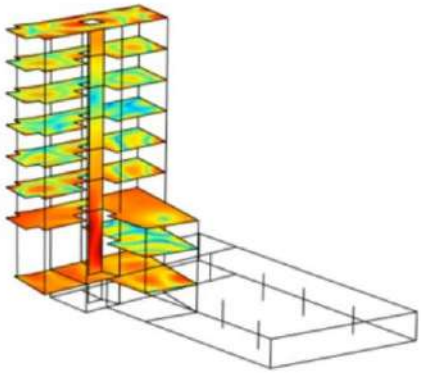
Carlos Bassó arquitectura, on behalf of his client Compras y Alquileres TransUnion S.L., requested ICR to carry out a computational model for the prediction of vibration immission levels based on the finite element method, in order to determine whether the vibration levels received in the future building would comply with current legislation (Decree 176/2009 of 10 November, approving the Regulation of Law 16/2002 of 28 June), regarding vibrations generated by the passage of passenger trains in railway infrastructure in proximity, without the need for remedial measures.

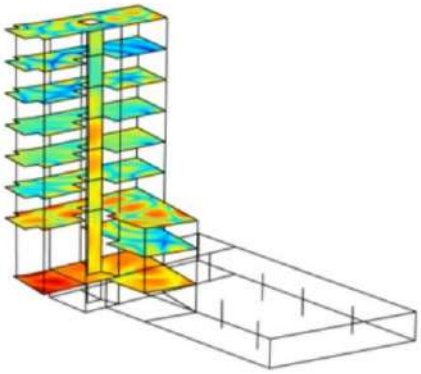
The railway infrastructure to be analysed was the tunnel of Ferrocarrils de la Generalitat de Catalunya, Llobregat-Anoia Line, between the stations of Ildefons Cerdà and Europa-Feria. At the time of the analysis the site was undeveloped and the infrastructure, the land and the building were modelled.

The finite element models were generated from the information of the architectural project and were adjusted with results of ground vibration measurements

TECHNICAL SPECIFICATIONS:

Client: Carlos Bassó Arquitectura
Location: L'Hospitalet de Llobregat
Year: 2019
Sector: Building, Infrastructures
Service: Measurement of vibrations, prediction of vibrations by means of computational model vibro-acoustic





Study of the effects of railway infrastructure on two buildings in the district of Gràcia, Barcelona.

Vibration measurements, predictive study by means of structural simulation of the building and on-site verification measurements.

The circulation of rolling stock through railway infrastructures generates vibrations that propagate through the ground to nearby buildings. It is common that, in the city, these infrastructures are located at a very short distance from existing or planned buildings. The vibrations propagated by the ground penetrate through the foundations in buildings, which can cause structural vibrations that compromise the vibro-acoustic comfort of its inhabitants or even exceed the maximum threshold established by the competent regulator (Law 16/2002, DOGC3675, of 28 June, on protection against noise pollution, and annexes amended according to Decree 176/2009, of 10 November).

In 2017, the company ELIX, requested ICR to a forecast of the vibration levels transmitted to the slabs of the houses of two projected buildings, caused by the normal operation of the FGC Barcelona-Vallès lines as they pass through the site located near the station of Gràcia in Barcelona.

This study begins with the measurement of the vibration level in different positions of the site where the construction project will be located, from which a provisional estimation study of the vibration levels based on semi -empirical procedures is carried out.

TECHNICAL SPECIFICATIONS:

Client: ELIX
Location: Barcelona (Spain)
Year: 2017-2020
Sector: Building, Infrastructures
Service: Affectation of vibrations by railway infrastructure, Computational Vibro-acoustics, Acoustic measurements and certification

The conclusions of this estimation are not favourable and it is for this reason that it is decided to carry out a more complex calculation that takes into account the real structure of the site building and its dynamic response.

It was decided to make a finite element model, only of the building closest to the vibratory source.

The prediction of vibration levels is performed based on the results of a structural dynamics simulation on a model of the building constructed in the mechanical analysis software CodeAster 2017.

In order to minimize the uncertainty in the results, a simplified model of the building was developed. This model reduced the computational requirements too. This parametric study includes a sweep of results for different values of structural damping, a parameter that can only be known experimentally after construction of the structure. The structural model is excited by means of a series of acceleration signals measured in the field, at the real site of the building, and calculated by means of a harmonic dynamic problem solving scheme.

The predicted levels obtained after the simulation did not exceed the limit defined by the applicable regulations (Decree 176/2009) in the field of vibrations in dwellings. Even so, ICR recommended to monitor the vibration levels during the construction work, after excavation, after construction of foundations, after crest of basement-parking and after crest of first floor, for verification and model adjustment if necessary.

In the year 2020, on-site verification measurements were carried out on different floors of the completed building, under the specifications of " Annex 7 of Law 116/2002, modified according to Decree 176/2009, specifically Annex 7 "Immission of vibrations inside buildings". The results obtained were in agreement with the levels of obtained in the previous simulation.

TECHNICAL SPECIFICATIONS:

Client: ELIX
Location: Barcelona (Spain)
Year: 2017-2020
Sector: Building, Infrastructures
Service: Affectation of vibrations by railway infrastructure, Computational Vibro-acoustics, Acoustic measurements and certification

Impact of line L1 (Bilbao) in a building in the design phase

Measurement, prediction and evaluation of subway-induced vibrations on a single-family house

The passage of trains generates vibrations that spread through the ground to the foundations of buildings constructed near railway infrastructures.

A client interested in building a single-family house near the L1 line of the Bilbao metro as it passes through Getxo (Bizkaia), contacted ICR, through PREDYCSA, with the intention of carrying out a study to determine the vibration effects caused by the passage of the metro at ground level on the projected single-family house.

The aim of the study was to predict if the projected building would comply with the royal decree 1367/2007 and with the decree 213/2012, of noise pollution of the País Vaso, in terms of vibrations.

For this purpose, vibration measurements were taken in situ, prior to the construction of the building, for subsequent calculation and evaluation. The vibration level was measured in the three coordinate axes, X, Y and Z, at all points located on the site under study, together with a reference point located near the railway infrastructure to validate that the vibrations received on the site corresponded to the metro tracks.

