

OR2: A Software Portfolio for NVH Optimization of Gearboxes

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Laboratorio per la Meccanica Avanzata



A Software Portfolio for NVH optimization of gearboxes

Parametric LP model
of gearboxes

Gear and Shaft vibration in operating condition
Variable forces on bearings and casing

Parametric FE model
of gearboxes

Natural frequency of casing
Casing vibration in operating condition

BE model of gearboxes

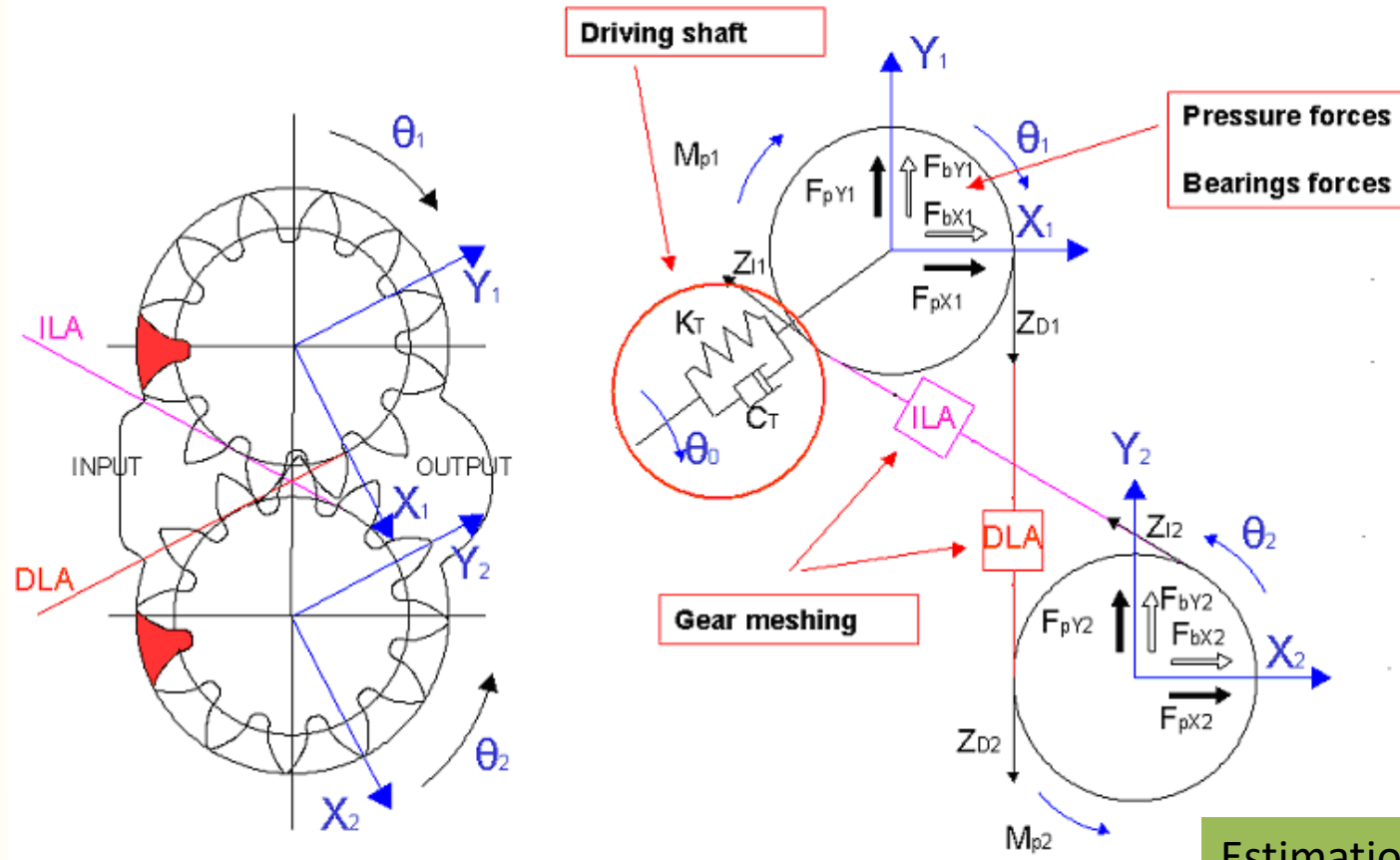
Acoustic radiation

Sound Quality Analysis
of gearboxes

Acoustic comfort metrics

Parametric LP model of gearboxes

> rotating components (gears and shafts)



