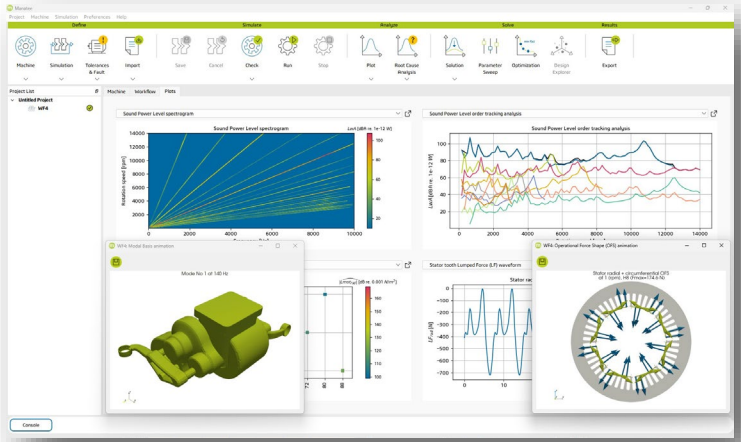
DASSAULT SYSTEMES

SIMULIA MANATEE

INTRODUCTION TO E-NVH SOFTWARE SERVICES

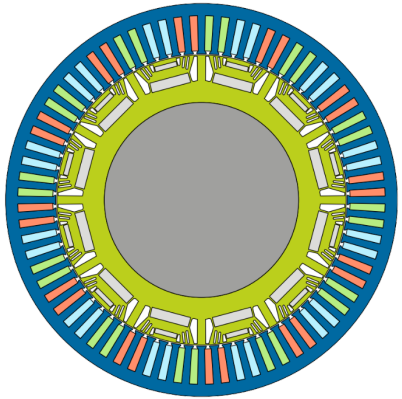
CONTROLLING MAGNETIC NOISE & VIBRATIONS OF ELECTRIC MACHINES AND DRIVES FROM CONCEPT TO PRELIMINARY DESIGN PHASE



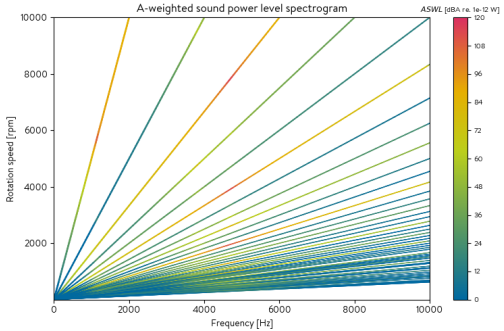
3DEXPERIENCE®

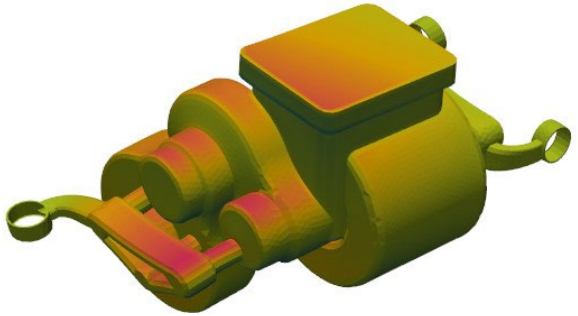
SOFTWARE SERVICES

From e-machine geometry
& control parameters…



… to electric drive level
electromagnetic noise and vibration





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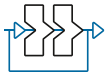
MANATEE IS A PIONEERING COLLABORATIVE SOFTWARE

Manatee is a collaborative CAE environment specialized in the **assessment and control of acoustic noise and vibrations due to Maxwell forces** (“e-NVH”) in electric machines and drives.



Predefined simulation workflows from basic to detailed design phases

Fast and accurate calculations adapted to each engineering field

Robust design based on faults and tolerance simulation

Root cause analysis using powerful post-processing

Mitigation techniques with specialized design environments

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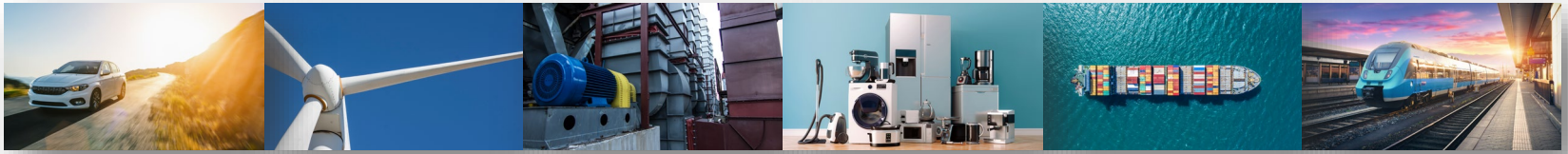
INSPIRED BY A WIDE E-NVH CONSULTING EXPERIENCE

- Up 40 dB acoustic noise reduction after redesign based on EOMYS consulting activities
- e-NVH models successfully applied on more than 170 industrial cases
- Wide range of topologies (IPMSM, SCIM, WRSM, DFIG, inner & outer rotor)
- Wide range of applications (from W to MW range, from 5 rpm to 150 000 rpm, from 10mm to 10m diameter)



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REDUCING DEVELOPMENT TIME OF ELECTRICAL SYSTEMS

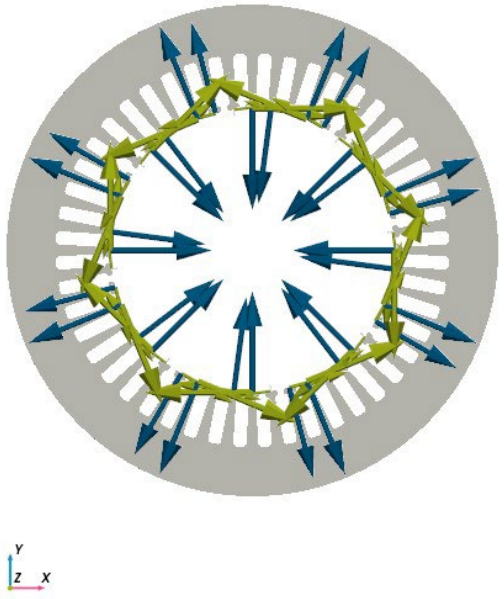
Fast simulation set-up of multiphysic model couplings, **quick calculations** including **predefined post-processing**

Accurate variable-speed vibroacoustic assessment based on proprietary algorithms specialized on e-NVH

Simultaneous collaboration of different engineering fields during whole development cycle

Insightful visualization and troubleshooting tools to quickly implement the most relevant noise control actions

Stator radial + circumferential OFS
at 1 (rpm), H8 (Fmax=174.6 N)



