



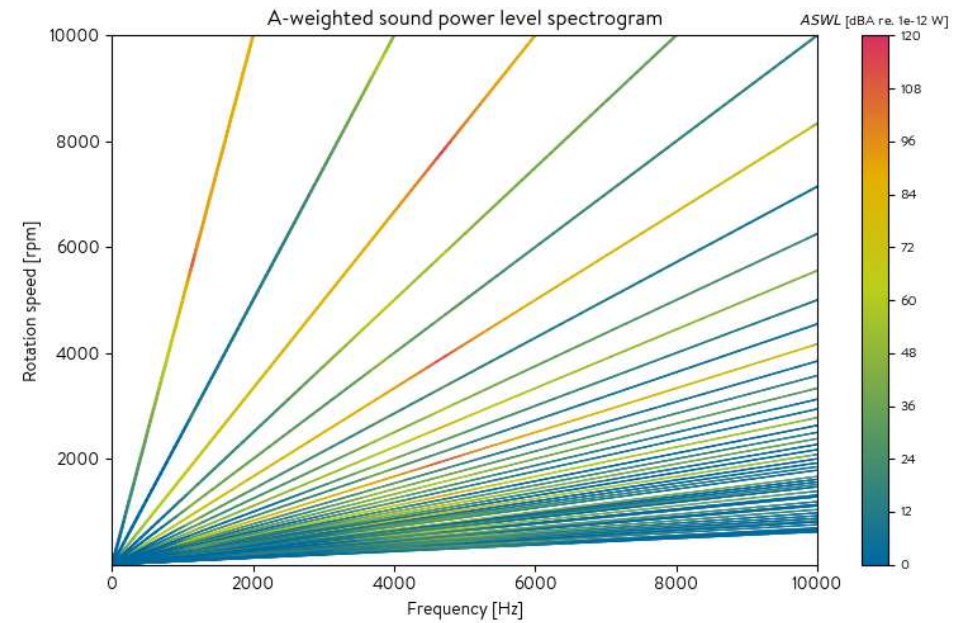
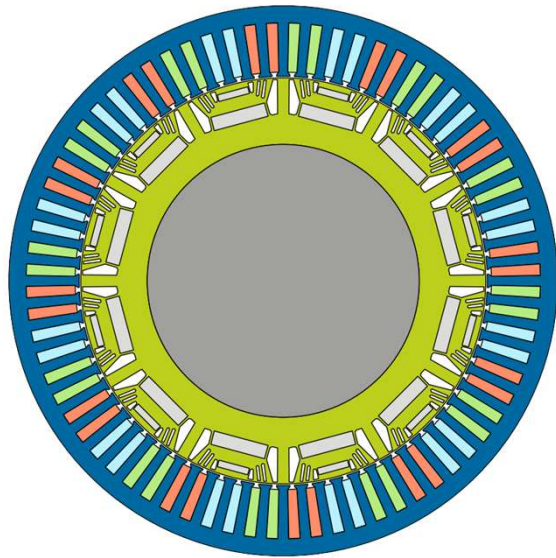
Introduction to Manatee® e-NVH software services

Improving e-NVH performances of electrical systems throughout their development lifecycle



SOFTWARE SERVICES

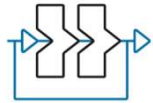
*From e-machine geometry
& control parameters...*



*... to system-level electromagnetic
noise and vibration*

Manatee is a pioneering collaborative software,

Manatee is the only collaborative CAE platform specialized on the assessment and control of acoustic noise and vibrations due to Maxwell forces (“e-NVH”) at all design stage of electrical systems.



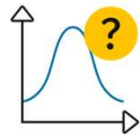
Predefined simulation workflows from basic to detailed design phases



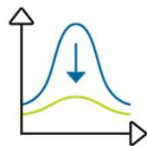
Fast and accurate calculations adapted to each engineering field



Robust design based on faults and tolerance simulation



Root cause analysis using powerful post-processing



Mitigation techniques with specialized design environments

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)