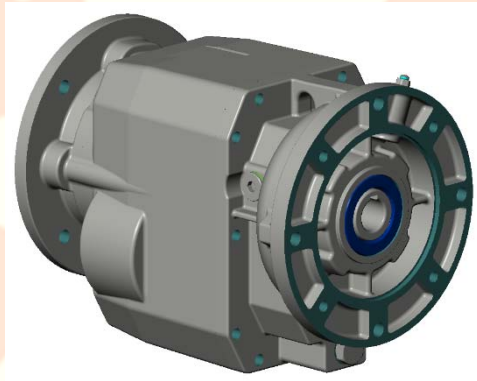
- Low number of DOFs
- LP non-linear model
- Inertia/stiffness/damping
- Variable meshing stiffness
- Profile errors
- Backlash
- Bearing stiffness

Estimation of variable forces on bearing and casing

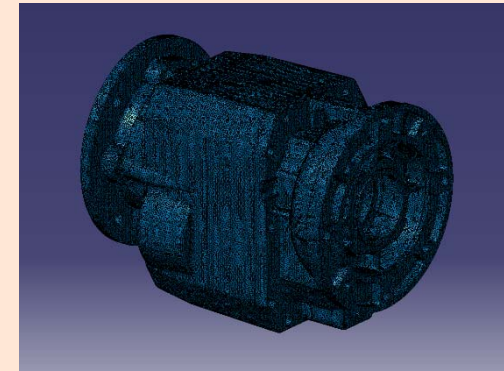


Parametric FE model of gearboxes > casing

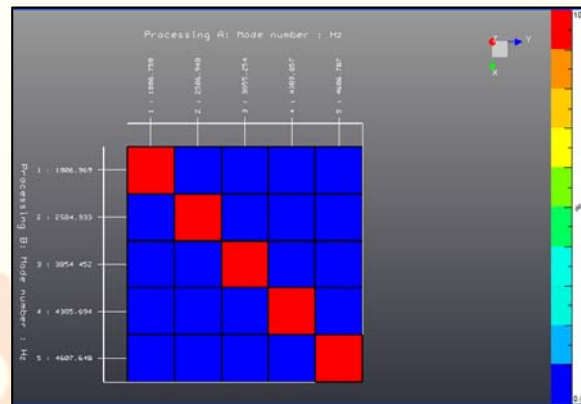
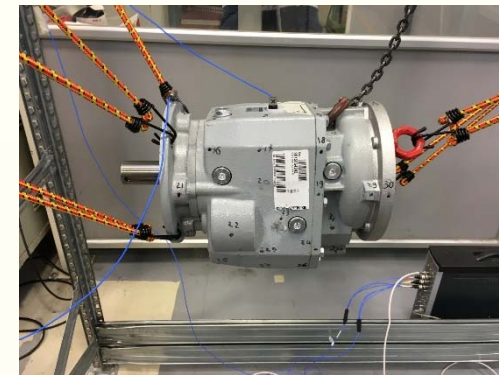
Metodology for FE analysis of gearboxes. Example on parallel gearbox and worm gearbox



Parametric CAD model



3D FE model

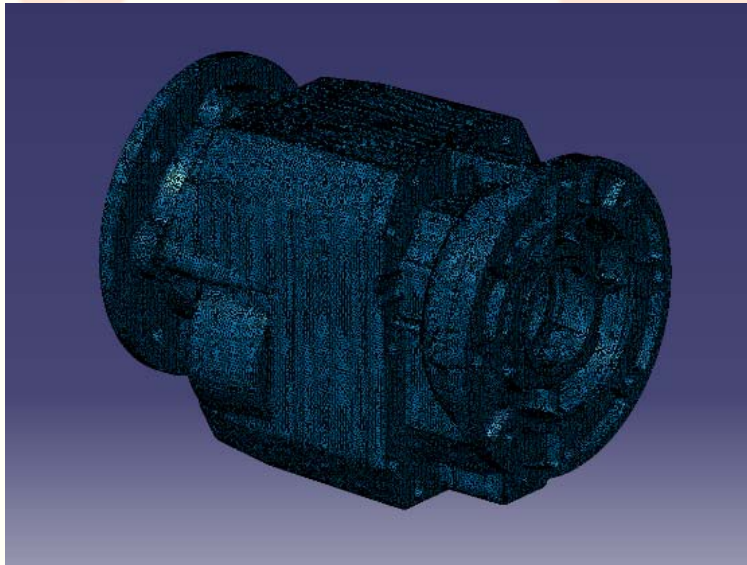


Validated FE model



Experimental validation

Parametric FE model of gearboxes – Modelling



Mesh Dimension:

10 mm

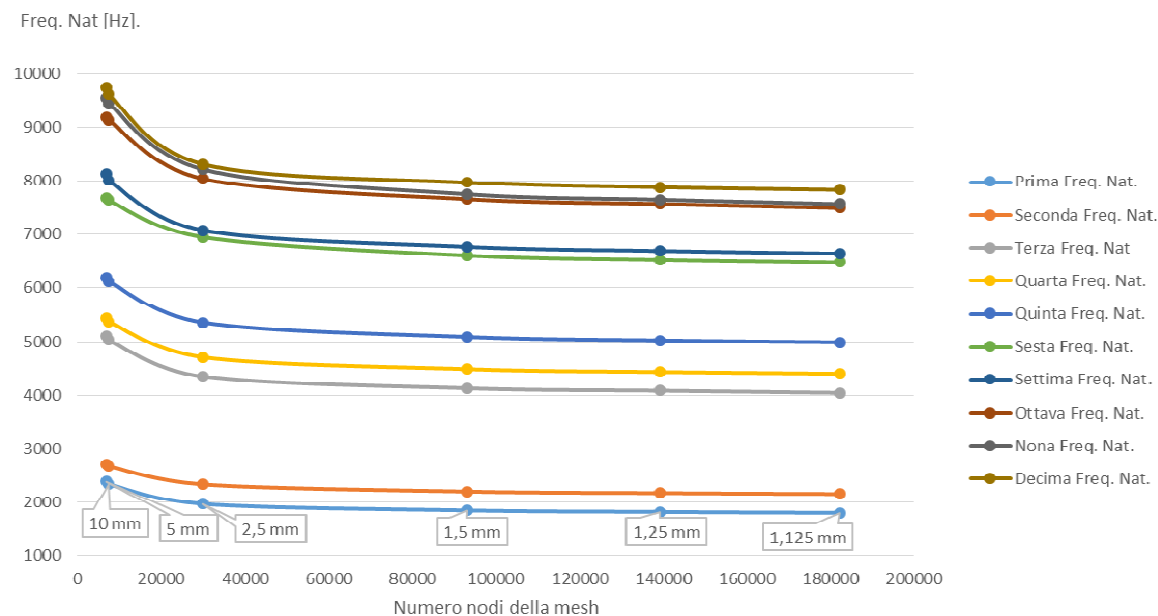
5 mm

2,5 mm

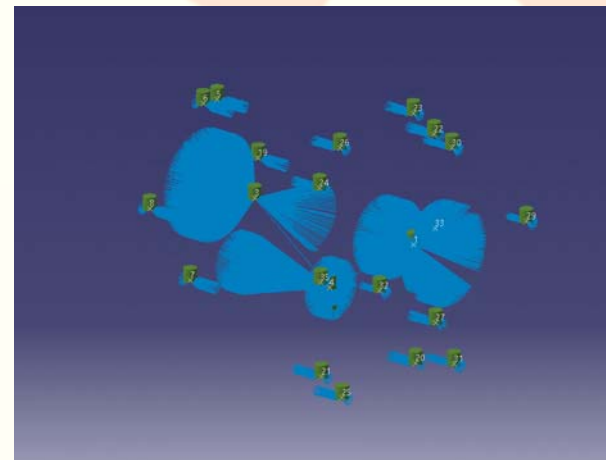
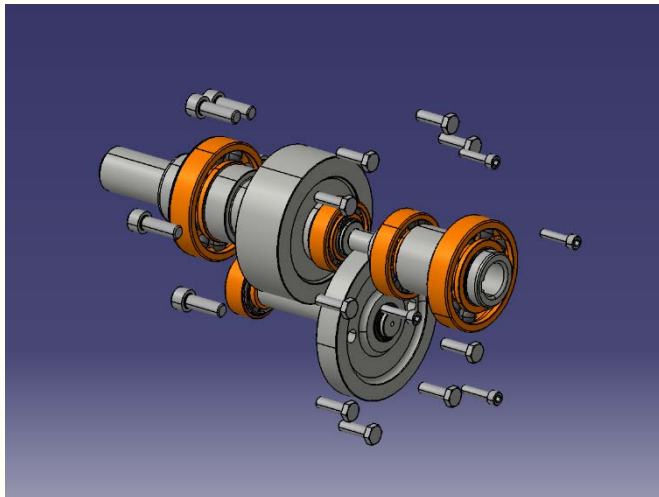
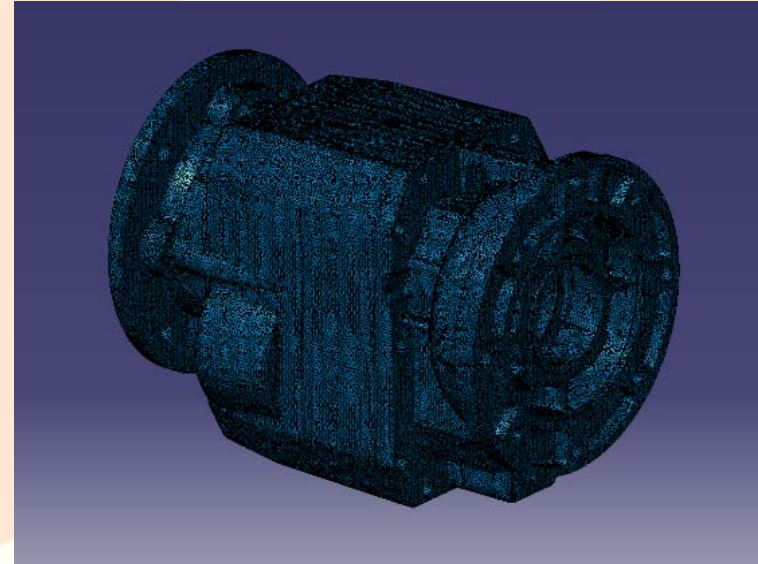
