

[contact@matelys.com](mailto:contact@matelys.com)



**SYMPOSIUM ON THE ACOUSTICS OF  
PORO-ELASTIC MATERIALS**

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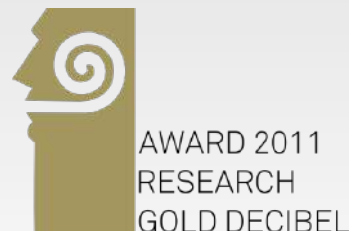
## Presentation outline

- Matelys – general presentation
- How to manage uncertainties and standard deviations from the measurements to the simulations

Matelys is an independent research laboratory  
which expertise covers  
materials, acoustics, mechanics, thermodynamics, flow



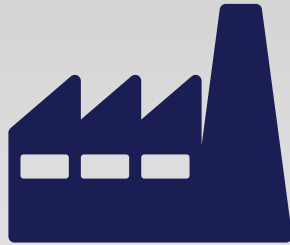
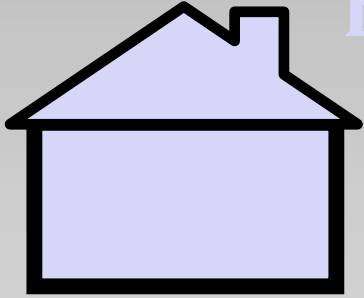
Accredited French Research Ministry (*CIR*) since 2007  
and awarded by peers



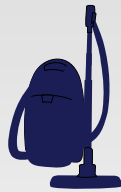
**Industry Award 2012**



## Buildings

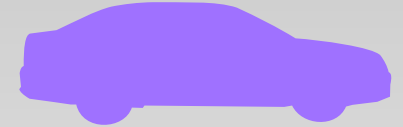


## Other industries

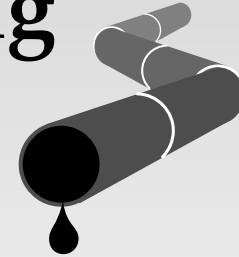


Measurement  
Characterization  
Simulation  
Optimization

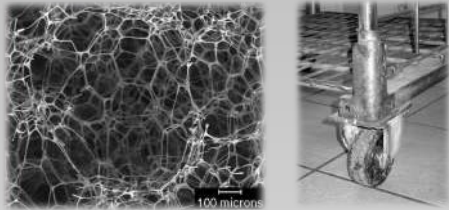
## Transportation



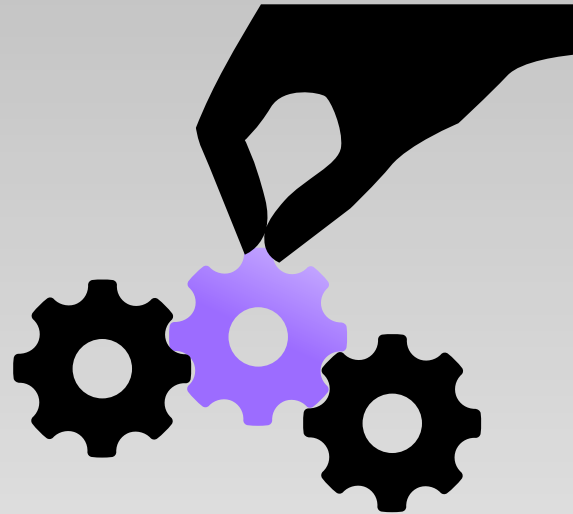
## Piping



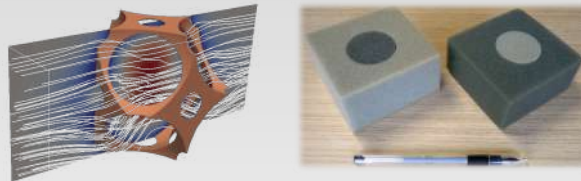
# Characterization



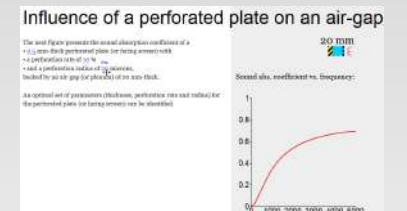
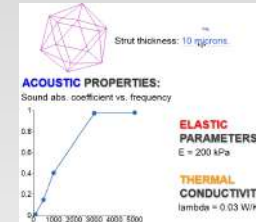
# Prescription