STELLANTIS



 GOLDWIND



Nidec



dyson



 **alconza**
Irizar Group



ALSTOM

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

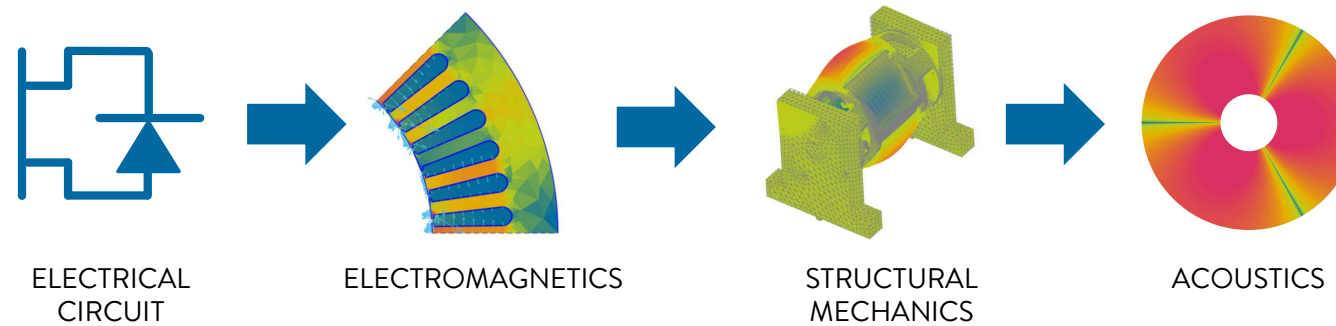


Simultaneous collaboration of different engineering fields
during whole development cycle



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

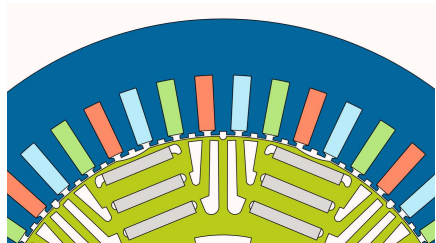
Integrating ready-to-use multiphysic models,



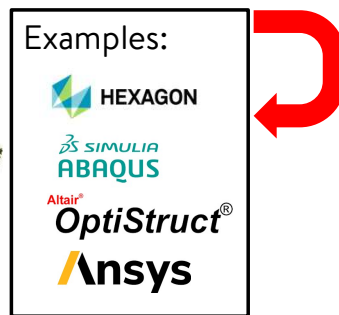
- Predefined coupling between physics
- Predefined simulation workflows with different speed Vs accuracy tradeoffs adapted to every design stage
- Automated set-up of numerical parameters to improve accuracy and accelerate calculations

Interfacing with third-party CAE tools at all design stages,

Iterations on e-motor
magnetic circuit & control
Air-borne noise
e-machine level



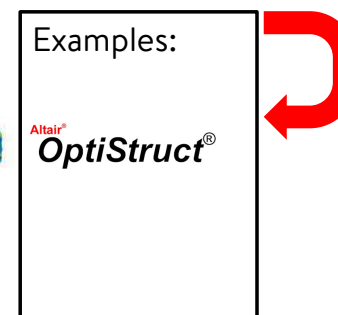
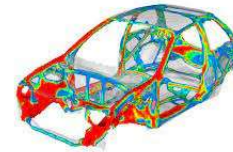
Iterations on e-motor mechanical
integration in powertrain
Air-borne + structure-borne noise
EDU level



modal basis



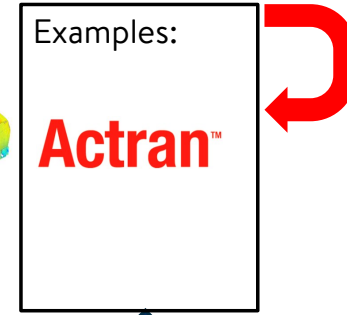
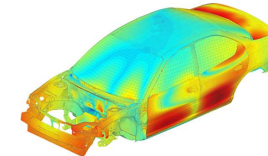
Iterations on powertrain
mechanical integration in vehicle
Structure-borne noise
Vehicle level



magnetic
forces



Iterations on powertrain
acoustic packaging in vehicle
Air-borne noise
Vehicle level