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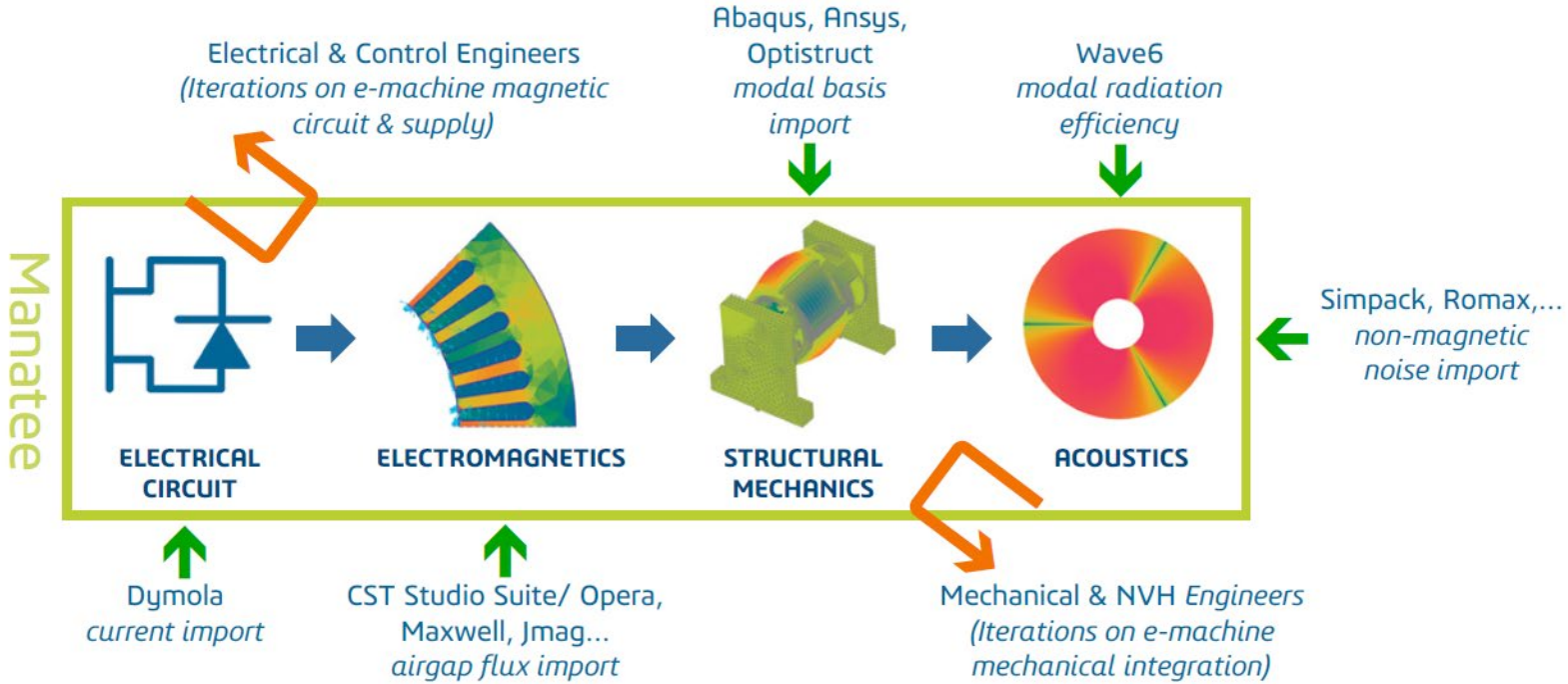
INTEGRATING READY-TO-USE MULTIPHYSIC MODELS

Standalone multiphysic capabilities including flexible import options



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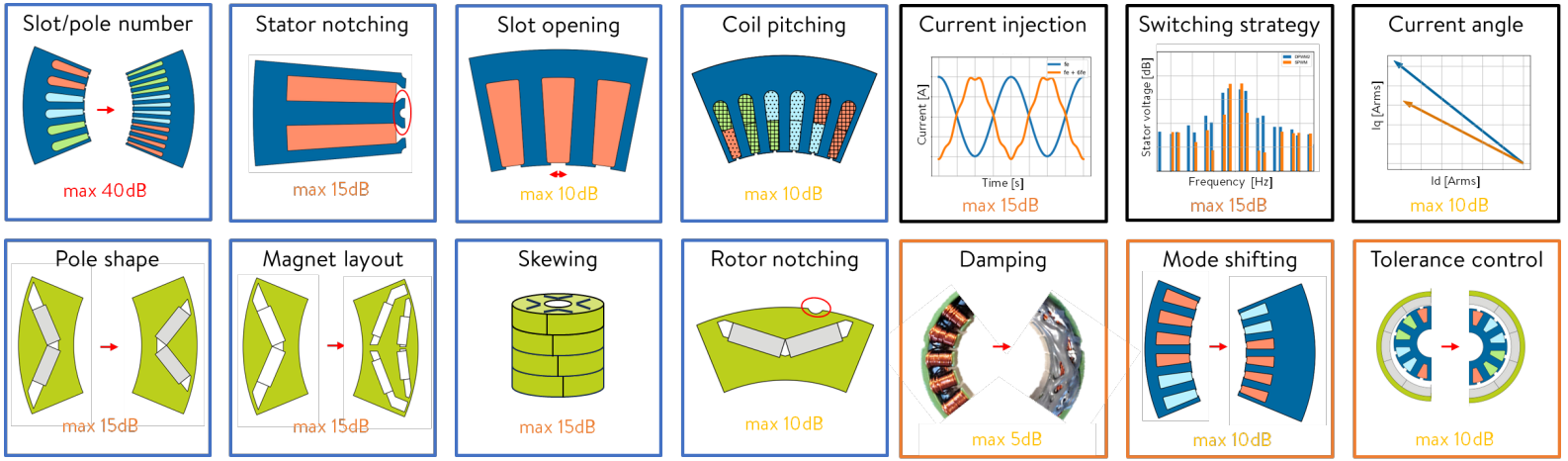
PROVIDING EXTENSIVE NOISE CONTROL TECHNIQUES

Predefined NVH mitigation techniques for electromagnetic, control, mechanical & NVH engineers



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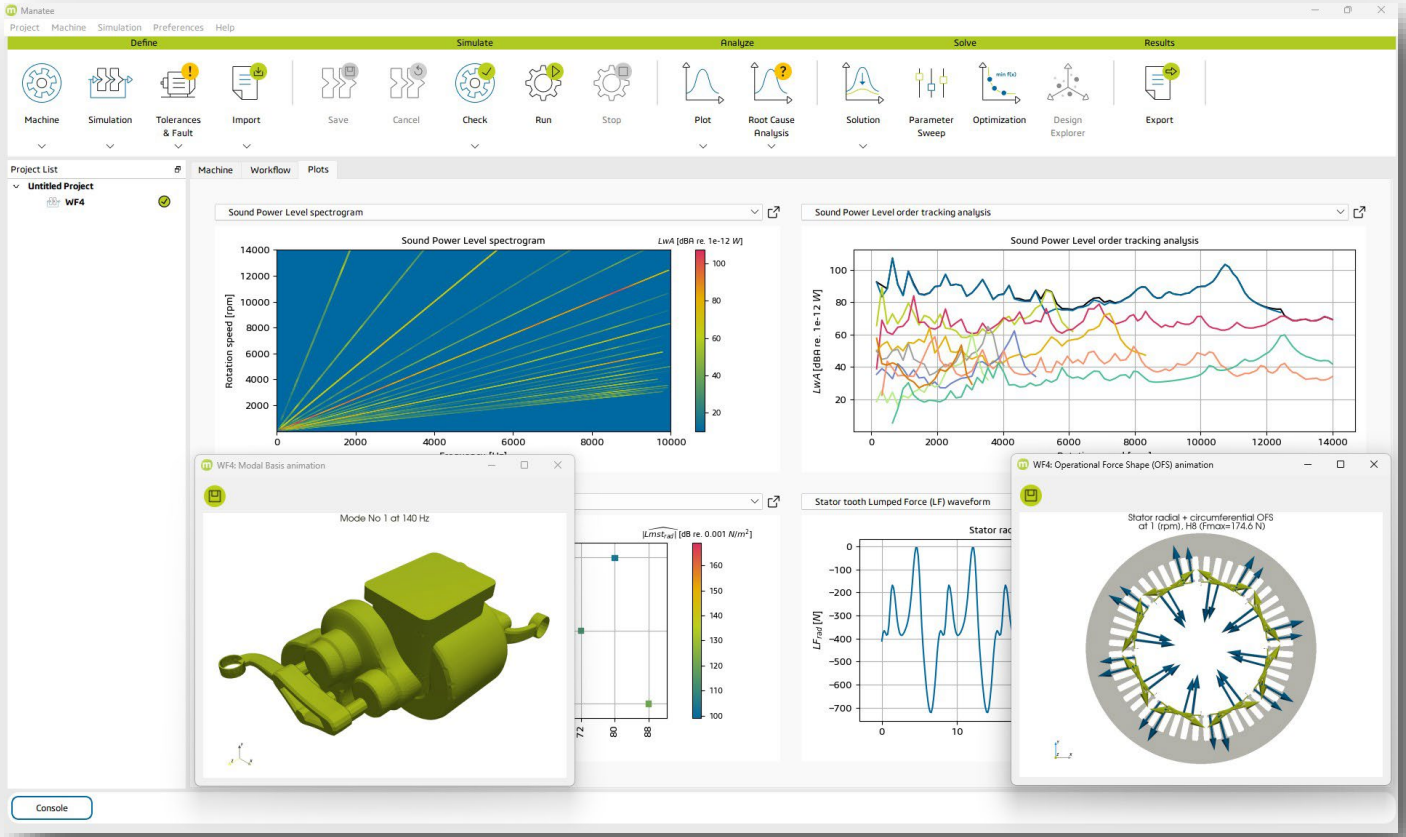
THROUGH A USER-FRIENDLY GUI DESIGNED FOR ALL ENGINEERS