# R&D services



# Training & Digest



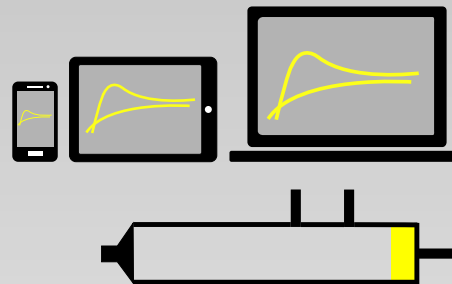
## Acoustic simulations



## Flow characterizations & simulations



## Material database



## Turnkey test rigs

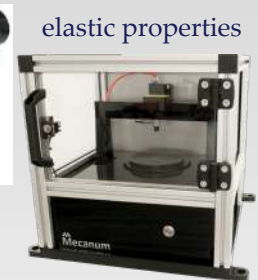
## Acoustic measurements & characterizations



porosity



impedance tube

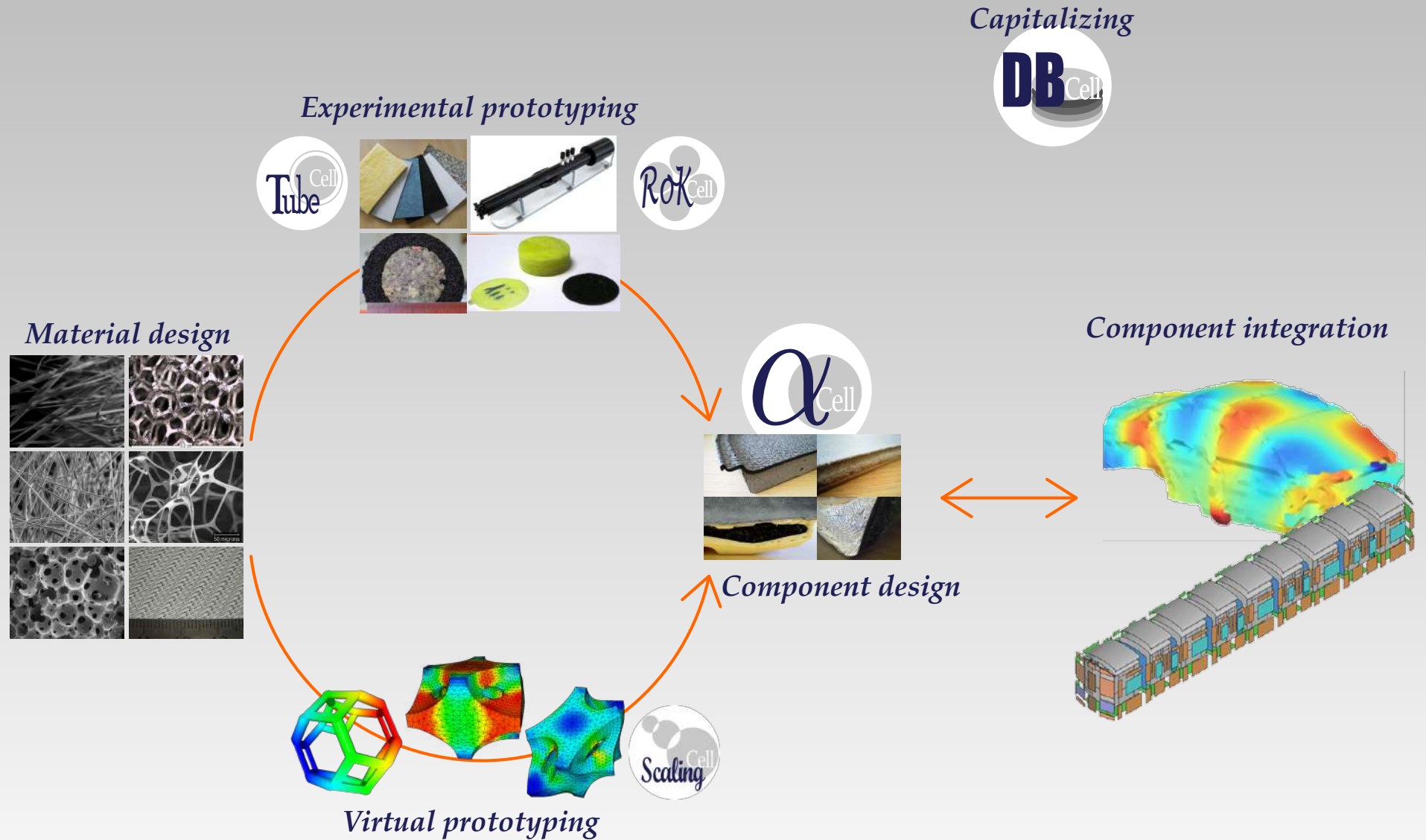


elastic properties

## R&D of common interest

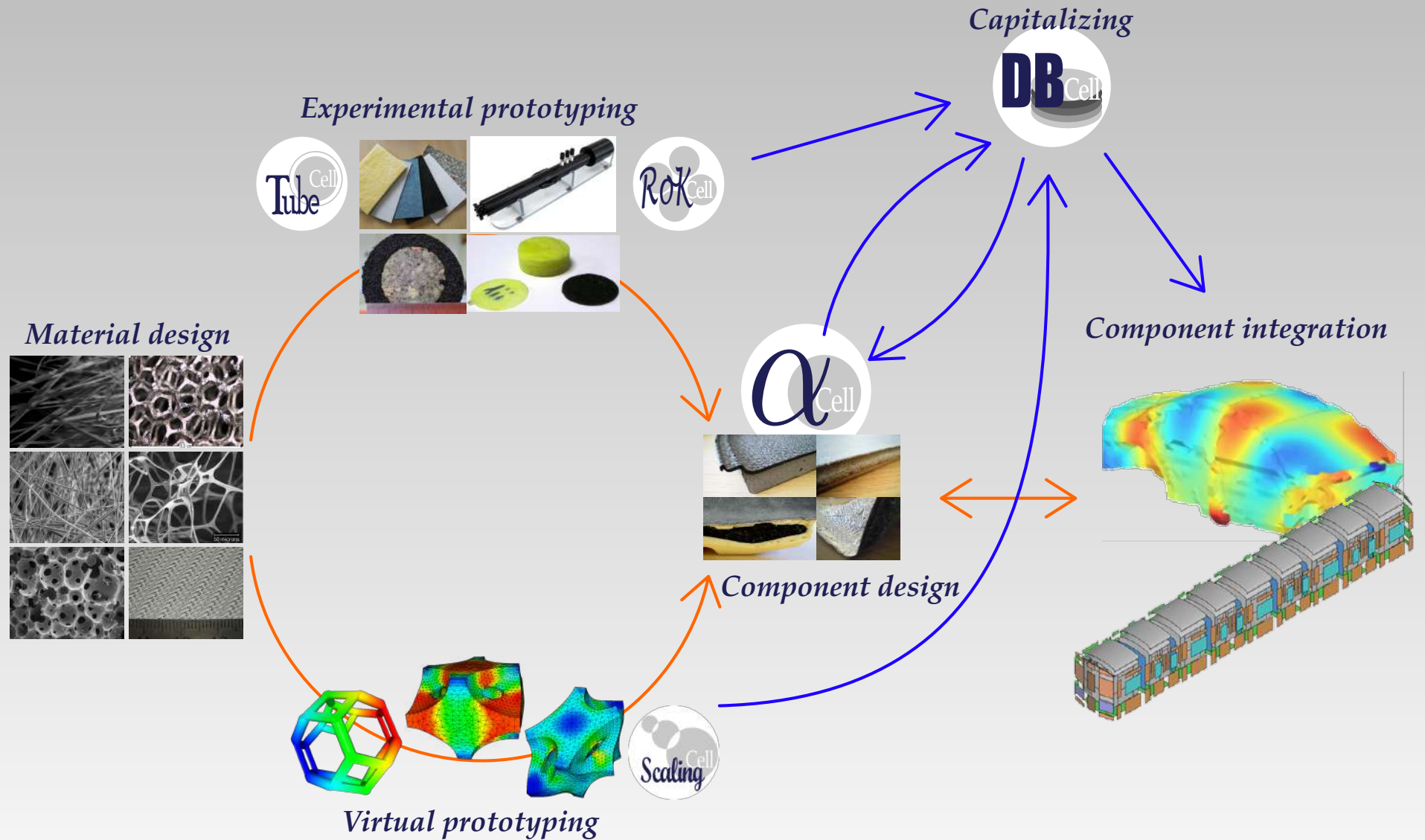
- Material development workflow
- Managing uncertainties and standards deviations from the measurements to the simulations