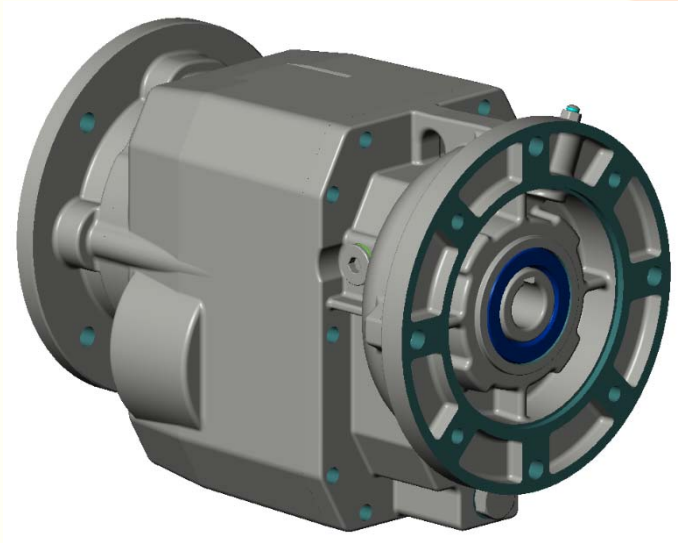
1,5 mm (Err% < 5%)

1,125 mm

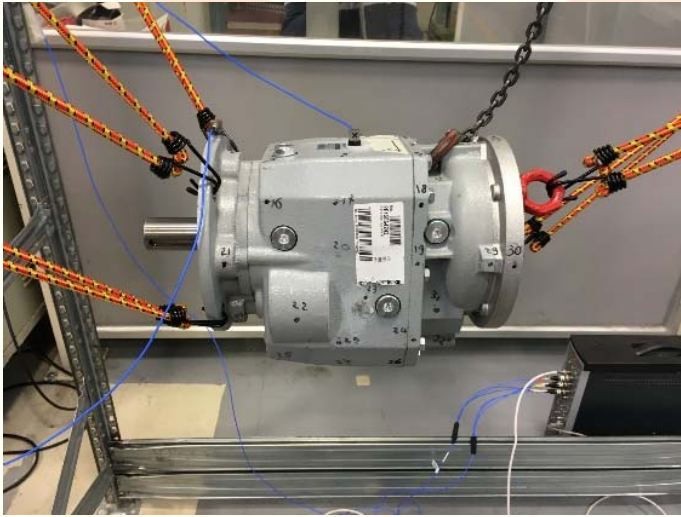
Analisi Convergenza componente 61109000b