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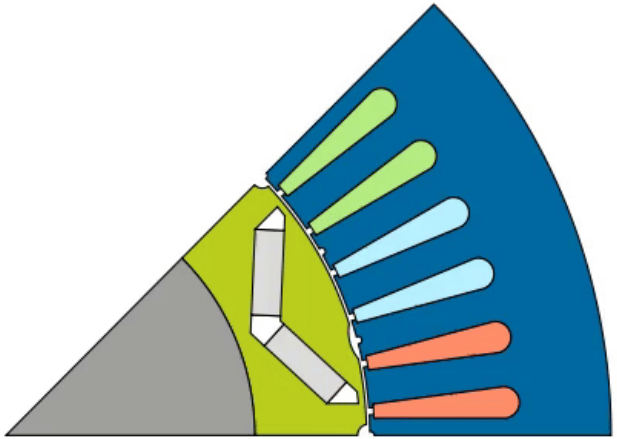
LICENSING & REQUIREMENTS

LICENSING

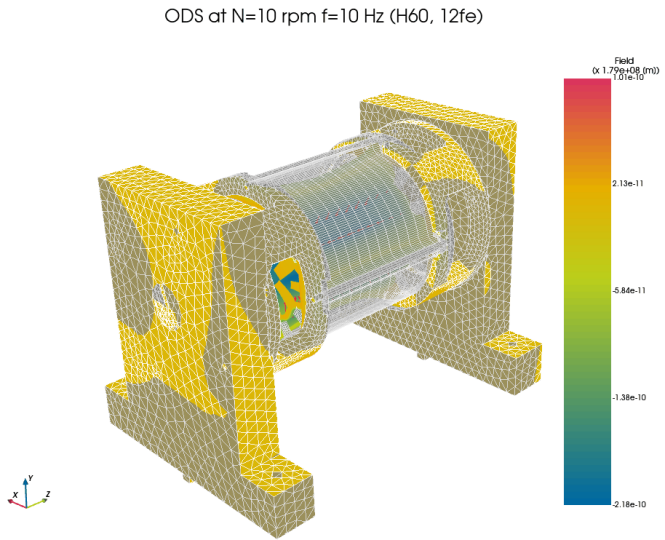
- SIMULIA Manatee licensing offer consists of
  - node-locked or floating licenses
  - “batch mode” available for all licenses
  - HPC option to run several jobs in parallel



- All leasing solutions come with a **technical training**:
  - training on e-NVH basics (magnetic forces, structural modes, resonances…)
  - Manatee software (applied to Customer case)

MANATEE TECHNICAL REQUIREMENTS

- Windows 8/10 64-bit architecture (includes parallelization of calculations)
- For cloud-based licenses (node-locked or floating licences): internet connection
- 16 Go RAM & 10 Go disk space recommended
- 3D FEA modal basis import with up to 6 million nodes & 1500 modes under 32 Go RAM



CONCLUSION

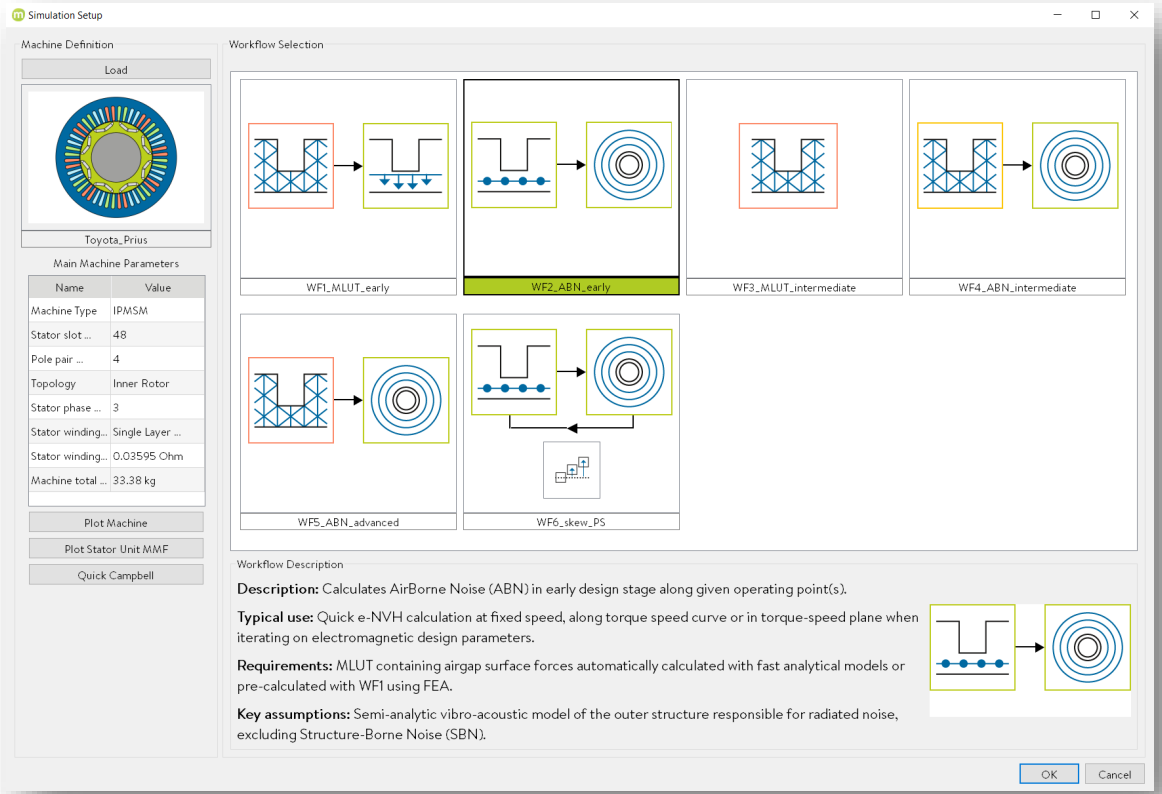
- **Pioneering software** specialized in the assessment of magnetic forces, vibrations and acoustic noise
- Only simulation & analysis environment combining **e-NVH troubleshooting and mitigation tools**
- Designed to **reduce electric system development time & costs** by improving **electrical, mechanical, acoustic, NVH test engineers** collaboration in a **modern, user-friendly GUI**
- Developed based on a extensive consulting experience of e-NVH (+200 e-machines analyzed) and R&D