# ■ Matelys in a typical engineering workflow



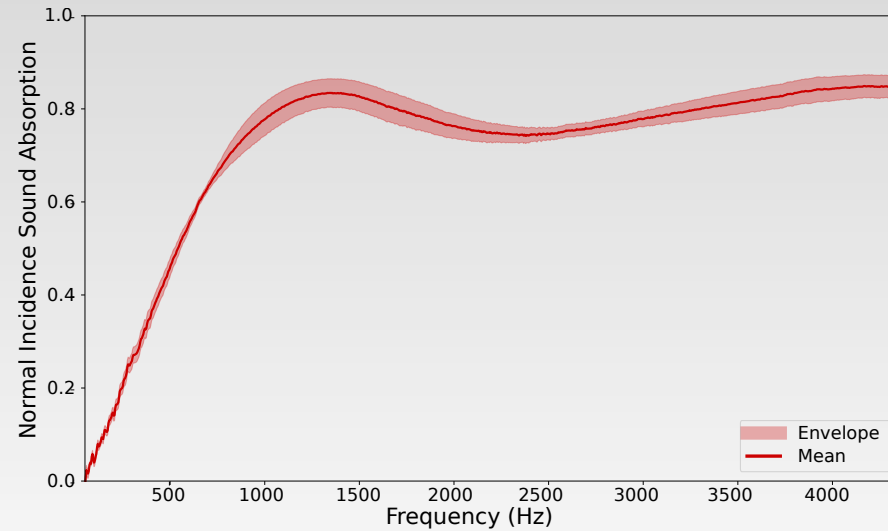
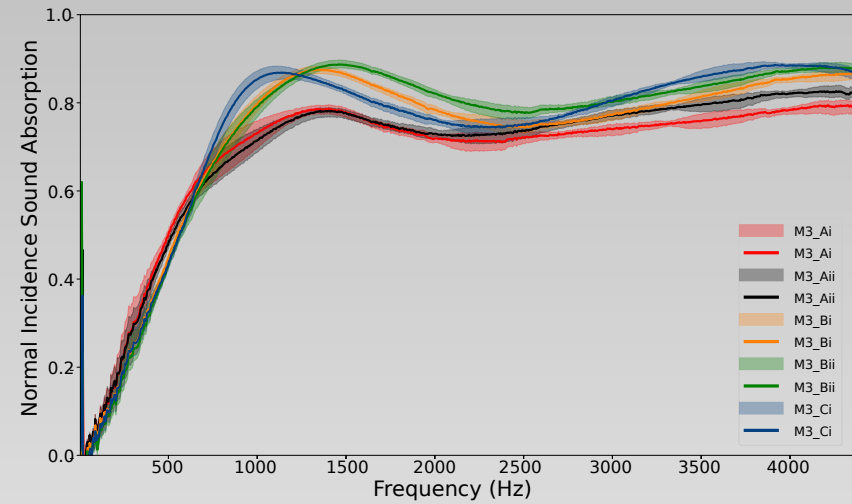
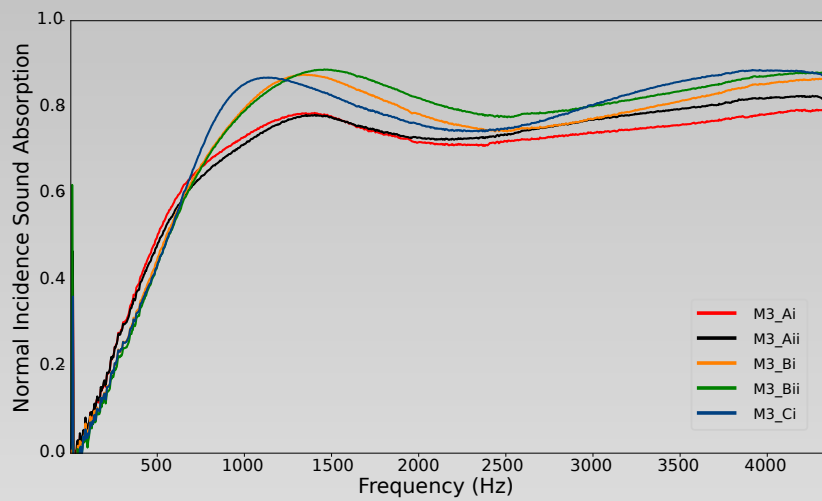