TECHNICAL SPECIFICATIONS:

Client: PREDYCSA
Location: Getxo, Bizkaia
Year: 2019
Sector: Building, Infrastructures
Service: Affectation of vibrations due to railway infrastructure

Location of noise of unknown origin in a building

Application of a proprietary method of acoustic photography

In 1995, Bureau-Veritas contacted ICR to locate some noises of unknown origin in an apartment building in Bordeaux (France).

These noises only occurred during the night, generating noise throughout the apartment building, which was very annoying for the tenants.

The technology applied to detect these unknown vibrations was a proprietary method of acoustic photography, developed by ICR, adapted to locate the origin of the noise using accelerometers. This method made it possible to graphically locate the origin of the vibrations and therefore the cause of the noise.

To detect the unknown vibration source, a series of accelerometers were placed along the building. From the post-processing of the impulse response between pairs of accelerometers, a general visual image was obtained that allowed us to detect where these vibrations were coming from.

Thanks to the continuous development of R&D in all our technology, ICR was able to solve this problem where other companies could not find a solution.

TECHNICAL SPECIFICATIONS:

Client: Bureau-Veritas (Construcciones y Auxiliar de Ferrocarriles)
Location: Bordeaux (France)
Year: 1995
Sector: Building, Infrastructures
Service: Computational Vibro-acoustics, Acoustic measurements and Certification

Development of software for vibration control of civil infrastructures

Specific software for semi-automated Operational Modal Analysis (OMA) for bridges and viaducts

In the field of vibro-acoustic engineering it is very common to carry out the analysis of vibrations generated by different industrial equipment (generators, pumps, etc.), in vehicles (trains, cars, etc.), in the automotive industry, airplanes, etc.) and it is even common practice to study the vibrations generated by the operation of large wind turbines. But what happens when it is necessary to analyse the vibrations of a civil infrastructure, such as a bridge?

The design, construction, commissioning and maintenance of large viaducts is one of the most technically and logistically complex engineering projects in the field of civil engineering. It is common that, during the management cycles of the useful life of these infrastructures, the owners of the infrastructures, managers, large engineering companies in charge of guaranteeing their correct operation, as well as maintenance companies usually need the support of specialists in the field of structural monitoring, both static and vibro-acoustic.

It is in the field of vibroacoustics, where ICR is the engineering specialist for the study and analysis of these structures once built and in service by means of dynamic monitoring.

In 2010, the company TIFSA (Tecnología e Investigación Ferroviaria, S.A) contacted ICR to request the development of a specific software for the semi-automated operational modal analysis (OMA) in civil infrastructures. Specifically, this project was developed between 2010 and 2012, for the study of the Contreras Viaduct, which is located between the provinces of Valencia and Cuenca, and through which runs the high-speed line between Madrid and the Region of Murcia.

TECHNICAL SPECIFICATIONS:

Client: TIFSA- Ofiteco
Location: Spain
Year: 2010-2012
Sector: Building, Infrastructures, R+D+i
Service: Custom software development, Modal Analysis

The developed software was implemented to meet two main requirements: first, to be able to be used directly during field measurements and second, to reduce the number of sensors needed by using a sectored measurement strategy, while keeping common reference measurement points. The program then obtains global results by processing these partial results.

Since the software was to be used during on-site measurements, it was important to be able to obtain reliable results quickly after acquiring a measurement in order to determine whether the measurement contained the desired information.

These measurements require a large number of variables to be taken into account during the calculation of the operational modal analysis (OMA) so the software was specifically designed to be able to manage the organization of the measurements, as well as to support a large amount of data.

The algorithm for the study of the OMA that was used to develop this software was based on the Auto-FDD method, a non-parametric method in the frequency domain.

The program generates reports automatically and has a simplified version for quick results in the field.

This program was subsequently acquired by Ofiteco, an international engineering company with more than 45 years of experience, dedicated to consultancy in hydraulic, environmental and water engineering works, transport.

TECHNICAL SPECIFICATIONS:

Client: TIFSA- Ofiteco
Location: Spain
Year: 2010-2012
Sector: Building, Infrastructures, R+D+i
Service: Custom software development, Modal Analysis

Acoustic study of a future air traffic control room in Madrid

Design and study of solutions for optimal acoustic insulation and acoustic conditioning of the future control room

The consultancy "Loop - New Business Models", with more than 30 years of experience, specialized in business models and focused on the market launch of products and services, required the acoustic services of ICR to perform an acoustic study for the company ENAIRE, a public company in charge of civil air navigation and civil airports in Spain.

ENAIRE needs an acoustic study for a future air traffic control room in Madrid, with the aim of defining the technical acoustic specifications to obtain a good acoustic insulation (from the outside to the inside) and an adequate acoustic conditioning (to guarantee the comfort and intelligibility of the air traffic control personnel).

The objective of the acoustic study is to define and specify which materials the room has to be composed of in order to obtain a good noise reduction with respect to the exterior and a good acoustic conditioning in the interior. For this purpose, the definition of the dimensions, location and types of acoustic materials is considered as well as the design and location of the consoles and receivers.

In order to be able to carry out the acoustic conditioning of the control room, the customer asks for different requirements to be taken into account:

• Reduce the reverberation of the space to reduce the level of amplification due to excess reflections of the sound emitted inside the space.

TECHNICAL SPECIFICATIONS:

Client: Loop - New Business Models
Location: Madrid (Spain)
Year: 2020
Sector: Building, Infrastructures
Service: Computer vibro-acoustics, Room acoustics.

• Minimize noise from foot traffic (footsteps, cars, etc.).

• Acoustic sectioning of the monitoring area with respect to the console areas, to introduce a degree of acoustic separation without reducing visibility.

ICR carries out an on-site measurement campaign in an already operational control room in Madrid, in order to determine its current acoustic insulation. These measurements allow to know the interior/exterior noise level with the arrival/departure of airplanes, as well as the residual noise levels without active air operations. From the results obtained, a calculation of the insulation of the façade is made, using the INSUL® program.