magnetic
forces



ELECTRICAL ENGINEERS



MECHANICAL / NVH ENGINEERS



MLUT

FRF

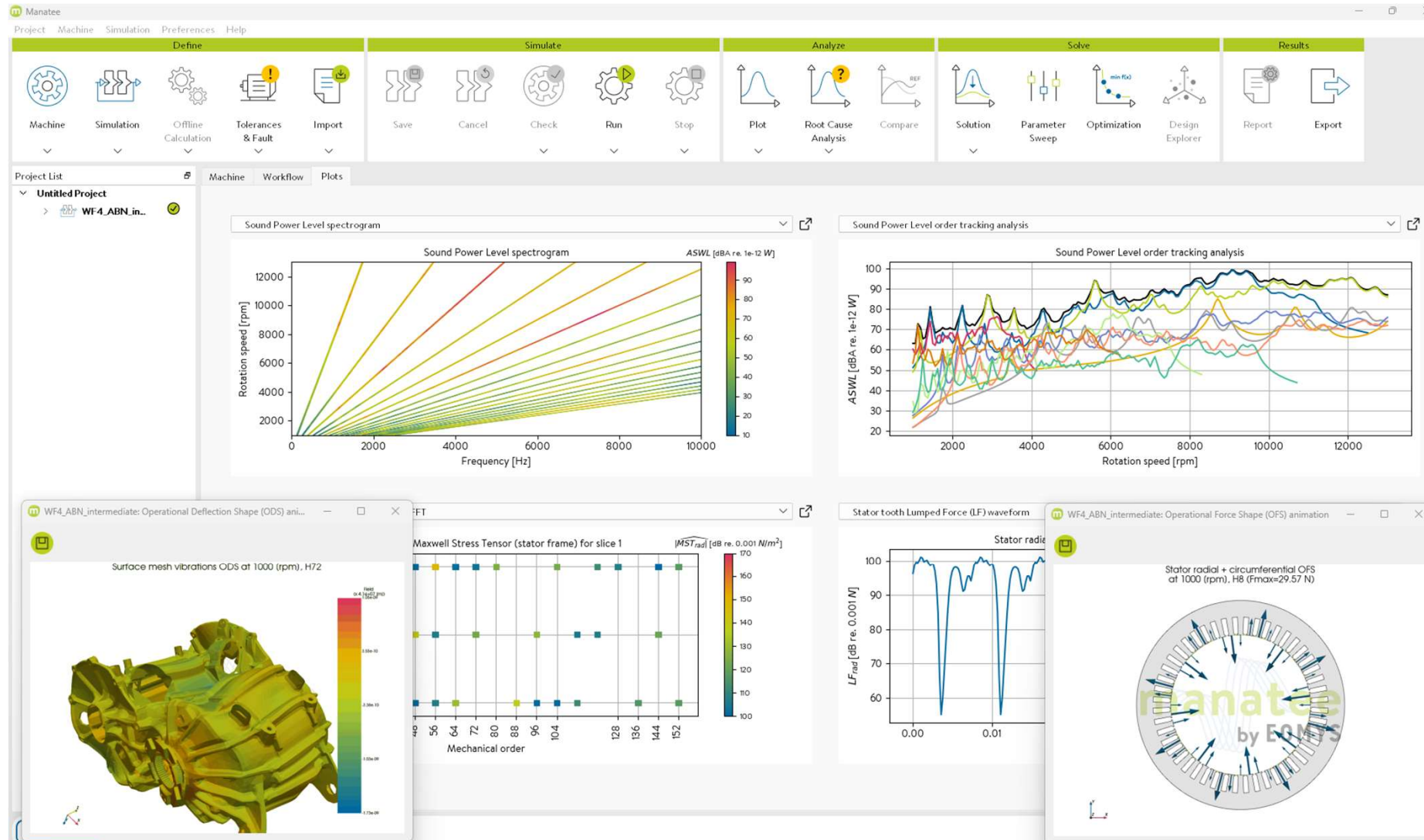
MECHANICAL / NVH ENGINEERS



ACOUSTIC / NVH ENGINEERS



Through a user-friendly GUI designed for all engineers.



LICENSING & DEVELOPMENT ROADMAP



Leasing licenses - overview

Our short-term to long-term leasing solutions include:

- all release updates (at least 4 per year)
- all available features at release time
- IT support
- e-NVH support package with our e-NVH experts
- available as single computer or as floating licenses with several tokens

Leasing solutions require a technical training:

- e-NVH basics (optional, can be avoided if Customer already attended EOMYS training on e-NVH)
- Manatee software (mandatory, applied to Customer case)



Leasing licenses - e-NVH support

- "e-NVH support" package provided with all Manatee leasing solutions
- Carried by our e-NVH engineers or software engineers and invoiced on an hourly basis

e-NVH support as consulting

- Deployment of Manatee within existing CAE tools
- Test data interpretation
- Test / model correlation
- ...