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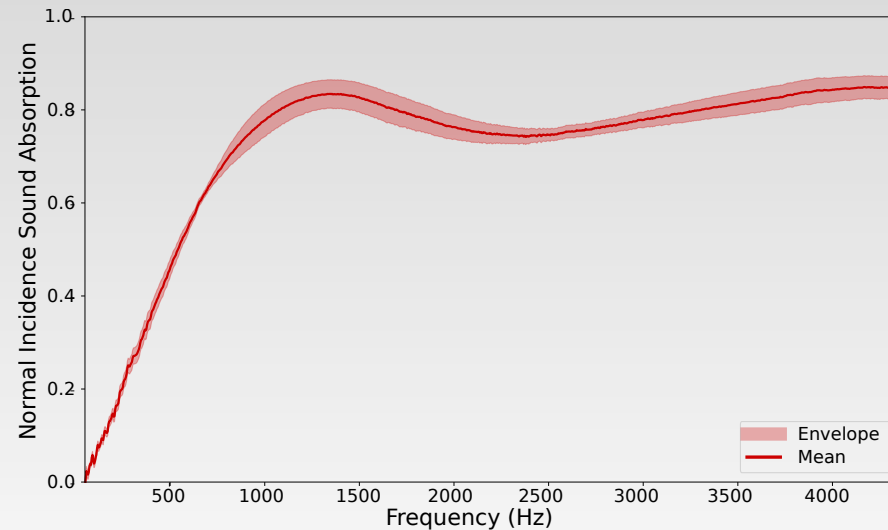
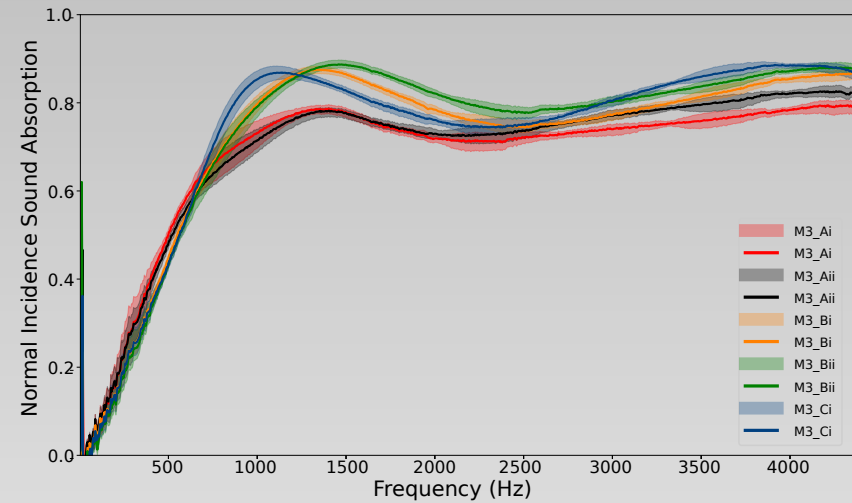
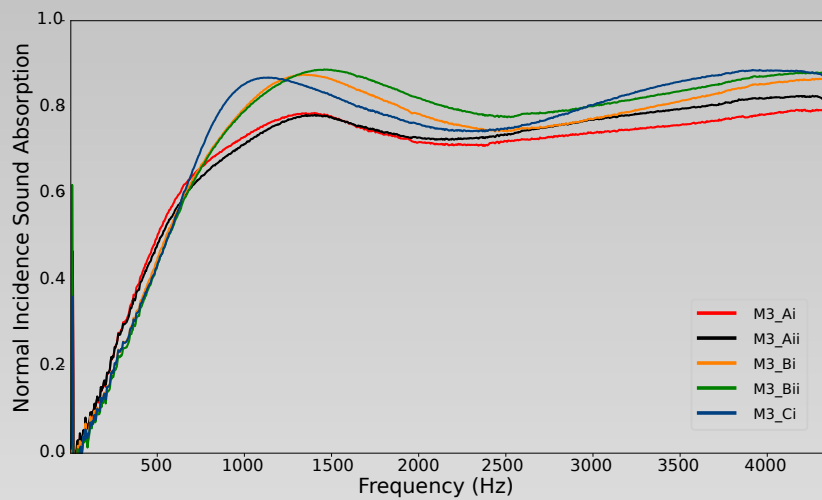
## ■ Managing uncertainties and standard deviations