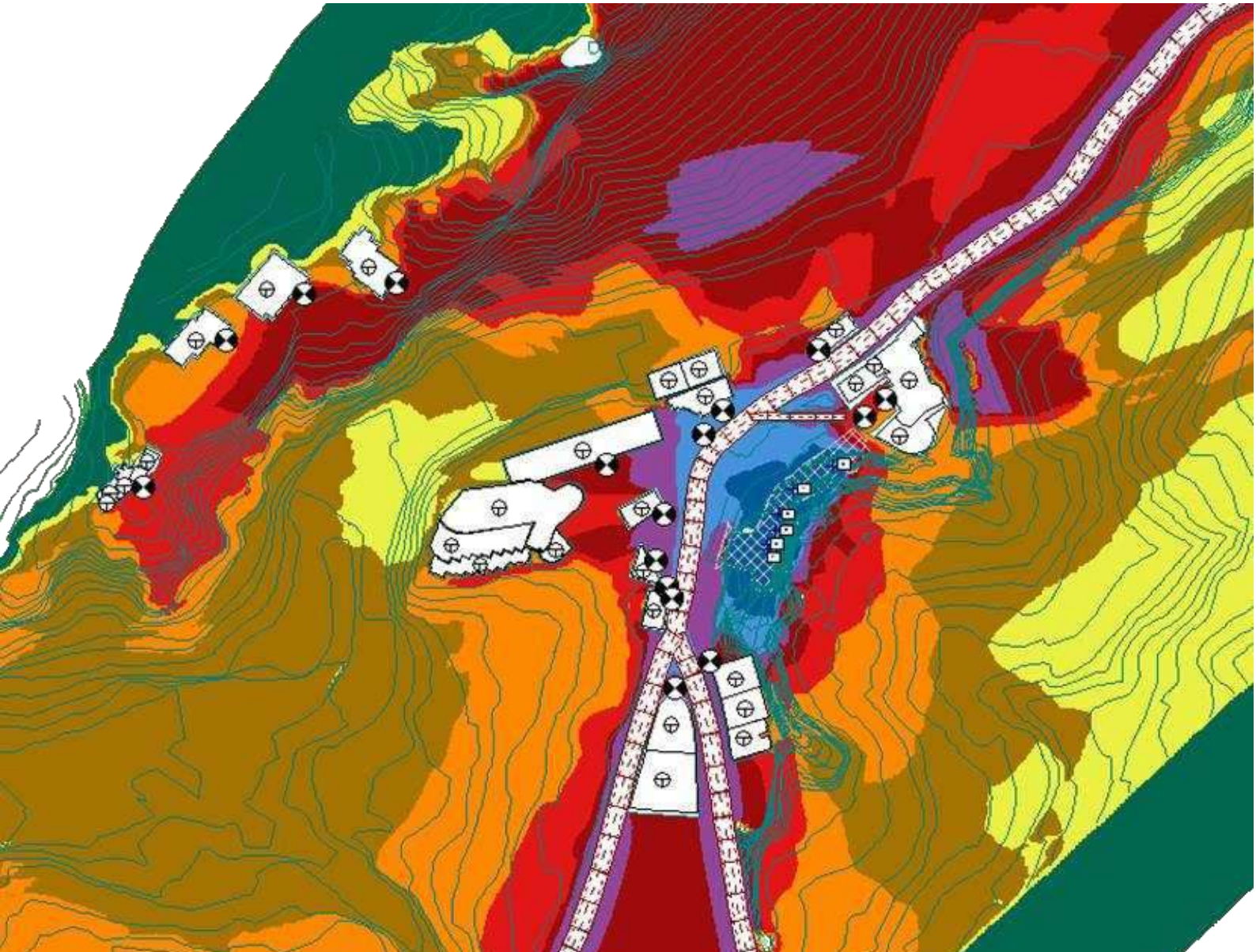
On the other hand, to determine the acoustic design of the future control room, an acoustic simulation was carried out, taking into account the interior linings used, their distribution in the space, their geometry and the volume of the room. The calculations are carried out using the acoustic prediction software COMSOL® Multiphysics.

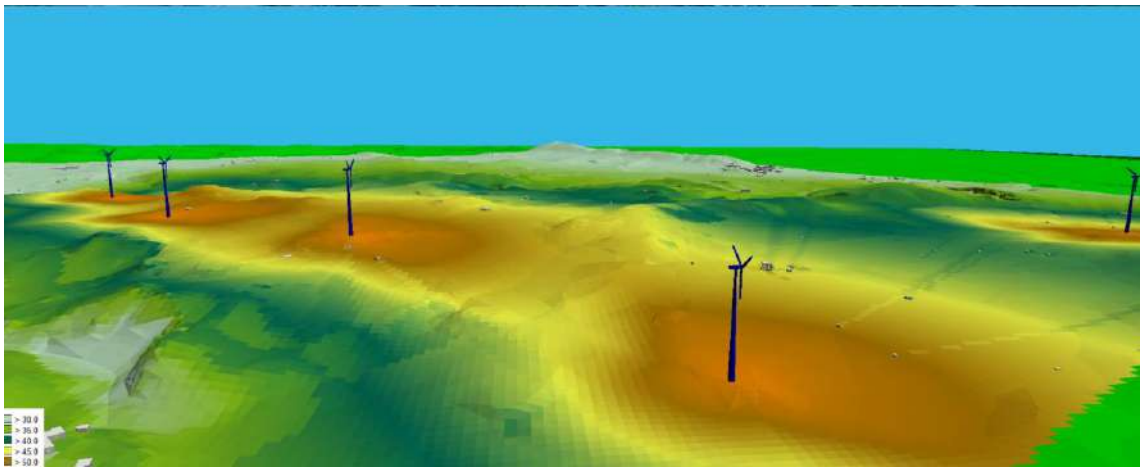
With the results of both studies, different proposals are made for solutions/improvements to optimise the acoustic comfort of the projected control rooms analysed.

TECHNICAL SPECIFICATIONS:

Client: Loop - New Business Models
Location: Madrid (Spain)
Year: 2020
Sector: Building, Infrastructures
Service: Computer vibro-acoustics, Room acoustics.

Environment





Acoustic impact of different wind farms in the vicinity of the village of Capmany

Estimation and evaluation of the noise levels produced by all the wind turbines of two planned wind farms

The Town Council of the village of Capmany, located in the Alt Empordà (Catalonia), contacted ICR to request an acoustic impact study due to the future construction of five wind farms in the vicinity of the village.