e-NVH support as training

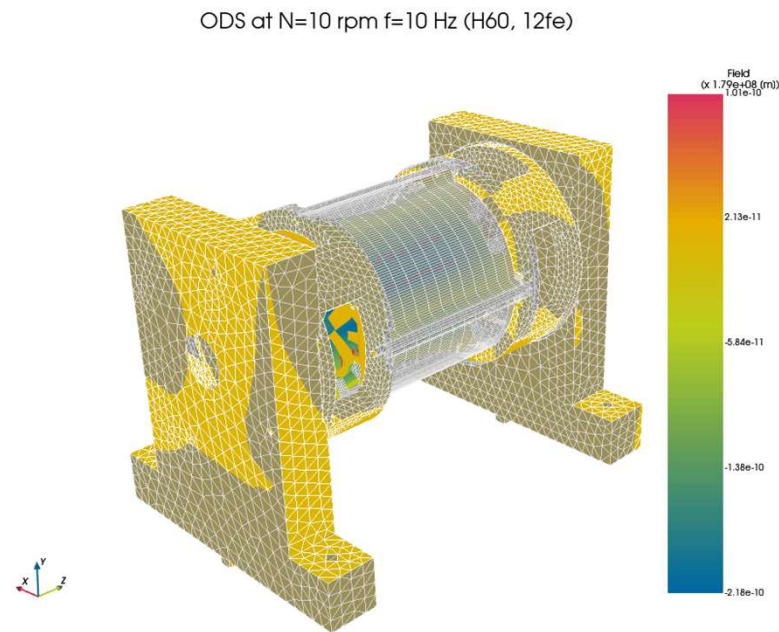
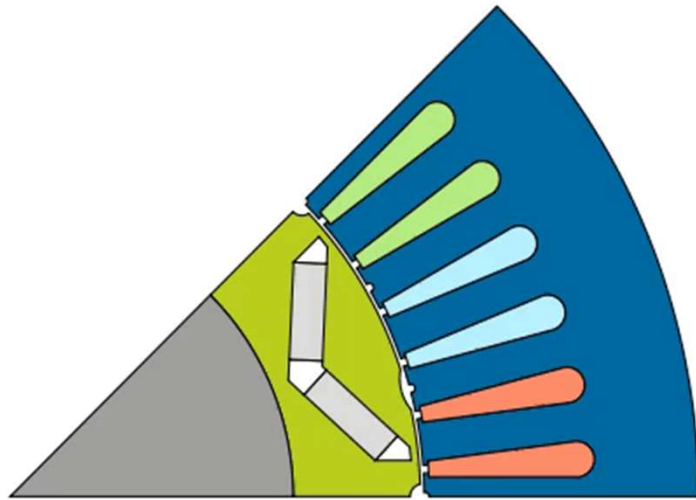
- Training on Manatee software
- Training on a special topic (e.g. impact of tolerances on e-NVH)

e-NVH support as scripting

- Accelerated release of some specific features
- Customized developments

Manatee free trial version

- Allows to perform a full e-NVH assessment of your own electrical machine at variable speed
- Free trial version does not grant access to Solution / Parameter Sweep / Optimization
- Electrical machines and simulation projects can be reused in a commercial license



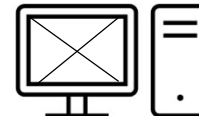
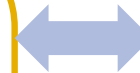
Manatee license offer types



Basic Manatee license

Computer n°1

- floating or single computer
- single token or multiple token
- parallelization of 1 simu over 4 to 16 CPU
- cloud-based or offline server-based



Batch mode dedicated license (*)