- Each parameter is measured or characterized with a given **uncertainty**



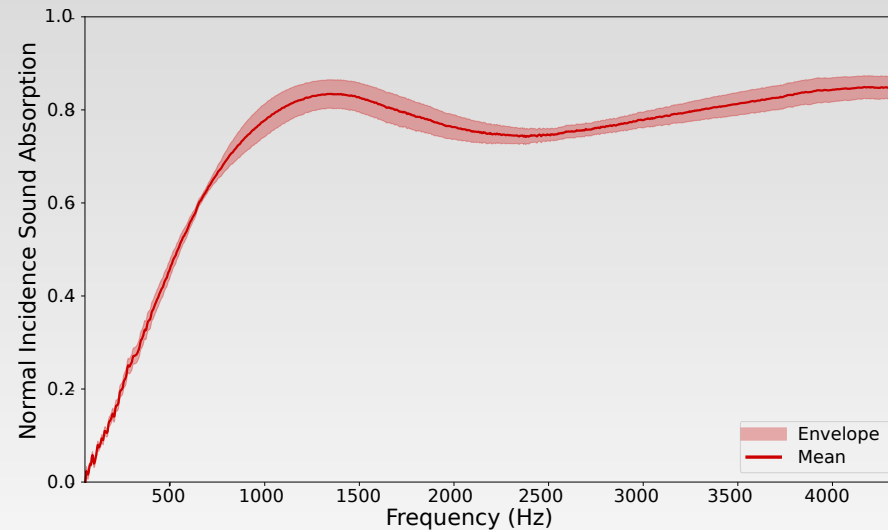
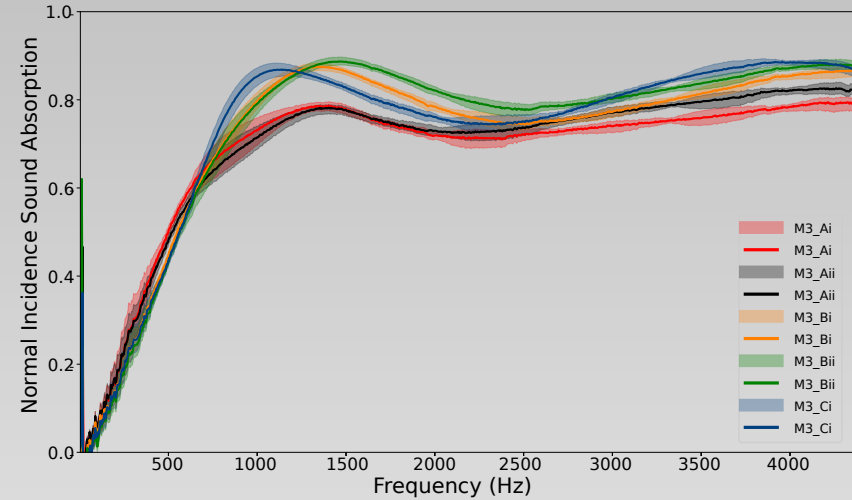
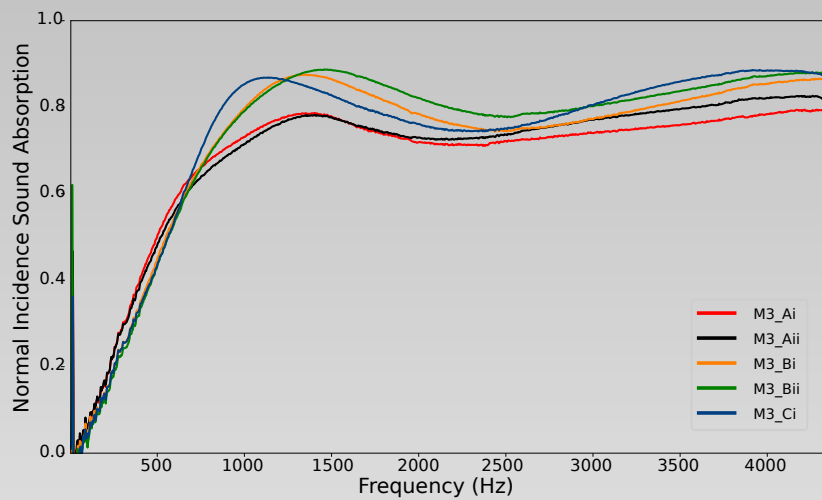
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## ■ Managing uncertainties and standard deviations