FURTHER DETAILS

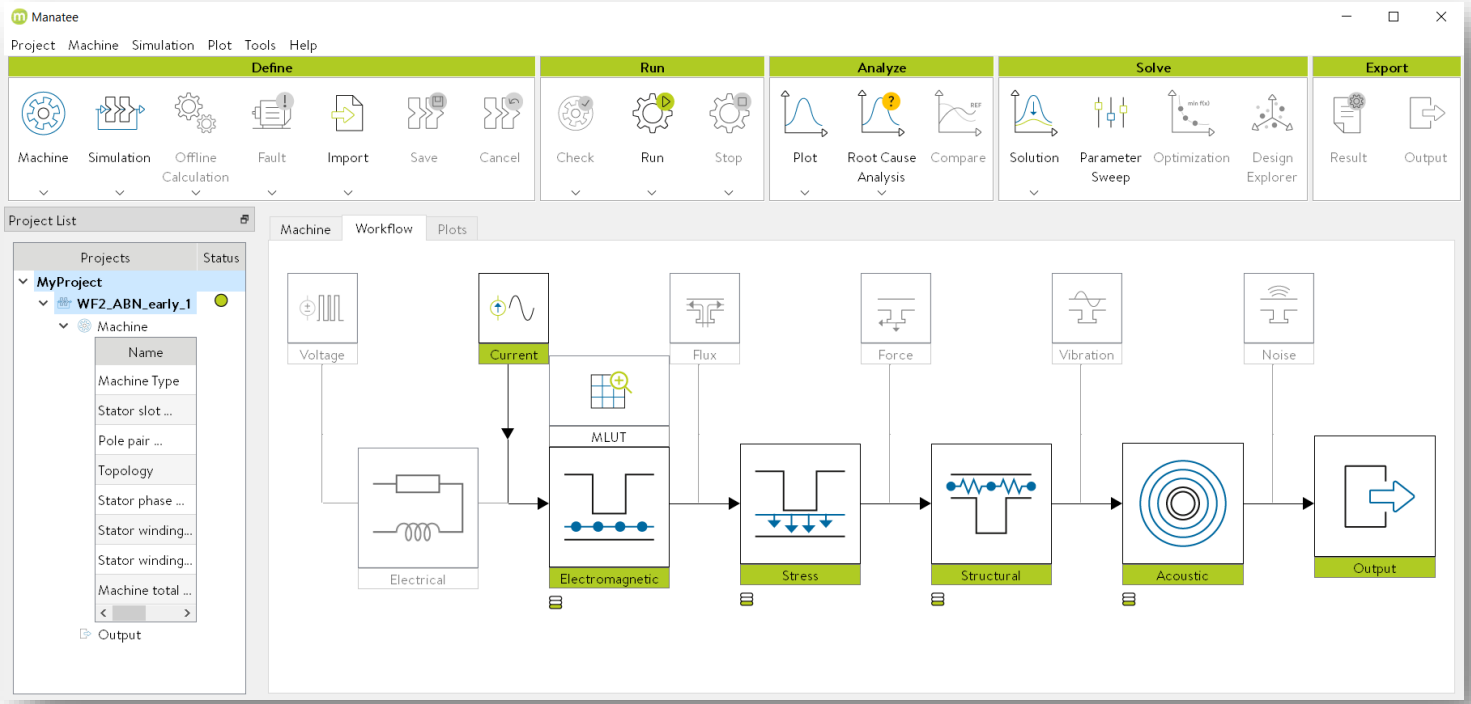
To access more information on SIMULIA Manatee & e-NVH (including free learning contents) please join SIMULIA User Community under https://www.3ds.com/products/simulia/user-communities