Parametric FE model of gearboxes – Modelling



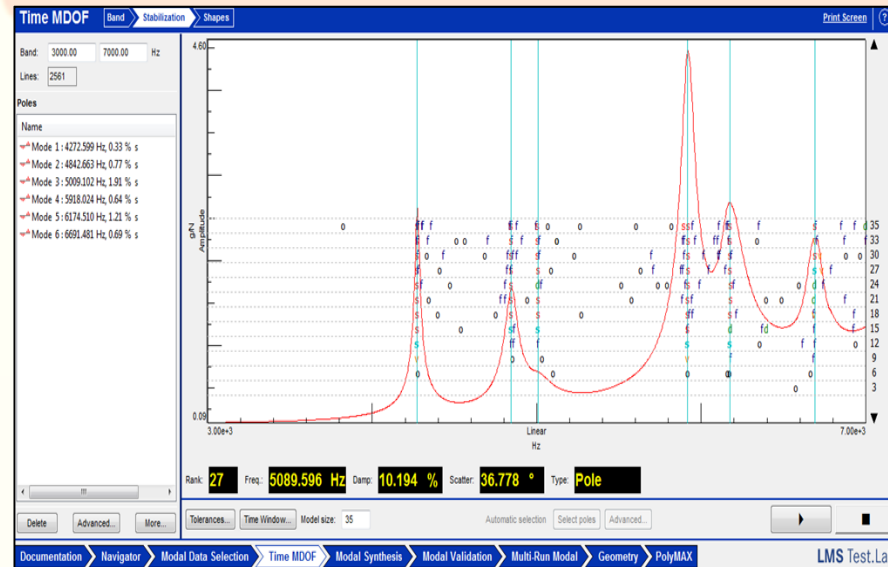
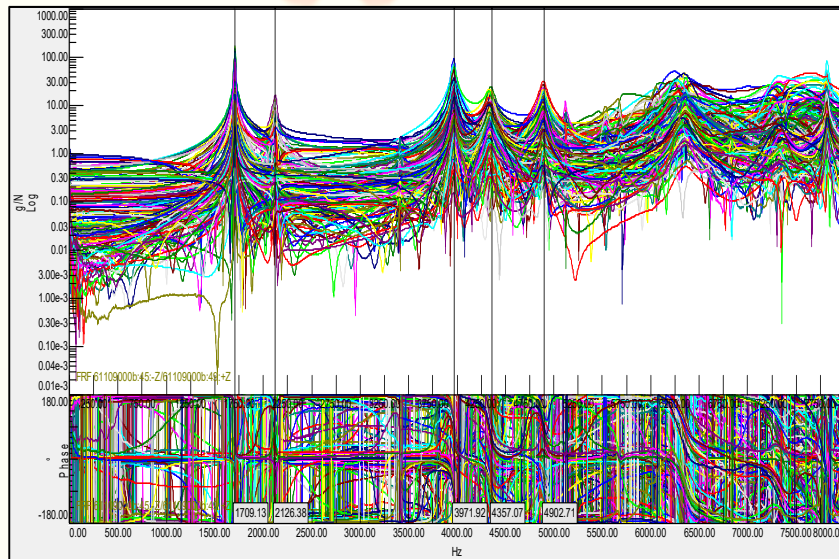
Parametric FE model of gearboxes – Validation



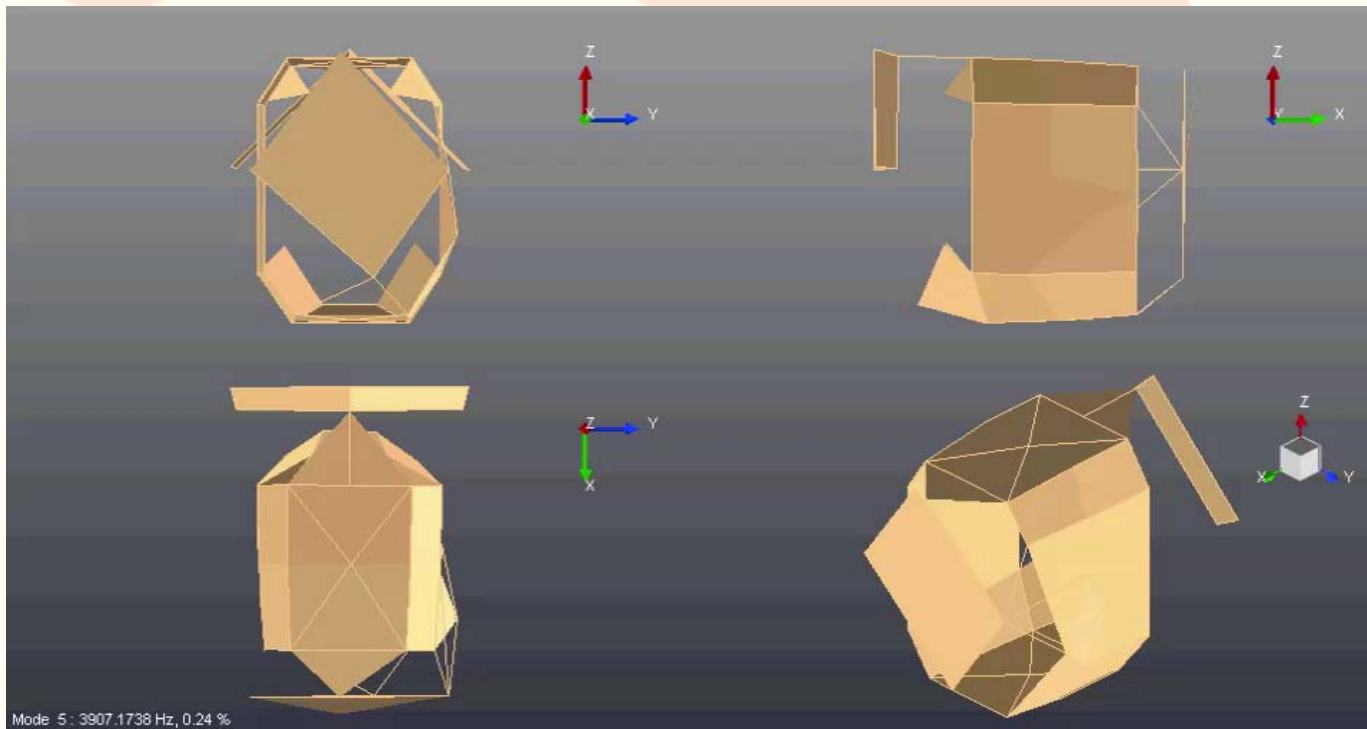
Validation based on
experimental modal analysis