- Each parameter is measured or characterized with a given **uncertainty**
- Several samples are tested to obtain a mean value and a **standard deviation**
- These uncertainties and standard deviations are rarely used in simulations



## ■ Analytical inversion or numerical fitting?\_\_\_\_\_

- Two main classes of characterization methods are employed: **analytical inversion** method or **numerical fitting procedure**

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- Numerical fitting methods can lead to non physical sets of parameters.



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- Numerical fitting methods can lead to non physical sets of parameters.
- The fitting procedure can be bounded by the analytical inversion.

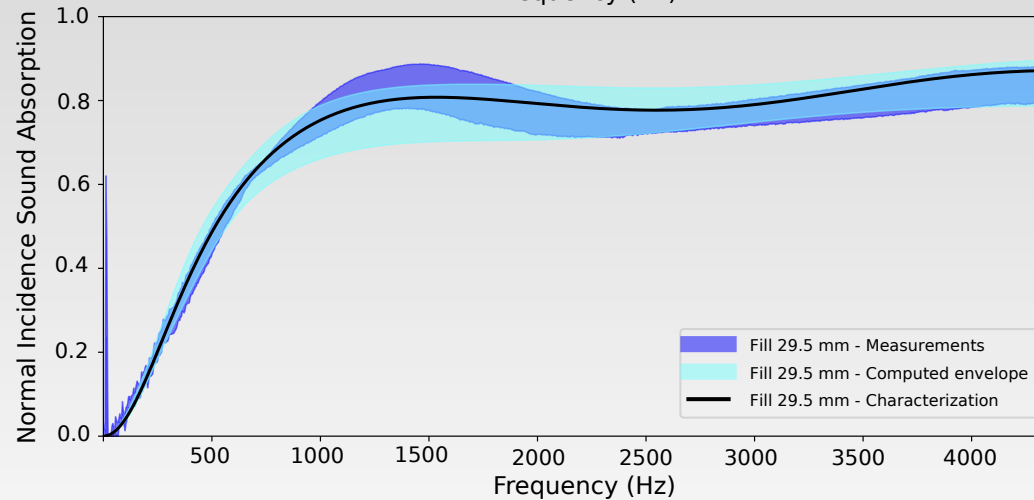
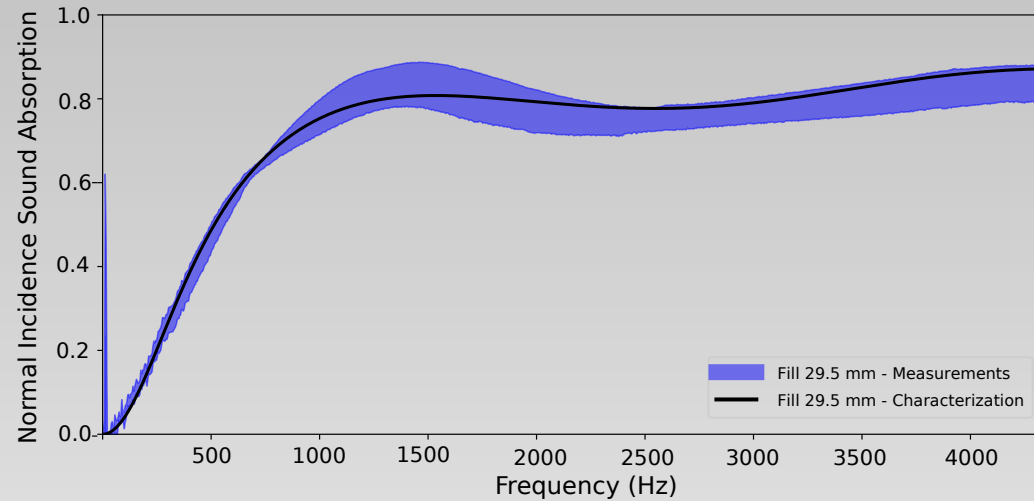
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- The fitting procedure can be bounded by the analytical inversion.
- **Bayesian method** enables to properly couple these methods in order to increase the **confidence in the resulting uncertainties**.

## ■ Comparing envelopes

- A **simulated envelope** can be compared to the measured one instead of comparing a single curve!



# Prepare to be MATELYS approved !

More about porous materials : <http://APMR.matelys.com/>

Motionless skeleton models | APMR

http://apmr.matelys.com/PropagationModels/MotionlessSkeleton/index.html

## Overview of the different motionless skeleton models

Three classes of models (i.e. expressions of  $\bar{D}$  and  $\bar{K}$  as functions of the frequency and of the pore shape) can be listed.