The study consists of the generation of a calculation model to predict the noise level of the wind turbines planned to be installed. To do this, it is necessary to know the acoustic power and directivity of these wind turbines, as well as to characterize the background noise of the study area.

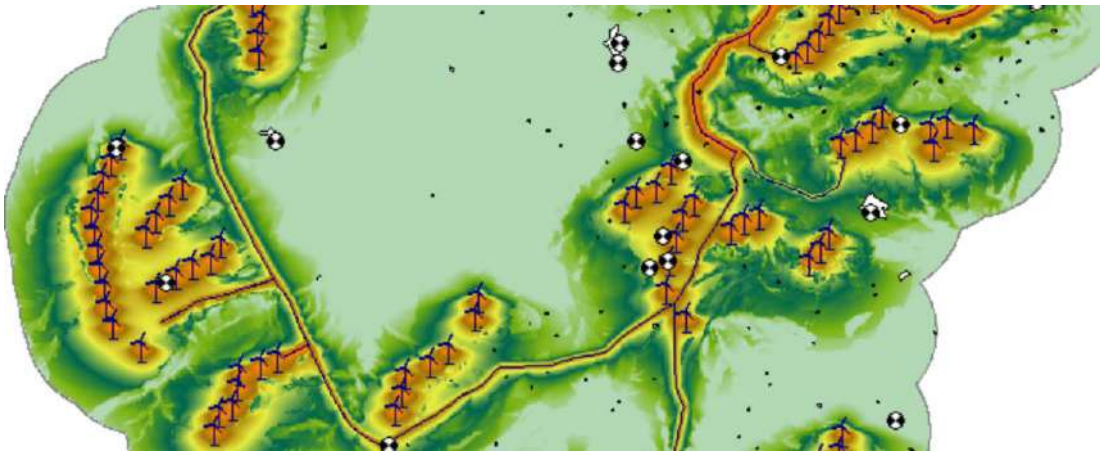
A campaign of acoustic noise measurements was carried out in the area where the wind turbines were planned to be installed. Also the measurements were carried out at points that may be considered particularly sensitive (such as nearby houses, or other rural areas, etc.).

All noise impact studies of wind farms take into account the different time slots, as well as the effect on each one, allowing to know the nuisance caused at the receptor points at each time of day.

In this project, the results obtained have been evaluated according to the current regulations "Decree 176/2009 of the Generalitat de Catalunya and Regulation of the Law 16/2002 de 28 de June".

TECHNICAL SPECIFICATIONS:

Client: Capmany City Council
Location: Capmany (Girona)
Year: 2021
Sector: Wind energy, Environment
Service: Acoustics environmental
Service: Acoustic impact study



Environmental Noise Impact of 22 wind farms

Forecast study of the acoustic influence of the installation of these wind farms.

The Spanish company Forestalia, dedicated to the promotion and energy development of wind farms, needed ICR's services in the midst of the global pandemic coronavirus (SARS-CoVid 2), to carry out different environmental acoustic impact studies of 22 wind farms with 161 wind turbines and 3 high voltage lines, located in the Maestrazgo Turolense.

The method implemented by ICR, in order to make an acoustic prediction of the influence of the installation of these wind farms. The forecasting process that ICR applied for these cases consists of:

• Carry out a campaign of acoustic measurements at various receptors in the area of influence of the parks in order to characterize their current acoustic situation (pre-operational study). This campaign should be carried out prior to the construction of the set of parks.

• Generation of a numerical calculation model to simulate the acoustic behaviour of the wind turbines and power lines that will form part of the 22 wind farms. This study aimed to draw conclusions on the noise levels caused by the set of facilities on a number of sensitive receptors identified.

In the event that the results of the study detect non-compliance with the applicable regulations in force, ICR offered its clients a complementary study consisting of a proposal of alternative operating regimes for each wind turbine that guarantee the compliance with current regulations at the control points defined in the model.

TECHNICAL SPECIFICATIONS:

Client: Forestalia
Location: Zaragoza (Spain)
Year: 2020
Sector: Environment, Wind Energy
Service: Acoustics environmental

To carry out this type of studies ICR uses the CadnaA program, which allows to obtain an acoustic map of the noise levels emitted by the noise sources, and to know the noise levels received at the defined receptor points. This allows the client to obtain a clear view of the noise impact of the installed equipment, in this case wind turbines.

TECHNICAL SPECIFICATIONS:

Client: Forestalia
Location: Zaragoza (Spain)
Year: 2020
Sector: Environment, Wind Energy
Service: Acoustics environmental

Vibration control of the reversible hydroelectric power plant of Sallente

Analysis, diagnosis and proposed solutions

The Cabdella lakes are a group of 27 lakes linked by underground tunnels at the head of the Vall Fosca, in the Lleida Pyrenees. Its function is to supply water to the Gento Lake, from where two hydroelectric power stations are supplied, the Cabdella Hydroelectric Power Station, and the Sallente Reversible Hydroelectric Power Station, in the Sallente reservoir.

The reversible hydroelectric power plant takes advantage of the low cost of electricity at night to pump water from the lower Sallente reservoir to the upper Estany Gento and the high cost of electricity during the day to generate energy by turbining the water from the upper reservoir to the lower reservoir

After the construction of the Sallente plant, excessive vibration was detected in the two main pipes that feed the four turbines of the plant. For this reason, the plant could not operate with a group load greater than 50%, due to the possible risk of pipe breakage due to fatigue caused by vibrations.

ICR worked to diagnose the problem and propose solutions for that. Vibration measurements, finite element models and ODS (Operational Deflection Shape) visualization were carried out to study the vibration modes of the pipeline, both at rest and in a forced regime under the effect of water. Mechanical fatigue studies were also carried out (with the collaboration of ST applied mechanics).

As a result of the study, it was detected that the second harmonic of the pressure pulsations, caused by the passage of the runner blades in front of the pump turbine distributor, provoked the vibration of the free section of the forced piping that entered in resonance with one of its own modes causing excessive movements.