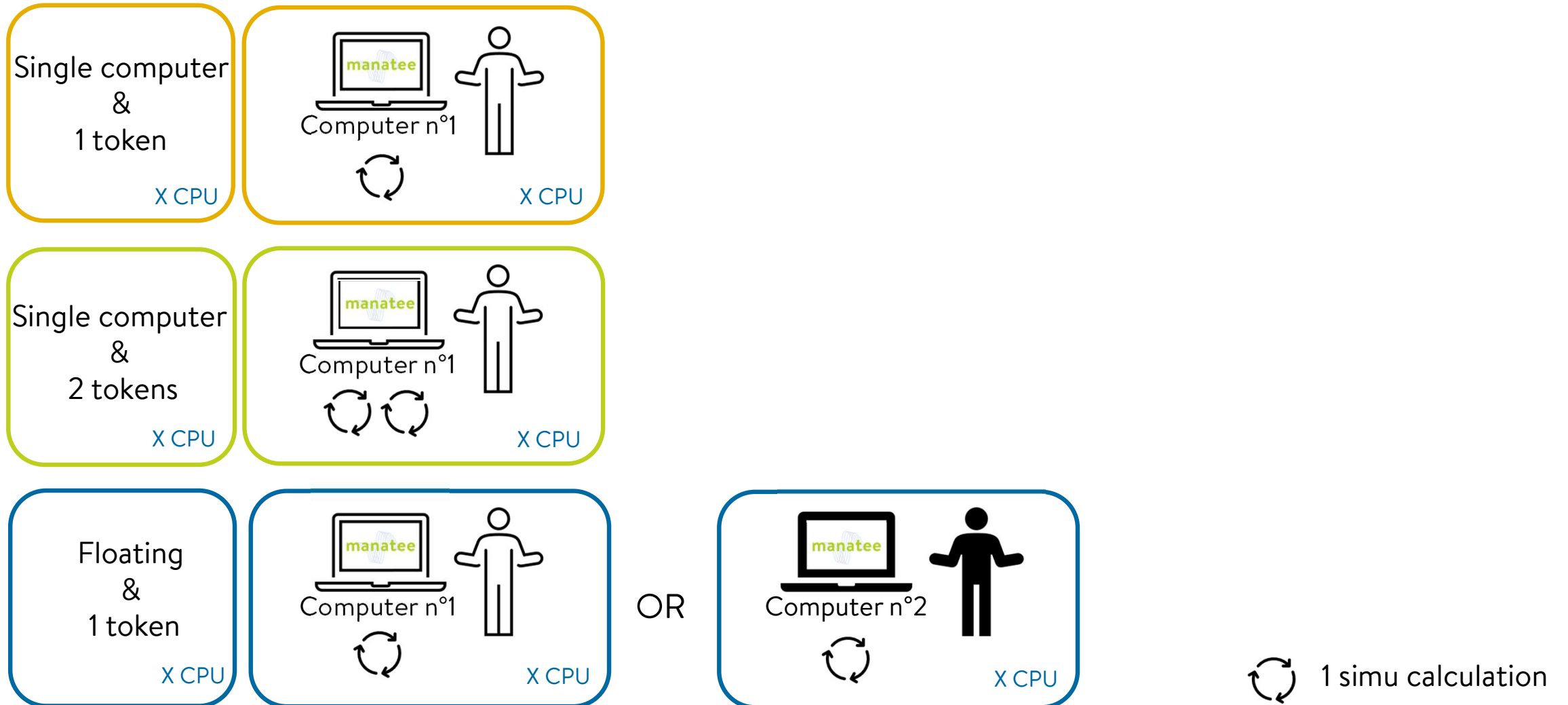
HPC Computer n°2

- single computer
- single token
- parallelization of 4 to 500 simulations over 4 to 500 CPU
- cloud-based only

