

## SPACES AND PRODUCTS

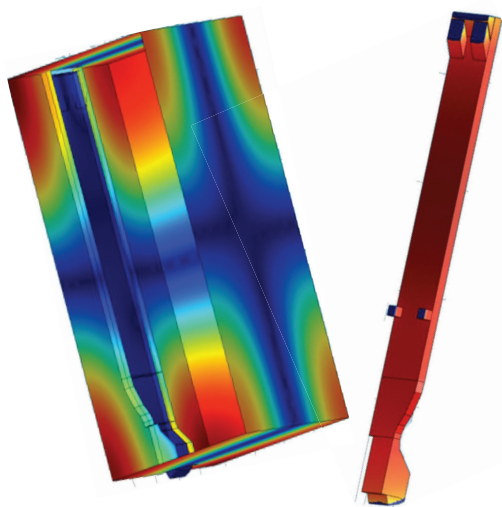
C. Asensio, I. Pavón

Instrumentation and Applied Acoustics Research Group (I2A2)  
Universidad Politécnica de Madrid - [info@i2a2.upm.es](mailto:info@i2a2.upm.es)

 ACÚSTICA APLICADA

### Abstract

The perceived quality of any electrical appliance, vehicle, or either interior or exterior spaces is influenced by the quality of its sound, and this includes the reduction of noise, but also a fine tuning of its sound features. Sound quality is growing field of study that transversally influences the design of products and spaces, combining objective measures with subjective perception of people. Closed to mechanical and acoustics engineering, sound quality and soundscapes bring people views into the scene, trying to translate their subjective response into objective parameters that can be implemented in a product or a space. I2A2 has been involved in several research projects closely related to the optimization of sound emissions of products, such electrical appliances or vehicle components, and spaces, such as vehicle cabins, building components or rooms in an industry.

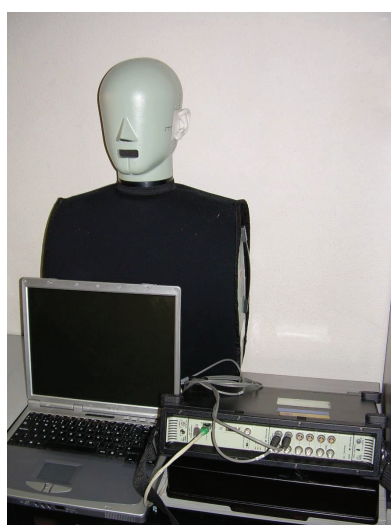
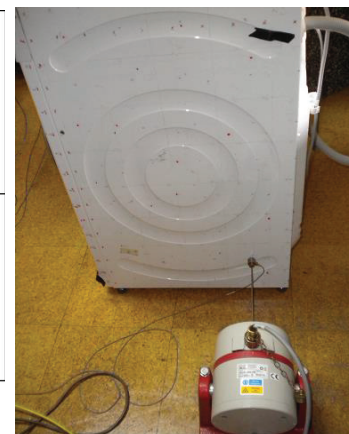
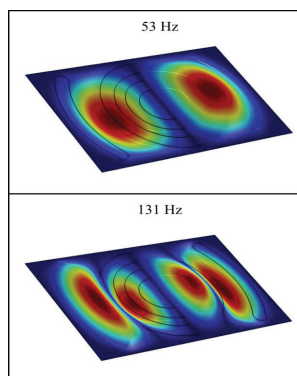


### Sound quality in electrical appliances

**THE REFRIGERATOR CASE** - The aim in this Project was to reduce sound emissions in a refrigerator, in order to improve the product acceptance and its commercial outcomes.

The first objective was to determine if it was the compressor or the fan the responsible for the noise levels. We made sound intensity, sound pressure and vibration measurements, to finally come to the conclusion that it was necessary to prioritize the mitigation measures in the fan. Cold air flow directed from the electric fan to upper compartment of the refrigerator produces turbulences that generate noise. This is a tonal sound with a main frequency closely related to the RPM and the number of blades in the fan. A FEM analysis was performed, in order to analyse the frequency response of mass of air that is enclosed by the duct and the upper compartment. We observed that the tonal noise was tuned with the resonances of the compartment, and this amplified the sound produced. Therefore it was suggested to adjust smoothly the RPM to break this coupling.

**THE WASHING MACHINE CASE** - A similar approach was followed, but vibrations were the main source of noise in this case. The aim of the project was to find a model to find the propagation paths and the influence of damping, when inserted in different parts of the structure.



### Indoor an outdoors spaces

The acoustics of a theatre, a cinema, or a conference room have been widely studied in the past, as room acoustics are important to improve the speech intelligibility, or the quality of a musical program. But, its basis can be also applied to the design of either interior or exterior spaces. Acoustic in the cabin of an aircraft can be crucial, in order to improve communications between the pilots and the air traffic control. And it can be also critical to improve the performance of an operator in machinery, or to reduce the accidents' risk. But the acoustic performance can be also important for the perceived overall quality of a product, like in the cabin of a car or a train.

Our most recent research in sound quality and soundscapes is closely related to model subjective response from users and citizens, in order to customize the acoustic environment.

### PAPERS IN JOURNALS

- Asensio, C.; Recuero, M.; Pavón, I.; *Citizens' perception of the efficacy of airport noise insulation programmes in Spain. Applied Acoustics* (2014)
- Tabacchi, M.; Pavón, I.; Ausejo, M.; Asensio, C. *Assessment of noise exposure during commuting in the Madrid Subway. Journal of Occupational & Environmental Hygiene* (2011)
- Ausejo, M.; Tabacchi, M.; Recuero, M.; Asensio, C.; Pagán, R.; Pavón, I. *Design of a noise action plan based on a road traffic noise map. Acta Acustica united with Acustica* (2011)
- Asensio, C.; Pagán, R.; Trujillo, J.; Recuero, M. *Intelligibility of Speech in the Spanish Congress of Deputies. Journal of Acoustical Engineering society* (2010)