TECHNICAL SPECIFICATIONS:

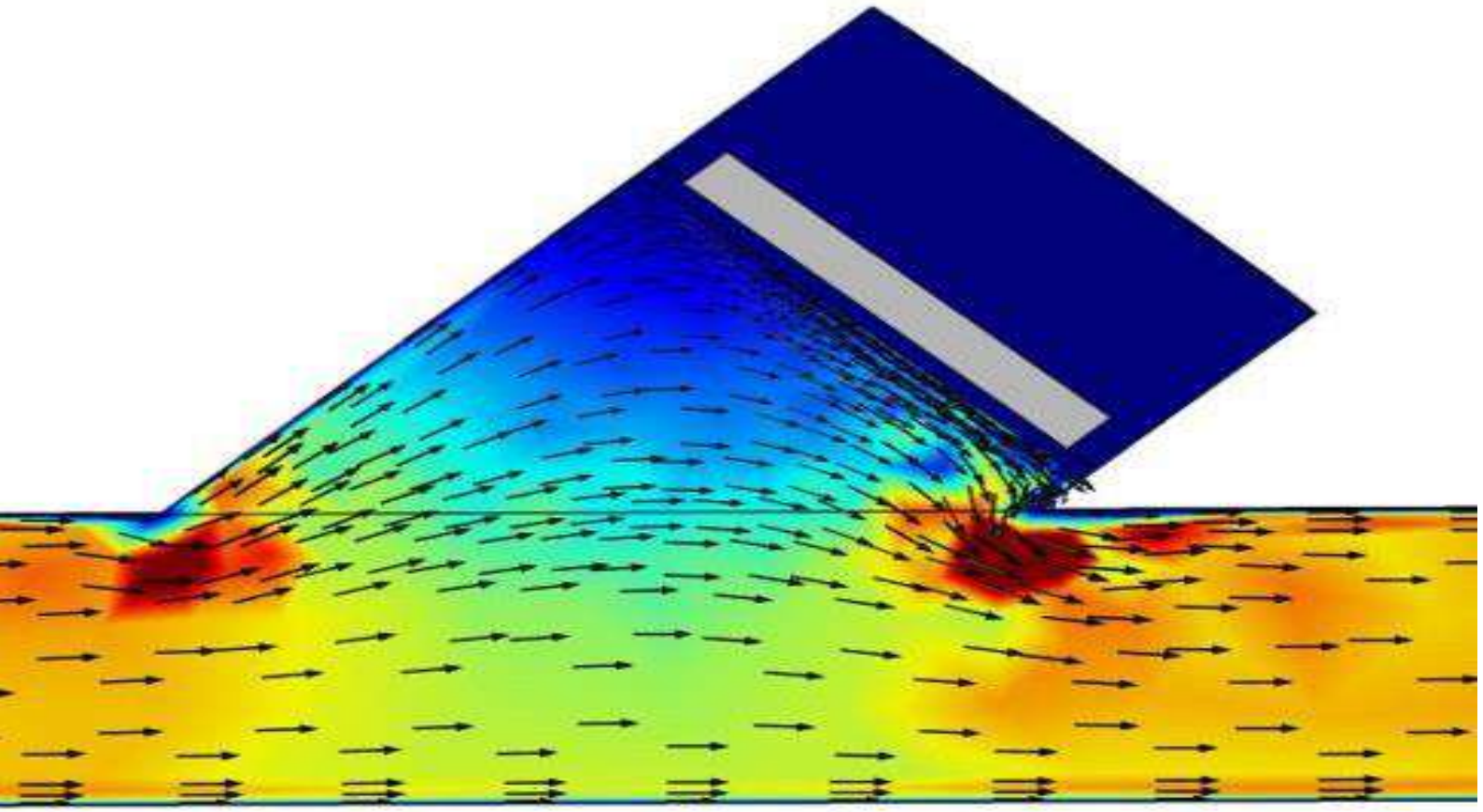
Client: ST applied mechanics
Location: Sallente (Catalonia, Spain)
Year: 1995
Sector: Environment, Industry
Service: Modal Analysis, Acoustic Measurements and Certification, Vibro-computational acoustics

This was solved by modifying the vibration modes with the placement of straps on the forced pipes, thus allowing them to work at full capacity. Since then, their position, tightening and vibration levels have been checked periodically.

TECHNICAL SPECIFICATIONS:

Client: ST applied mechanics
Location: Sallente (Catalonia, Spain)
Year: 1995
Sector: Environment, Industry
Service: Modal Analysis, Acoustic Measurements and Certification, Vibro-computational acoustics

R+D+I



ICR leads the European project Clean Sky 2 - PIANO

Application of ATPA (Advanced Transfer Path Analysis) method in Active Noise Control (ANC)

The Clean Sky 2 initiative of the European Commission's H2020 programme has as one of its main pillars the support to the development of the "New Generation Civil Tilt Rotor (NGCTR)" prototype to respond to the needs of the commercial aviation sector in the operation segment between routes operated by transport helicopters and regional commercial aircraft. One of the main problems identified in this type of aircraft is the lack of acoustic comfort inside the passenger cabin.

In the framework of this European programme, ICR leads the PIANO project (Path Identification for Active Noise Control), in which it acts as Project Coordinator, and which aims to combine Advanced Transfer Path Analysis (ATPA) and Active Noise Control (ANC) technologies, with the support of important partners in the ANC sector, such as the French company Technofirst and the DSL laboratory of the National University of Athens (NTUA). ICR brings its experience in project management in industrial vibroacoustics and its proprietary technology of transmission path analysis (ATPA).

The ATPA methodology will allow to know and quantify the noise transmission paths in the aircraft, identifying the most critical ones for the interior noise. This information will be key, on the one hand, for the adjustment of SEA numerical models and, on the other hand, for the subsequent noise reduction by means of ANC techniques.

In order to predict the aircraft interior noise levels, simulation models based on SEA (Statistical Energy Analysis) are usually used. A good choice of the values assigned to the coupling factors in these models is essential in order to obtain an accurate good representation of reality.

TECHNICAL SPECIFICATIONS:

Client: Clean Sky 2
Location: European Union
Year: 2020-2022
Sector: R+D+i
Service: Advanced Transfer Path Analysis (ATPA)

Thanks to the ATPA method, it will be possible to obtain the coupling parameters between the various subsystems of the vehicle, allowing to obtain the vibro-acoustic connectivities between them, and the SEA coupling factors.

The second main objective of this project is the reduction of noise, both tonal and broadband, by means of active noise control (ANC) techniques. Noise control techniques through active attenuation systems allow to obtain benefits that classical insulation and absorption solutions do not allow, such as low frequency noise attenuation using global ANC approaches and tonal noise reduction through local ANC concepts, such as personal acoustic comfort bubbles.