DETAILED FEATURES

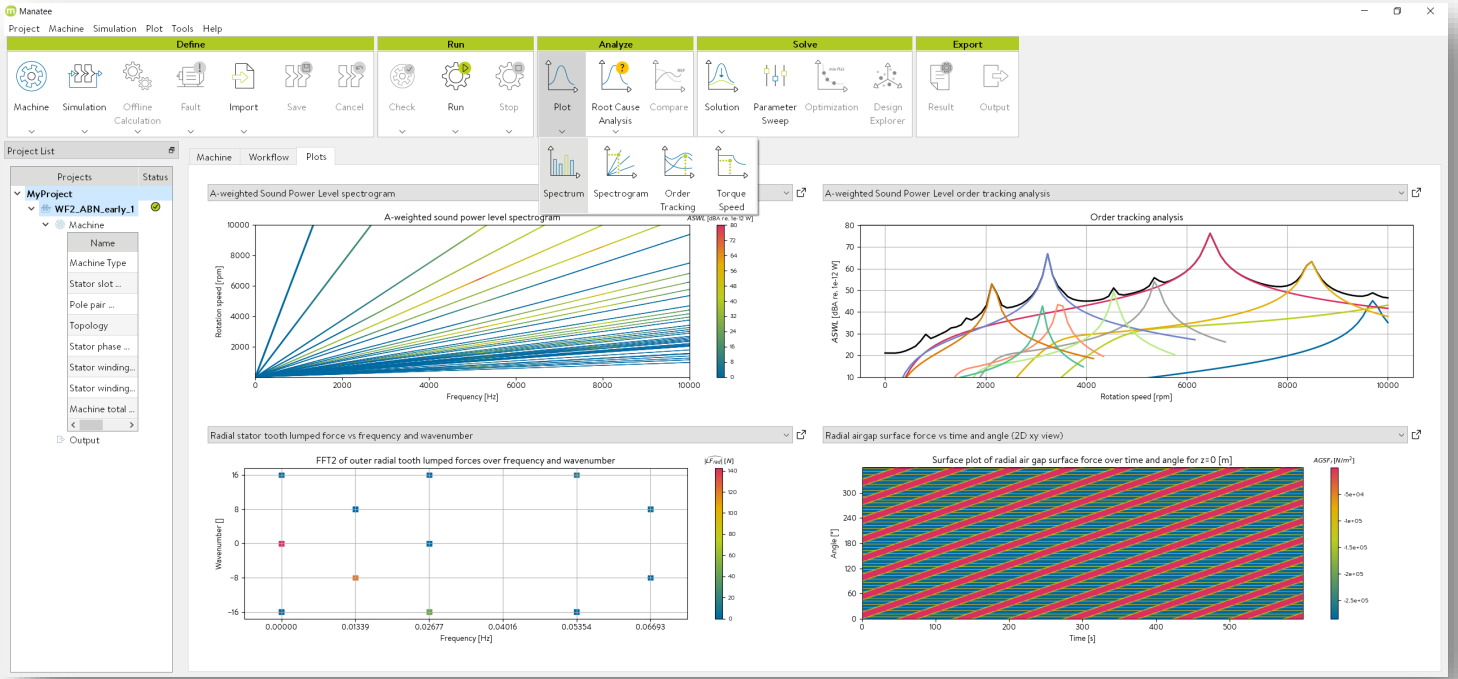
E-NVH PREDEFINED WORKFLOWS



E-NVH PREDEFINED WORKFLOWS



E-NVH PREDEFINED GRAPHICAL POST PROCESSING



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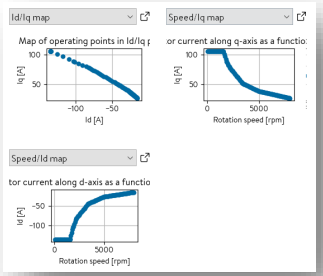
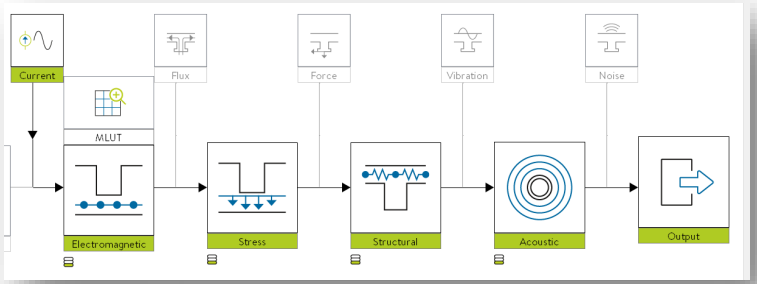
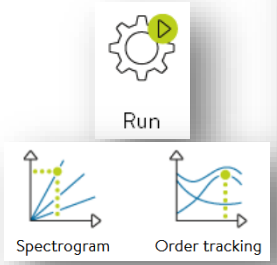
E-NVH CALCULATION ALONG MAX TORQUE SPEED CURVE

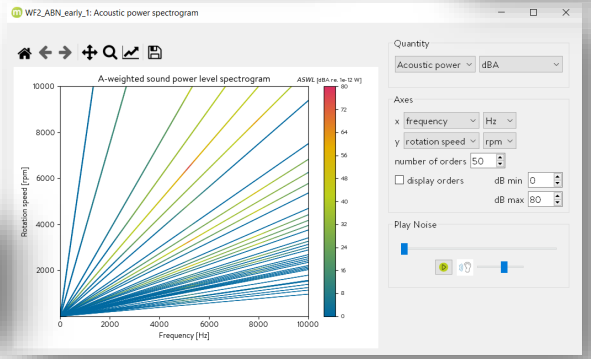
1. **Define variable speed current control law**

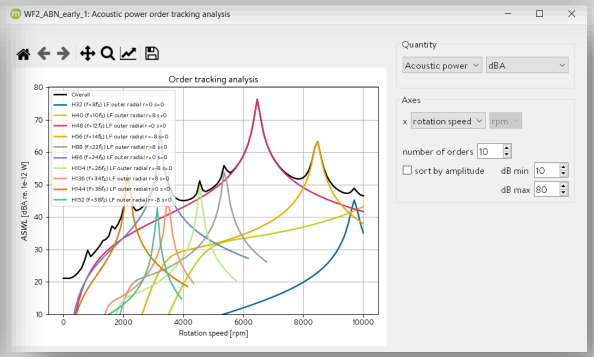




2. **Run & plot**

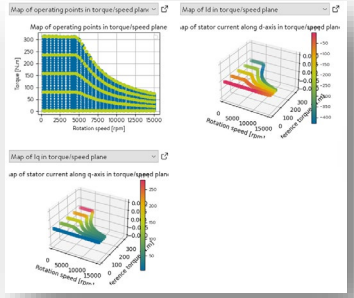


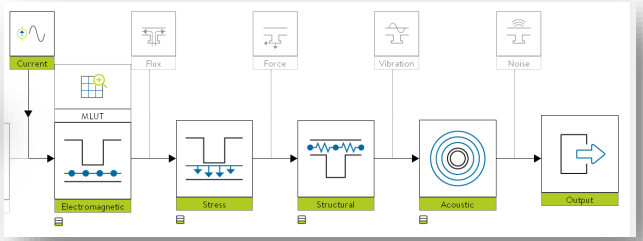




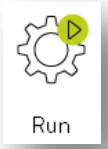
E-NVH CALCULATION ON WHOLE TORQUE-SPEED PLANE

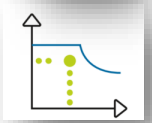
1. **Define variable speed current control law**

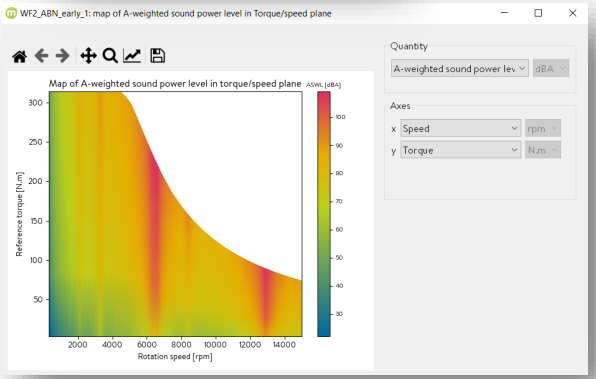




2. **Run & plot**







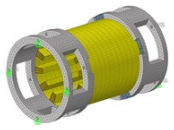
ELECTROMAGNETIC VIBRATION SYNTHESIS

Faster than direct vibration calculation at variable speed/torque, with more physical insights

Unit magnitude magnetic load vector harmonics (r=0, ±1, ±2 ...)
radial + tangential + moments applied to stator + rotor

STRUCTURAL CHARACTERIZATION

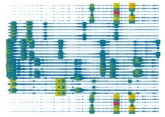
STRUCTURAL MODEL



3D external FEA software (rotor+stator)
or Manatee stator structural models

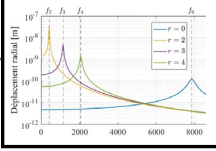
Modal force projection

UNIT MODAL FORCE MATRIX



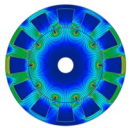
Modal expansion

VIBRATION FRF



CALCULATION OF OPERATIONAL LOADS

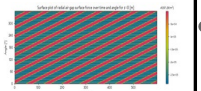
MAGNETIC MODEL



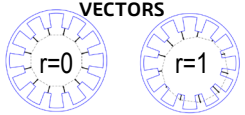
2D or 2.5D external FEA software
or Manatee magnetic models

Magnetic flux distribution

MAGNETIC FORCE CALCULATION

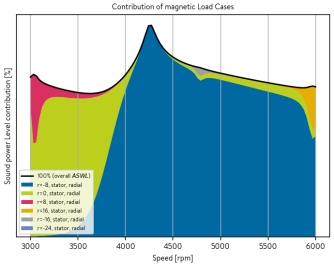


HARMONIC LOAD VECTORS



manatee by EOMYS

ELECTROMAGNETIC VIBRATION SYNTHESIS



AIR-BORNE NOISE

Stator Load Case contribution
Structural mode contribution
Noise-induced by stator torque ripple & UMP

STRUCTURE-BORNE NOISE

Rotor Load Case contribution
Structural mode contribution
Noise-induced by rotor torque ripple & UMP

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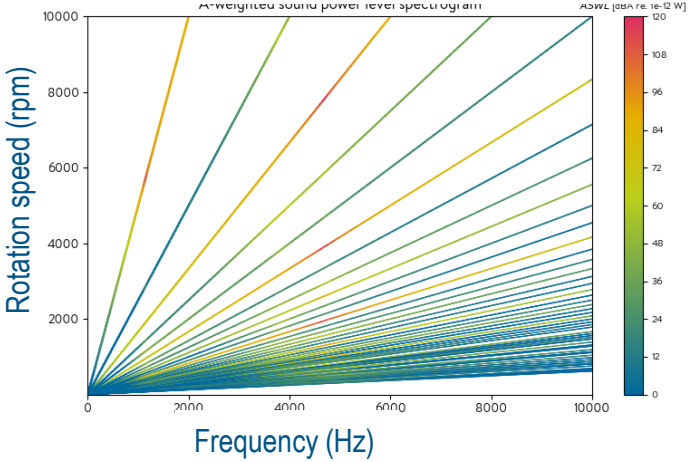
ACCELERATED E-NVH CALCULATIONS BASED ON MLUT