Parametric FE model of gearboxes – Validation



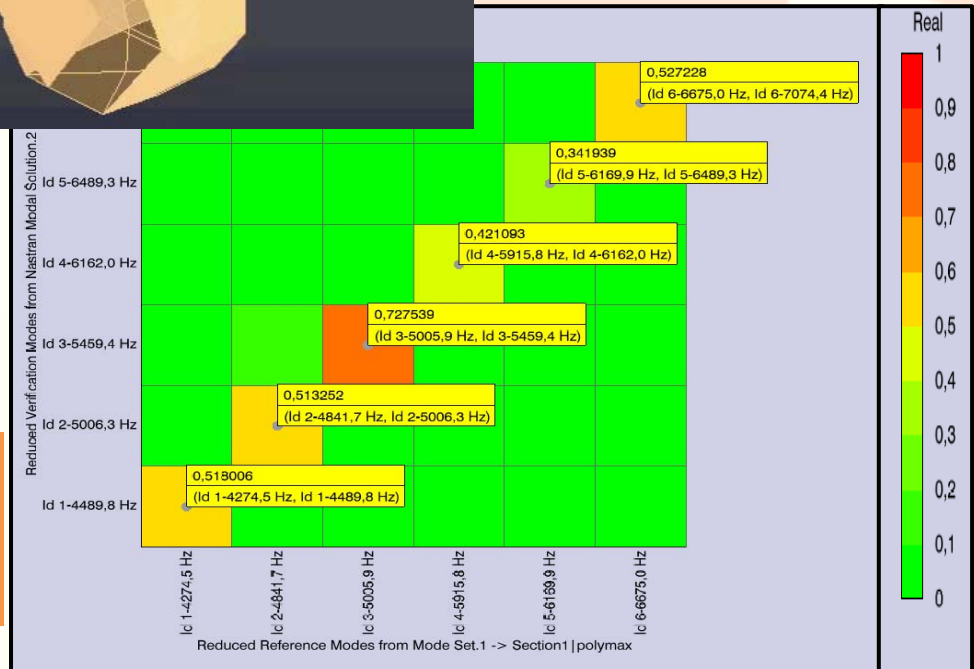
Parametric FE model of gearboxes – Validation