The final results will provide a complete definition of the architecture of the active noise control (ANC) systems on-board the aircraft, as well as the components to be installed to reduce noise in cabin operation considering the restrictive aircraft weight requirements at a reasonable cost.

TECHNICAL SPECIFICATIONS:

Client: Clean Sky 2
Location: European Union
Year: 2020-2022
Sector: R+D+i
Service: Advanced Transfer Path Analysis (ATPA)

ICR participates in the ambitious European project TRANSIT in the framework of H2020 Shift2Rail

Application of the ATPA method for the identification of noise from the track or wheels.

ICR participates in the European project TRANSIT (TRAin pass-by Noise Source characterization and separation Tools for cost-effective vehicle certification) providing its expertise in the GTDT-ATPA method.

The TRANSIT project aims to provide the railway community with a set of innovative and proven tools and methodologies to reduce the environmental impact and improve the interior acoustic comfort of railway vehicles.

Rail transport produces less CO2 and consumes less energy than other modes of land transport as well as air transport and requires less space than road transport. However, noise and vibration (N&V) levels in the vicinity of rail infrastructure are a major environmental challenge for the sector.

In order to achieve greater acceptance in rail transport, it is necessary to be able to have a new generation of vehicles with a low noise profile, which will result in a lower environmental impact and therefore greater comfort for the user.

The aim of the European TRANSIT project is to achieve a breakthrough in virtual testing and virtual certification through the development of validated source characterization characters, outdoor noise simulation models and noise source separation techniques based on the measurement, which can be incorporated into current test standards, such as TSI specifications.

TECHNICAL SPECIFICATIONS:

Client: Shift2Rail
Location: European Union
Year: 2020-2022
Sector: Railway, R+D+i
Service: Advanced Transfer Path Analysis (ATPA)

ICR's participation in this ambitious project consists of providing all the technological knowledge regarding the methods of analysis of the transmission paths. The specific GTDT-ATPA analysis method allows to obtain the contribution of each subsystem as an element decoupled from the rest of the set

The application of the method allows to identify which part of the total noise comes from the track and which part comes from the wheels in order to prioritize interventions on particular components to reduce the levels of environmental noise impact. The method can also be applied in order to evaluate the individual contribution of each subsystem to the vibration propagated to the ground.

The project also aims to study and propose advanced acoustic solutions, including those based on metamaterials, with the objective of improving both the interior acoustic comfort levels and the railway acoustic impact on the infrastructure environment.

The expected results of this project include a reduction in the cost and effort required for certification testing, improved comparability and reproducibility of test results, a deeper understanding of the contribution of different sources of overall pass-by noise, an improvement in the acoustic quality indices of trains, as well as boosting the competitiveness of the European Union (EU) railway industry and its social acceptance.

TECHNICAL SPECIFICATIONS:

Client: Shift2Rail
Location: European Union
Year: 2020-2022
Sector: Railway, R+D+i
Service: Advanced Transfer Path Analysis (ATPA)

Development of custom software for the railway sector

Software to determine the structure-borne noise level in any equipment of a train.

ICR has developed a specific calculation program for Alstom Transport, which allows to calculate the vibration levels of the different equipment, without the need for these to be installed on the train.

LEViS (Launcher for the Equipment Vibration Specification) allows to determine the level of structural noise due to any auxiliary equipment of a train, as well as to calculate the maximum vibration level of an equipment in a test bench, in order to be able to comply with the maximum structural noise level specifications of the train. The equipment subjected to these types of studies are usually static converters, traction converters, ventilation and air conditioning systems (HVAC), compressors, among others

LEViS is structured in three different modules related to each other, which allow to follow the process from the input of measurement data from the equipment to obtain the specifications:

• Noise and vibration prediction module

• Equipment specification mode, starting from a maximum structure-borne noise level

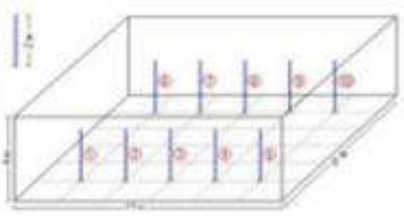
• Equipment verification mode

LEViS allows the user to visualize the results graphs, export and store them in databases, as well as to obtain an automated final report.

TECHNICAL SPECIFICATIONS:

Client: Alstom Transport
Location: Barcelona (Spain)
Year: 2019
Sector: Railway, R+D+i
Service: Development of custom software, Development agreements technological

European research project - EUROPRO



EUROPRO European Project

Design of a complete real-time acoustic source localization system in a reverberant field environment

In the same period in which ICR participated in the European project on noise reduction of tunnel boring machines (LINK), it was part of another European research project on new computing technologies, called ESPRIT HPCN Project Num 21040 - EUROPRO.

The objective of this project was to develop a new generation of HPCN (High Performance Computing and Networking) embedded platforms, as well as their corresponding software development environment. These platforms allowed to reduce costs and improve the cost/performance ratio for companies.

The multiprocessor software development environment would allow working with several computational models in parallel, and included a very complete set of modelling and simulation tools.

The consortium of this project was formed by different companies of the technological sector coordinated by Thomson Marconi Sonar S.A.S.

Intecs Sistemi and Simulog were in charge of providing their software, providing modelling, simulation and monitoring tools. The hardware used integrated SHARC and PowerPC processors, the Direct Switching technology was provided by Thomson CSF-SDC and the link technology by Bull S.A. The company Cetia was in charge of exploiting the resulting product abroad. In particular, the companies Prakla-Seismos, Dicesva, LGAI and ICR used the system in their next generation of acoustic photography systems.

TECHNICAL SPECIFICATIONS:

Client: European Union
Location: Barcelona (Spain)
Year: 1994-1998
Sector: R+D+i
Service: Custom software development

ICR designed a complete real-time acoustic source localization system in a reverberant field environment using the processing of data in parallel (multiprocessor) and the LGAI (now APPLUS) facilities were used to validate it. Dicesva used the method designed by ICR to realize its physical (hardware) implementation.