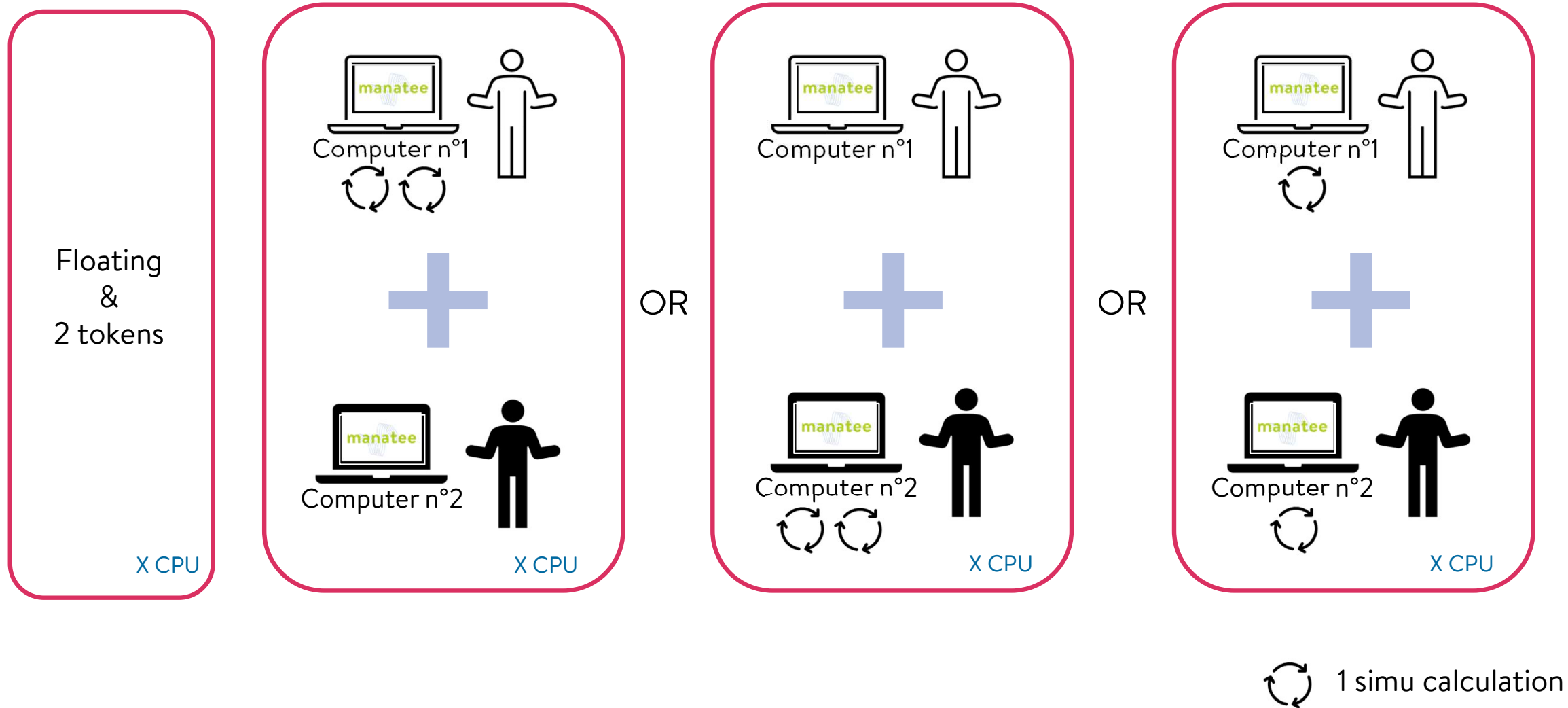
(*) Pre-requisites:

- Basic Manatee license activated on Computer n°1
- Batch mode license activated on Computer n°2

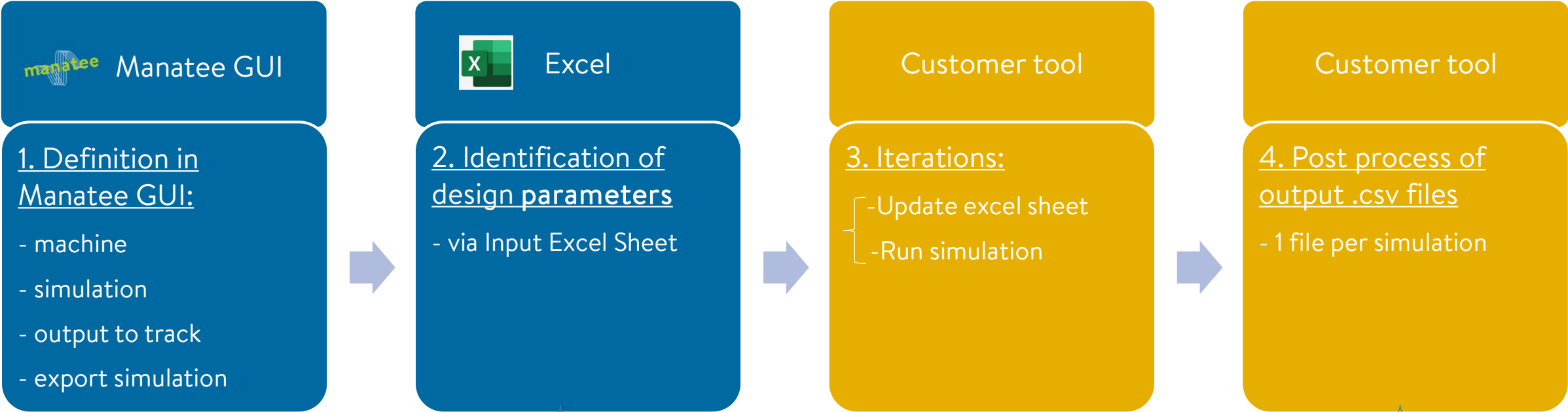
Manatee licensing options: single computer vs floating / token