Calculation along torque speed curve

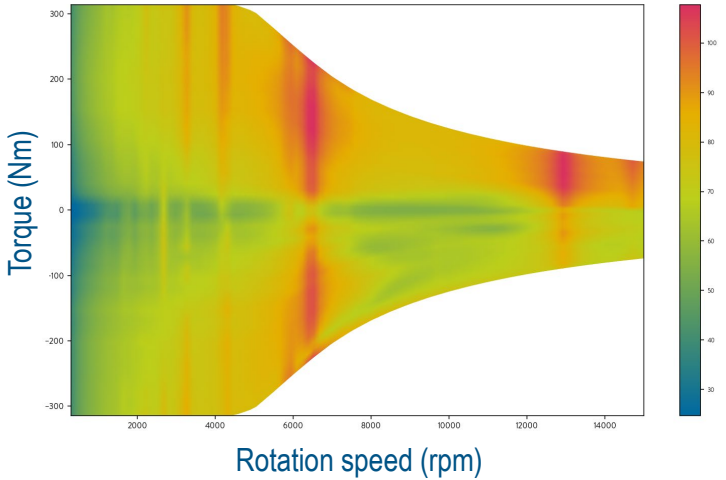
A-weighted sound power level spectrogram



- **~ 200 Operating Points**
- <2min (depends on machine symmetries and OP)

Calculation on torque speed plane

Map of A-weighted sound power level



- **~ 2000 Operating Points**
- <20 min(depends on machine symmetries and OP)

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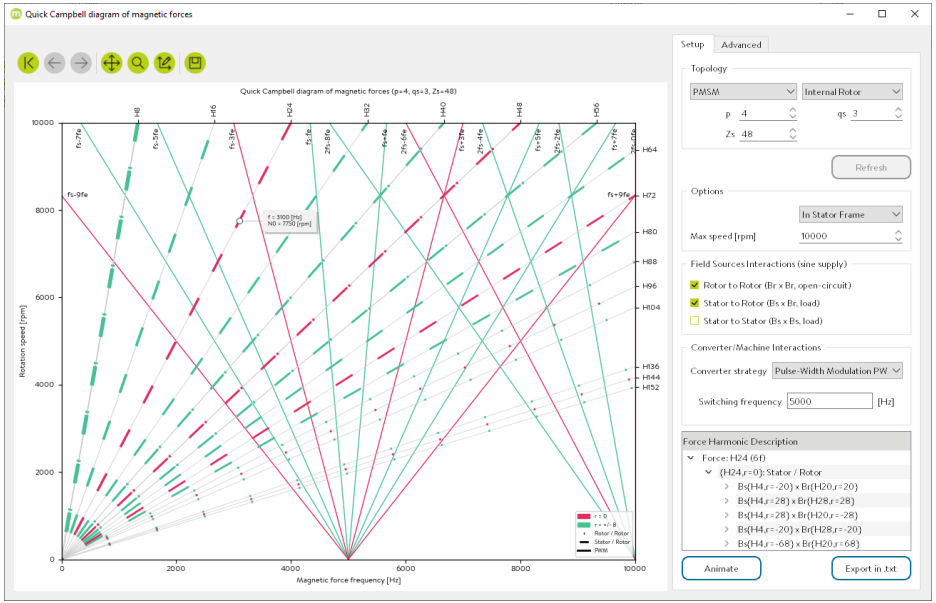
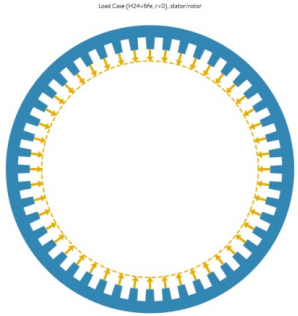
E-NVH ROOT-CAUSE ANALYSIS WITH CAMPBELL DIAGRAMS

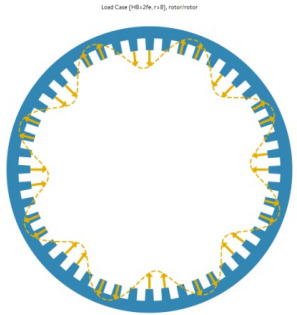
Automated offline Campbell diagram based on load state, topology and slot/pole combination:

Example of a 48s8p PMSM (Zs=48, p=4)