Natural mode shape

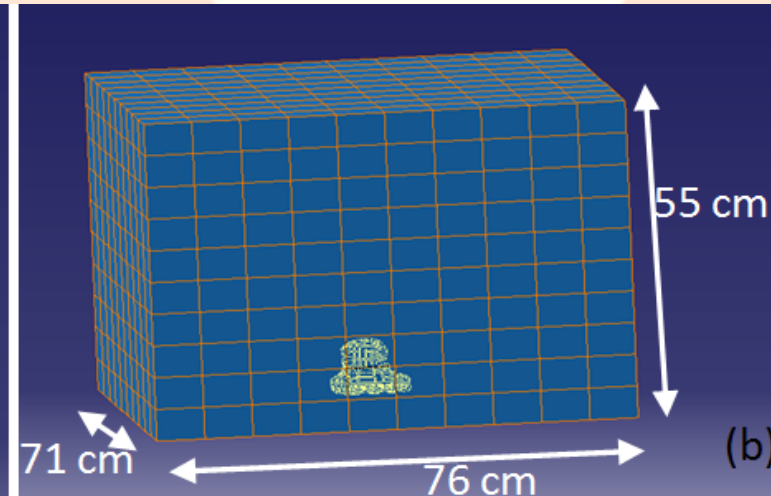
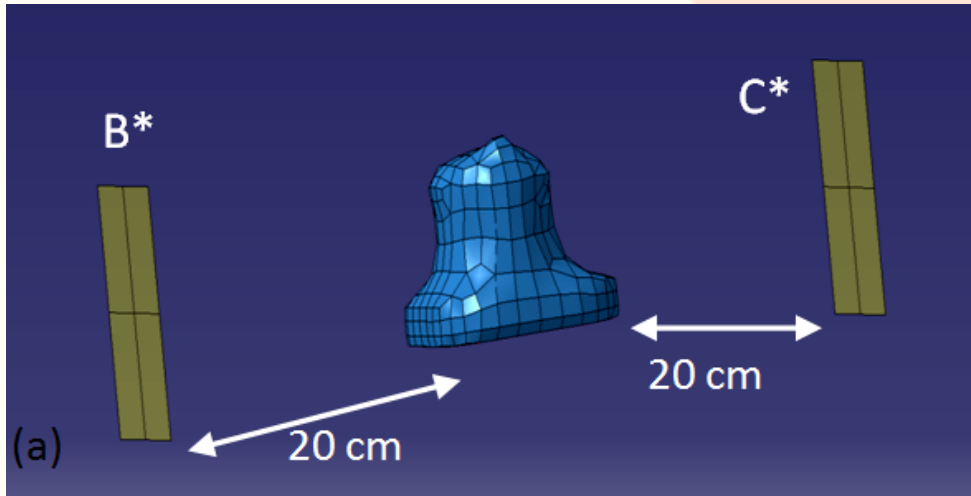
Mode 5: 3907.1738 Hz, 0.24 %