The method created to achieve this goal was called "MELF" Method. This consisted of using an array of microphones as a sound pickup, which obtained the impulse response of pairs of microphones from the delay between them. This allowed to locate the sources of noise in 3 dimensions, in the studied area.

TECHNICAL SPECIFICATIONS:

Client: European Union
Location: Barcelona (Spain)
Year: 1994-1998
Sector: R+D+i
Service: Custom software development

Proyecto de investigación europeo - STBM

Tunnel Boring Machines

STBM - Tunnel Boring Machines

Study to improve tunnel boring machines in operation

25 years ago we began our journey as ICR participating in two European projects. The first was part of the BRITE Project (BRITE BE95-1735) entitled “STBM: Tunnel Boring Machines”. This project, dedicated to the analysis of tunnel boring machines, was developed between 1995 and 1998.

The STBM project was aimed at improving safety, providing better quality and a more cost-effective excavation technique for TBMs. The consortium that was formed for this study consisted of a main contractor (BOUYGUES) that operated many TBMs as an end user and a major European manufacturer of TBMs (HERRENKNECHT). ALGOSYSTEMS S.A was in charge of supervising the development of the software, while DICESVA and ICR contributed their experience in noise control and specific acoustic measurements to reduce the noise generated by the tunnel boring machine in operation. Two research organizations, LRP and IAI, provided the necessary theoretical framework.

ICR studied different options and proposals on how to treat the tunnel boring machine, the external equipment used and how to take into account the level of noise received by tunnel workers, it was decided to define the tunnel as if it were a conduit. Usually, to treat a duct acoustically, the walls are reinforced with absorbent material and silencers are installed.

For practical reasons, treating the tunnel walls with absorbent material was impossible, so it was decided to design a silencer that would reduce the noise caused by the drilling wagon.

TECHNICAL SPECIFICATIONS:

Client: European Union
Location: Lille (France)
Year: 1995-1998
Sector: Infrastructures, R+D+i
Service: Acoustic measurements and certification, Computational Vibro-acoustics.

Using some measurements carried out while the Lille metro tunnel was being built together with the measurements made on a tunnel boring machine model for the Sydney airport tunnel (from the Herrenknecht company) as well as the realization of a BEM numerical model of the tunnel boring machine, the ideal solution was designed for this project: a silencer wagon. Since the noisy equipment was all located at the head of the TBM, the silencer car acted as a silencer in a duct, preventing the propagation of noise throughout the tunnel.

This innovative solution would allow the noise produced by the tunnel boring machine to be reduced by up to 30 dBA, together with the option of being able to treat external equipment without reducing its accessibility.

TECHNICAL SPECIFICATIONS:

Client: European Union
Location: Lille (France)
Year: 1995-1998
Sector: Infrastructures, R+D+i
Service: Acoustic measurements and certification, Computational Vibro-acoustics.

European Project - Roll2Rail

Research and technological development in railway vibro acoustics

The European Roll2Rail Project arises from the need to develop innovative technologies in the railway sector as part of a long-term strategy to revolutionise this market. The main objectives are both to influence the performance of rolling stock through the introduction of cutting-edge technologies and to propose radical changes to revolutionise the concept of the train for the future.

One of the study blocks has been dedicated to the improvement of the acoustic comfort of passengers, where ICR collaborates with the railway sector companies, Alstom Transport and CAF. In order to propose innovative solutions to this acoustic comfort, it is essential to know the origin of the noise radiated by railway operations, and thus focus efforts on noise reduction.

ICR's contribution to the project is framed in the separation of the noise radiated by the railway infrastructure from the noise radiated by the vehicle. In this study, the technology developed by ICR for the analysis of noise and vibration transmission paths, called ATPA (Advanced Transfer Path Analysis), has been applied.

This technology makes it possible to establish the connectivity relationships between the different subsystems of a network that represents a given physical model to be analysed. From the vibration of each of the subsystems in which the track system is discretized, its relative contribution received at an external noise control point can be determined. In this way, the method allows to obtain the contribution of each subsystem as an element decoupled from the rest of the set.

TECHNICAL SPECIFICATIONS:

Client: Shift2Rail
Location: European Union
Year: 2015-2017
Sector: R+D+I, Railway
Service: Advanced Transfer Path Analysis (ATPA)

The application of the method makes it possible to foresee which are the elements that contribute most to noise at the receiving control point (for example, a microphone located at a certain distance from the track axis) and thus be able to prioritise interventions on particular components to reduce noise emission to the outside.

This project is supported by the Horizon 2020 programme of the European Commission, with Roll2Rail being one of the flagship projects of the Shift2Rail programme.

TECHNICAL SPECIFICATIONS:

Client: Shift2Rail
Location: European Union
Year: 2015-2017
Sector: R+D+I, Railway
Service: Advanced Transfer Path Analysis (ATPA)

Research project
META - X and
META - W

ALSTOM

Design and development of a vibro-acoustic characterization tool

R&D&I on trains - META-X and META-W

The French multinational company Alstom Transport, relied on the technological background of ICR, in 2001, to carry out an R&D project with the aim of designing a methodology and developing an advanced tool for the vibro-acoustic characterization of a train.

This project, which lasted 5 years, was developed in two phases: META-X and META-W.

The first phase of the study, the META-X project, was carried out between 2001 and 2004. The aim of this initial phase was to provide a measurement procedure that be able to identify and quantify the vibro-acoustic contributions of the different subsystems of the train inside and outside, as well as the different existing transmission paths. For this purpose, experimental measurements were done on different trains in England and Germany. Different test procedures were also developed in order to separate and quantify airborne and structure-borne noise.

The procedure developed was applied in two phases: the first phase included the vehicle in the stationary mode. The Objective was to characterize the physical behaviour of the structure, using the GTDT (Global Transfer Direct Transfer) transmission path method.

The second phase was the vehicle in normal operation. This phase aimed to quantify the different contributions of each part of the train to the total noise, based on the analysis of the vibrations and noise measured in each subsystem. This characterisation method is the well-known as ATPA (Advanced Transfer Path Analysis) method, developed by ICR.

TECHNICAL SPECIFICATIONS:

Customer: Alstom Transport
Location: Barcelona (Spain)
Year: 2001-2006
Sector: Railway, R+D+i
Service: Custom software development, Technological development agreements

This method allows the client to optimize costs, since they offer the client useful results for decision making in a reasonable time.