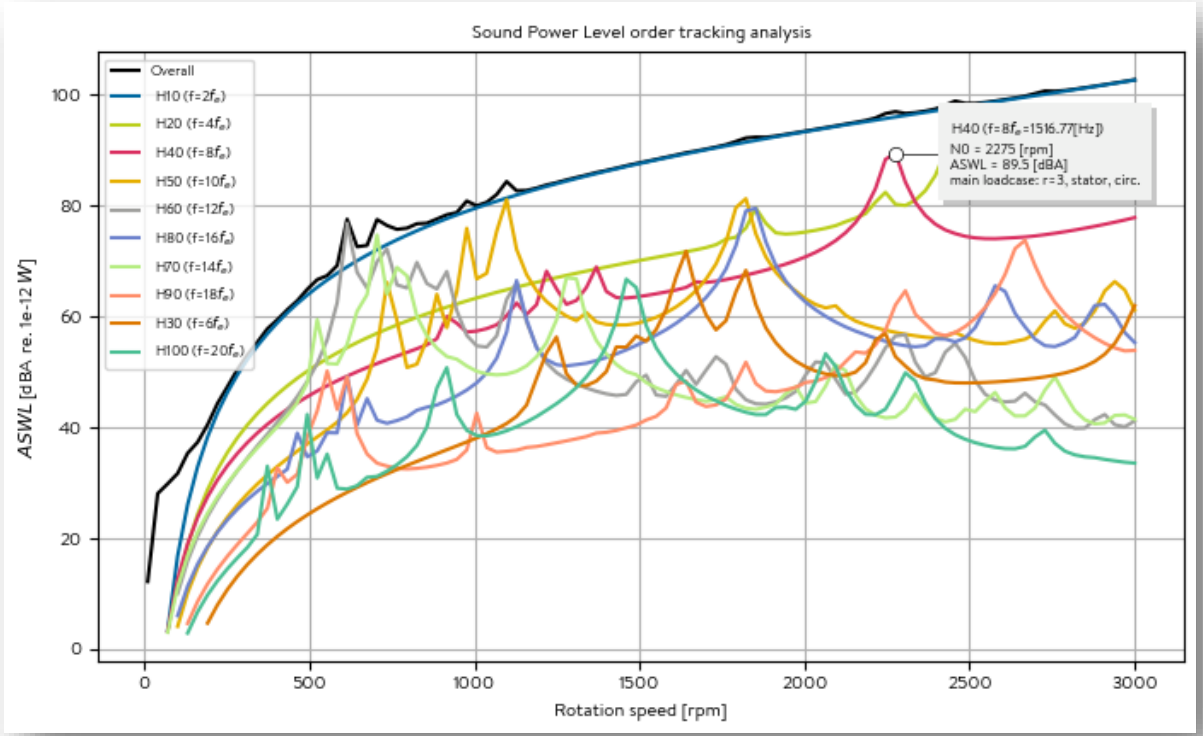
wavenumber
r=0



wavenumber
r=+/-8

Feature tutorial video

ORDER TRACKING BASED ON AUTOMATED IDENTIFICATION OF MAIN FORCE WAVENUMBERS



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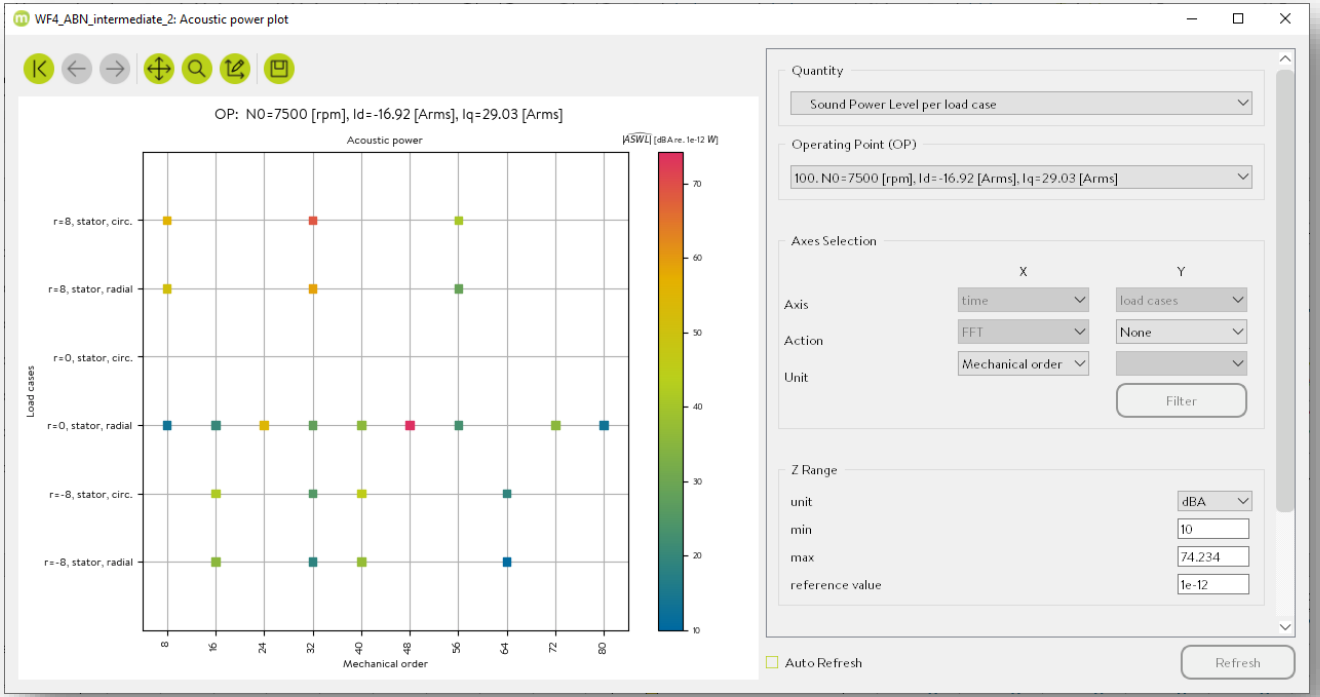
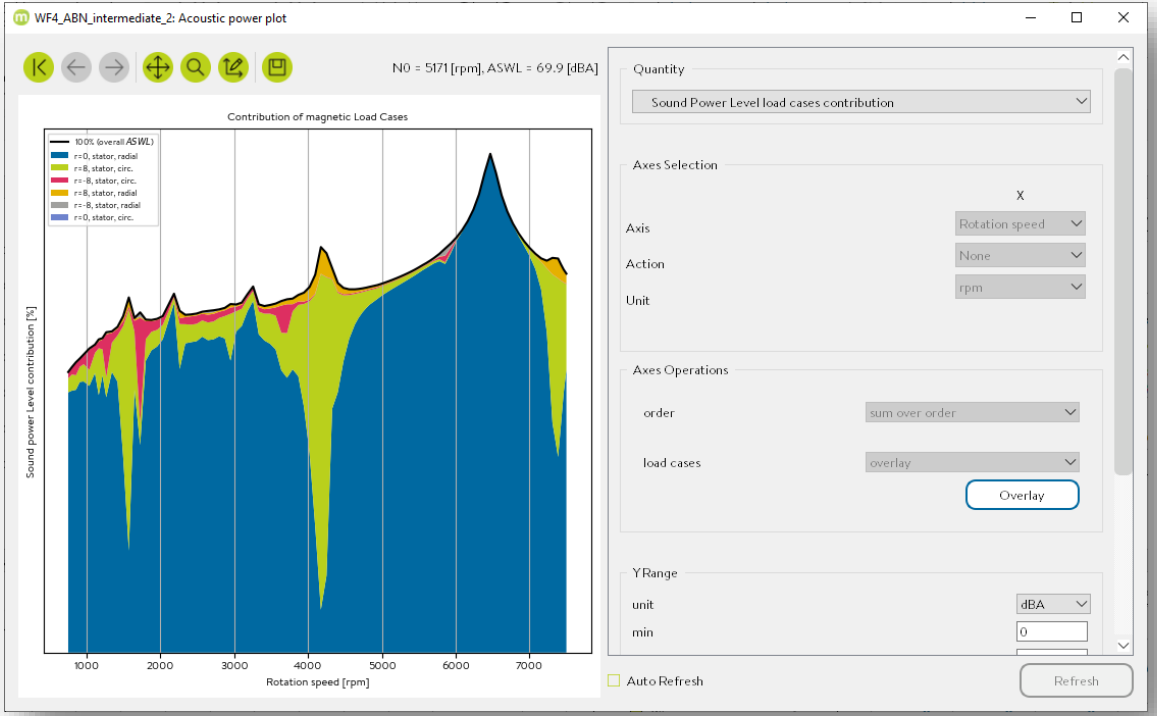
E-NVH ROOT-CAUSE ANALYSIS WITH ADVANCED PLOTS

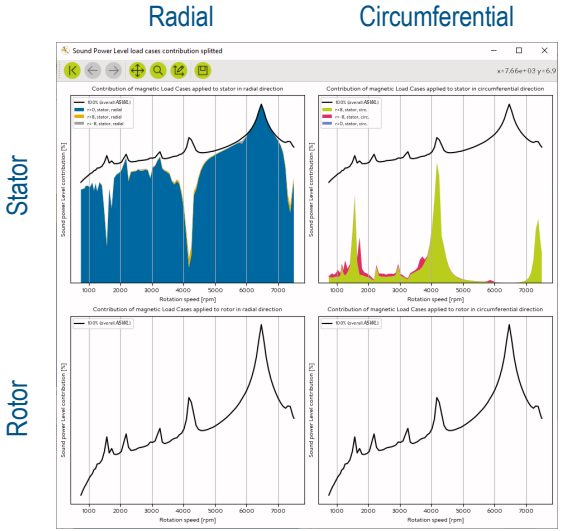
Automated Load Case contribution at fixed operating point