Validation based on MAC on entire gearboxes



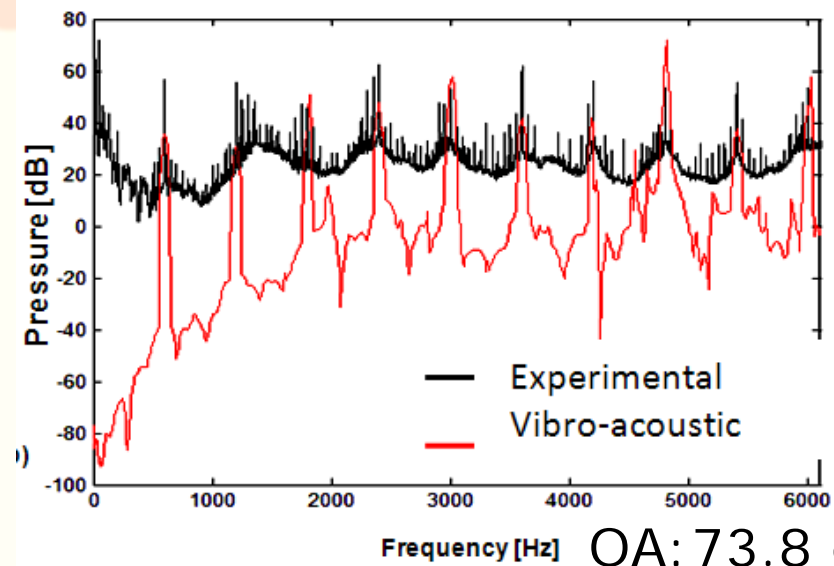
BE model of gearboxes

BEM indirect



Validated BE model:
Guidelines for acoustic
radiation reduction in
gearboxes

3000
rpm
Point B*



Frequency [Hz] OA: 73.8 dB

OA: 74.4 dB

Sound Quality Analysis of gearboxes

Results of BE model
or experimental data



Matlab/Octave

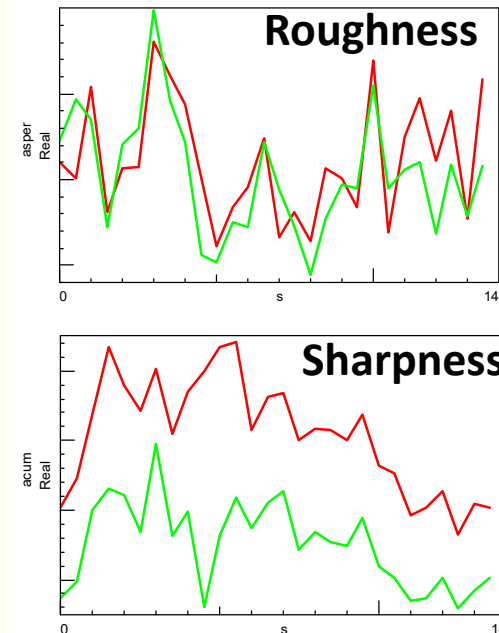
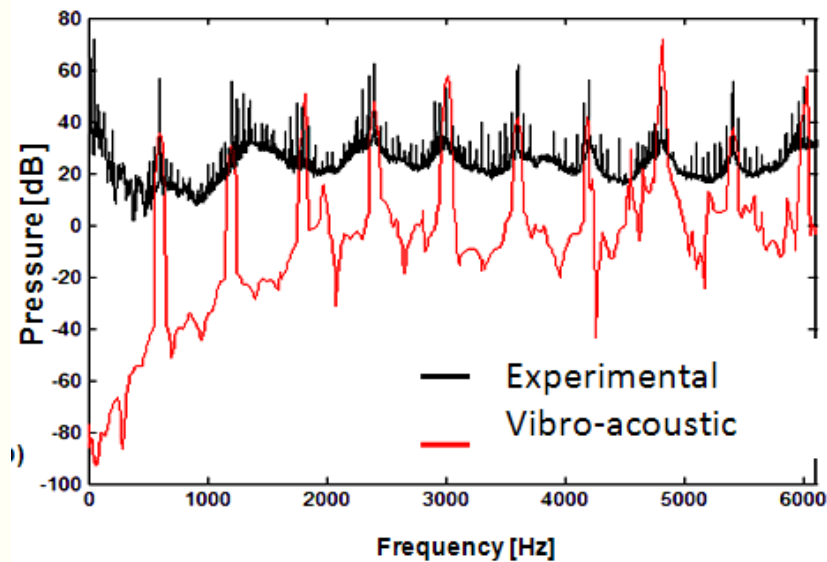


NVH Metrics:

- Loudness
- Sharpness
- Roughness
- Impulsiveness
- Modulation index



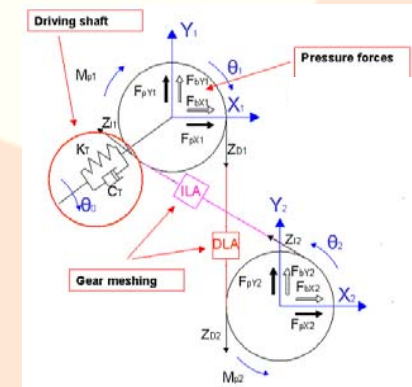
Sound quality of
gearboxes by using
numerical or
experimental data



Conclusions: A Software Portfolio for NVH Optimization of Gearboxes

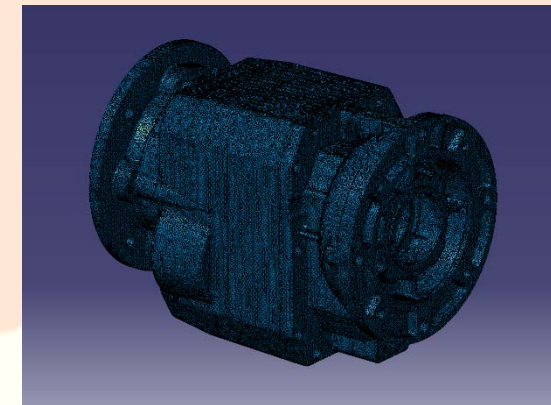
Parametric LP model of gearboxes

Gear and Shaft vibration in operating condition
Variable forces on bearings and casing



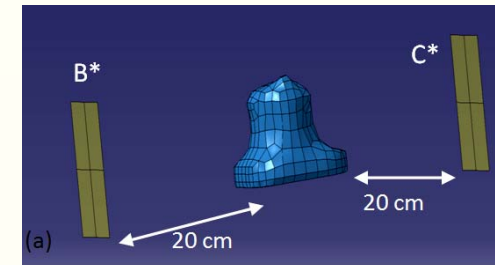
Parametric FE model of gearboxes

Casing vibration in operating condition



BE model of gearboxes

Acoustic radiation



Sound Quality Analysis of gearboxes

Acoustic comfort metrics

Conclusions

- **Software portfolio for NVH optimization of gearboxes:**
 - FE modelling
 - LP modelling
 - BE modelling
 - Sound quality analysis
- **All the tools have been experimentally assessed**
- **The methodology can be applied to every gearboxes**

Thanks for your kind attention

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