To finalize the project, ICR designed a custom software tool called VARSALAB for the organization and management of the experimental data, as well as post-processing using ATPA technology.

In a second phase, the META-W project allowed to developed a new methodology for vibro-acoustic diagnosis and prediction, which provided much better results than the initial META-X method or any other method in use at that time.

The META-W project aimed to achieve the same results as in the META-X project, but without the need to carry out the initial measurement with the vehicle stationary. This would save a minimum of 70% of the test time, which, valued in terms of working days and time spent immobilising a complete train, which is of considerable economic importance to the customer.

Another objective of the META-W project was the adaptation of the VARSALAB software (implemented in the META-X project) to the new TestLab platform, replacement of SCADA-X, thus implementing the new VARSALAB post-processing tool.

Thanks to the research carried out in the META-W project, a new transmission pathway analysis method was developed, which was also included in the new post-processing tool VARSALAB.

The META-X and META-W projects are yet another example of ICR's differentiating and highly customer-focused technical capabilities, making it possible to provide high value-added solutions to its customers specific needs.

TECHNICAL SPECIFICATIONS:

Customer: Alstom Transport
Location: Barcelona (Spain)
Year: 2001-2006
Sector: Railway, R+D+i
Service: Custom software development, Technological development agreements

Research project
INVENT

General Electric

Research project in the wind energy sector – INVENT

Automated operational modal analysis (OMA) software for wind turbines

In 2009 the company Ecotecnia Energías Renovables (later Alstom Wind and currently GE Renewables) trusted ICR to develop a research project with the aim of automating the process of analysis of the vibration modes of its wind turbines, applying oma (operational modal analysis) technology. this work was developed within the framework of a research project, funded by ACCIÓ, called "Proyecto InVent".

Ecotecnia was interested in the use of techniques to identify the vibrational responses of wind turbines, in order to correlate their numerical models and adjust them to the experimental results, being able to predict the response under specific operating conditions.

The company's objective was to define a methodology capable of determining the wind turbine modes in an automated way, based on real measurements made on wind turbines in operation, and thus be able to optimize the design of future prototypes.

ICR was in charge of designing and defining the protocol for the operational modal analysis, specifically in two wind turbine prototypes: the ECO100 and the ECO110. Together with the definition of the measurement protocols for the operational modal analysis, a specific software was developed that incorporated the possibility of automating the OMA process from temporary records at different operating conditions, automatically generating diagrams of the evolution of the wind turbine's own frequencies in the following ways depending on the wind speed. This software was tailor-made for the customer.

TECHNICAL SPECIFICATIONS:

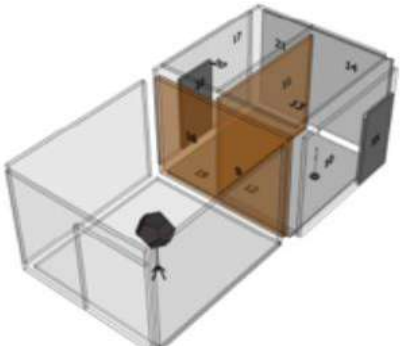
Client: Ecotenia - GE (General Electric)
Location: Barcelona (Spain)
Year: 2009-2021
Sector: Wind Energy, R+D+i
Service: Custom Software Development, Technology Development Agreements, Analyses modal

Once the functionality of the software was validated and tested to perform calculations according to the OMA (Operational Modal Analysis) technology, an extension was implemented for the application of the ODS (Operational Deflection Shape) method in wind turbines. This integration to the InVent software allowed to perform calculations in the time and frequency domain, as well as to visualize the operational deflection shapes.

Finally, once the modal analysis procedure had been defined and the validation protocols had been implemented, a tailor -made course was held to train the Ecotecnia engineering team in the protocols implemented and in the use of the software.

TECHNICAL SPECIFICATIONS:

Client: Ecotenia - GE (General Electric)
Location: Barcelona (Spain)
Year: 2009-2021
Sector: Wind Energy, R+D+i
Service: Custom Software Development, Technology Development Agreements, Analyses modal



Research project
VITRASO

Collaborators:

Research project in the construction sector – VITRASO

Analysis and prediction of noise and vibration transmission paths in the building sector.

The VITRASO project, carried out in 2009, is part of the ICR philosophy of being in constant evolution and technological growth because it is in research projects where we find the source of knowledge that allows us to be more competitive, growing business and providing customers with the most advanced tools to solve their particular problems.

The project is based on the need to improve and develop experimental and numerical calculation methods for the analysis and prediction of noise and vibration transmission paths in the building sector.

The methods proposed in the framework of VITRASO allow to identify and quantify existing sound insulation problems in existing buildings, and on the other hand, to improve the predictions of vibro- acoustic transmission between enclosures in the design phase of new buildings, which make it possible for more optimal designs.

ICR participated in the project together with different entities such as LGAI (APPLUS technological center), La Salle Ingeniería (Universitat Ramon Llull), Servià Cantó, S.A., FCC (Fomento de Construcciones y Contratas) and the Construction Technology Center (Imat).

ICR defined and actively participated in the measurement protocols of the different tests carried out in the transmission chambers of the APPLUS facilities in order to locate and quantify the main and secondary transmission paths between the transmitter and receiver enclosure in different configurations, and thus be able to contrast them with the results obtained from the calculation models.

TECHNICAL SPECIFICATIONS:

Client: Generalitat de Catalunya
Location: Barcelona (Spain)
Year: 2009
Sector: Building, R+D+i
Service: Acoustics of the building, Computational Vibro-acoustics

In this project, SEA (Statistical Energy Analysis) calculation methods, hybrid methods for the medium frequency range, and finite element models (FEM) and boundary element models (BEM) at low frequency were used. Sound insulation predictions were also carried out, including the analysis of lateral transmission paths according to the UNE-EN12354 standard, using the dBKAisla insulation calculation software.

Finally, both the calculation methods and the experimental procedures, developed in the project, were applied to two real construction projects, a private house and a school, resulting in an adaptation of the methodology to the building sector.

TECHNICAL SPECIFICATIONS:

Client: Generalitat de Catalunya
Location: Barcelona (Spain)
Year: 2009
Sector: Building, R+D+i
Service: Acoustics of the building, Computational Vibro-acoustics

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