**Empirical models** which usually require to know a small number of parameters (or information). They are very popular and will very used in spite of their restrictive limits.

**Analytical models** are valid for porous materials with simple pore morphologies: parallel cylindrical pores with a singular cross-section (circular, square, triangular).

Finally, **semi-phenomenological models** have been developed for more complicated pore morphologies. For these latter models, only the asymptotic behaviors are known. A behavior between these asymptotes is assumed without it has been mathematically proven.

The figure below shows the growing complexity of propagation models assuming a motionless skeleton since Zwikker & Kosten. A [PDF version of this image](#) is available for download.

Note that the expression 'equivalent fluid' is widely used to qualify porous materials with rigid and motionless skeletons. This confusing expression, which usually refers to the homogenised medium and not its fluid phase, should not be employed for the sake of clarity.

	Straight cylindrical pores	Slanted cylindrical pores	Non uniform sections	Non-uniform sections with possible restrictions
Material morphology and number of parameters	1-2	2-3	4-6	8
Model and parameter examples	Zwikker-Kosten $\phi, \sigma, \tau, \kappa$	Mik $\phi, \sigma, \tau$	Attenborough $\phi, \sigma, \tau, \kappa, \tau_0$	Wilson $\phi, \tau, \kappa, \tau_0$ Johnson-Champoux-Allard $\phi, \sigma, A, A', \tau, \tau_0$