E-NVH ROOT-CAUSE ANALYSIS WITH ADVANCED PLOTS

Automated Load Case contribution at variable operating point

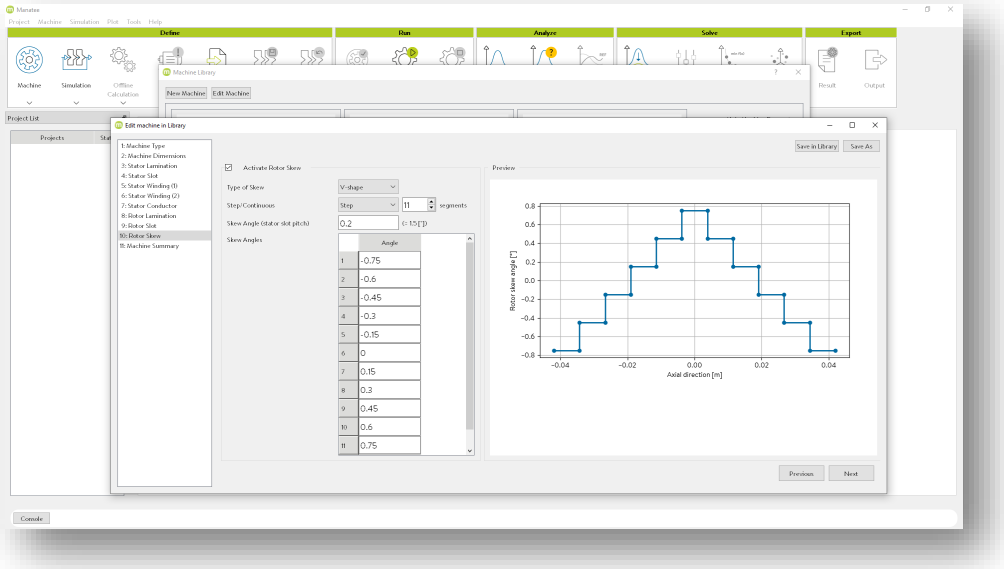




E-NVH MITIGATION WITH ROTOR SKEW

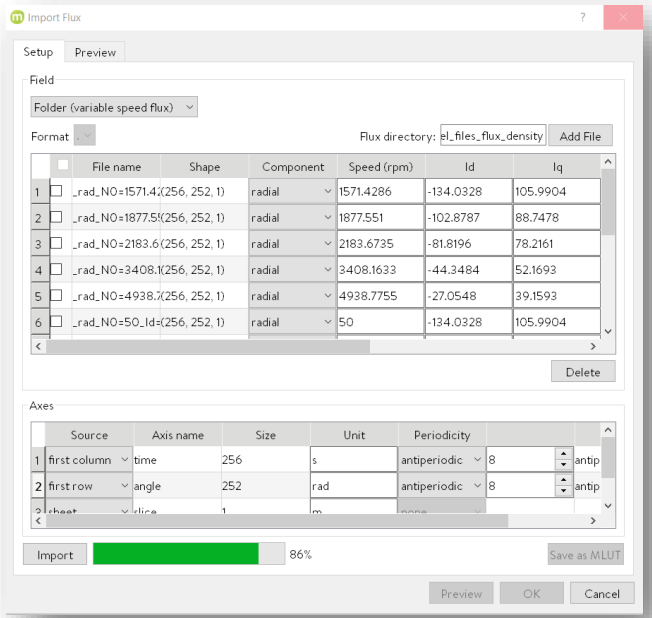
Manatee includes built-in design environment of skewing technique

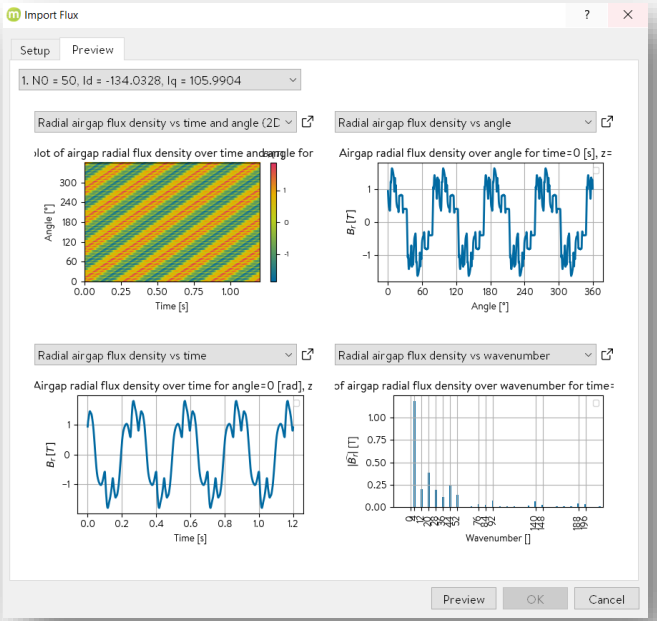
- Possibility to define any rotor skew shape
- Automated **parameter sweep** of NVH & torque ripple function of **skew** angle



IMPORT OF FLUX DENSITY DISTRIBUTION

Import of third-party flux density distribution (fixed speed, variable speed, multi-slice) in Excel format





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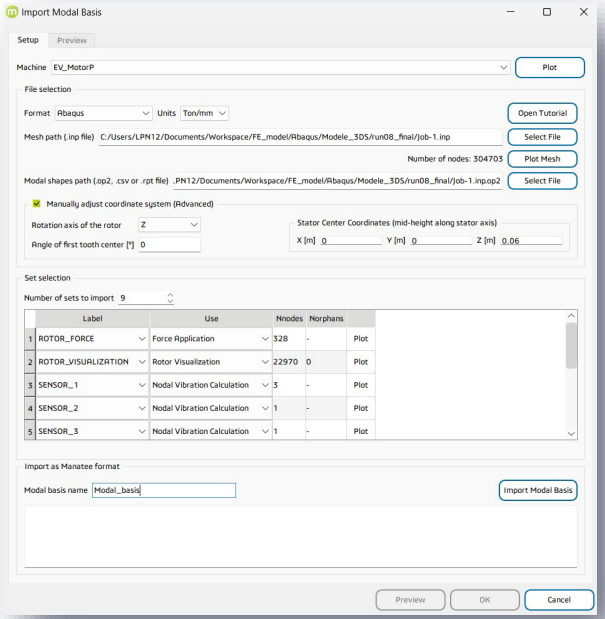
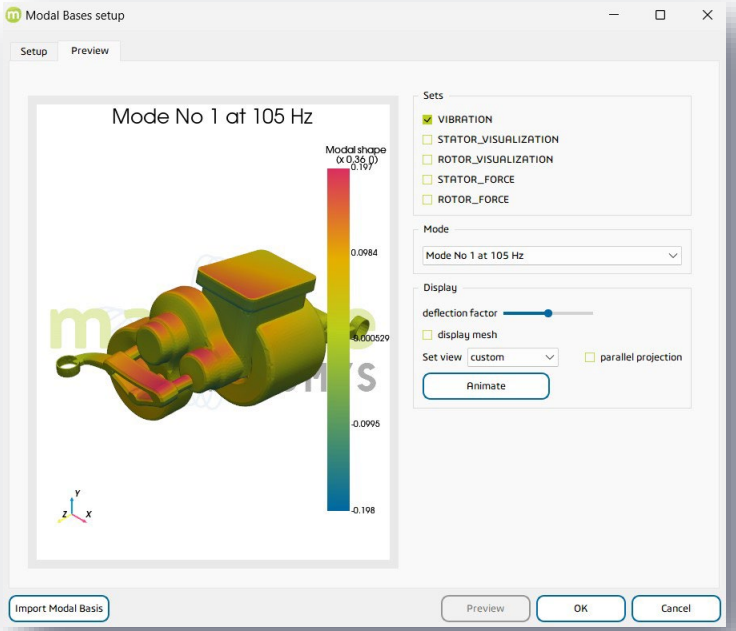
IMPORT OF MODAL BASIS

- Import of third party modal basis on a structural mesh in different formats: .unv(o), .disp + .fem (Optistruct), .txt + .mesh (Ansys), .OP3 etc.





DISCOVER MORE ON 3DS.COM

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