Manatee licensing options: single computer vs floating / token



Batch mode process

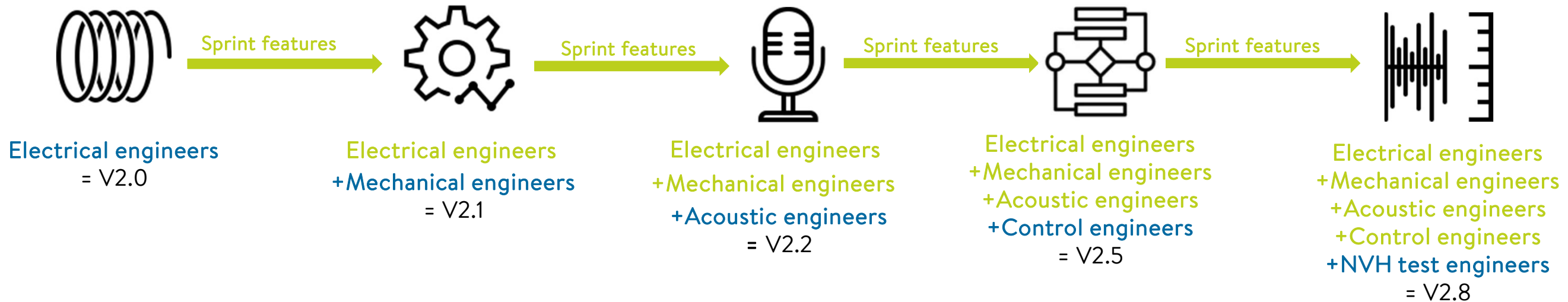


	A	B	C	D
1	Name	Path	Value	Unit
2	Stator slot opening	simu.machine.stator.slot.W0	10	mm
3	Rotor magnet height	simu.machine.rotor.hole[0].H3	5.00E-03	m
4	Stator slot height type	simu.machine.stator.slot.H1_is_rad	True	-
5	Stator slot intermediate height	simu.machine.stator.slot.H1	45	deg
6	Number of rotor skew slice	<PARAM_PATH>/setter_skew_slices_rotor.py	13	-

/!\ It does not include yet flux import and modal bases import

	A	B	C	D	E	F	G	H	I	J
	W0s [mm]	H3r[mm]	H1s_is_rad[mm]	H1s[deg]	Nskew_slices_rotor[]	Max_I_{rms} [Arms]	Max_J_{rms} [Arms/m^2]	Max_LV_{rms} [dB re. 1e-09 m/s]	Max_ASWL [dBA re. 1e-12 W]	Max_ASPL [dBA re. 2e-05 Pa]
1										
2	1.93	3	1	2	4	0	0	111.222	61.791	53.809
3	1.93	5	1	2	4	0	0	111.171	61.750	53.768
4	2.316	3	1	2	4	0	0	110.821	61.244	53.262
5	2.316	5	1	2	4	0	0	110.767	61.202	53.221

Manatee V2 release plan - overview



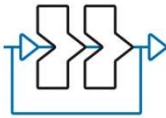
- “Key features” according to development roadmap + “Sprint features”
- Manatee V2 is developed according Agile methodology with continuous production
- Regular releases (code optimization, GUI improvement, sprint features) every 3 months
- Sprint feature development prioritized according to customer feedback
- High reactivity (2-week patch)
- Continuous development of tutorial on Manatee website

Manatee technical requirements

- Windows 8/10 64-bit architecture (includes parallelization on 4 CPUs, more CPUs optionally)
- For cloud-based licenses (Single Computer or Floating):
 - internet connection
- For server-based licenses (Floating only):
 - administration rights to start Manatee Server which runs as a service on Windows
 - host computer for Manatee Server and host computer for Manatee connected on same local network
 - no internet connection required
- 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
- FEMM 4.2 pre-installation when running electromagnetic simulations (see www.femm.info)

DETAILED FEATURES

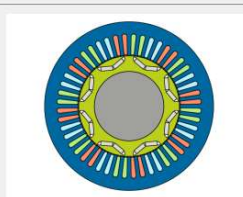
e-NVH predefined workflows



Simulation Setup

Machine Definition

Load



Toyota_Prius

Main Machine Parameters

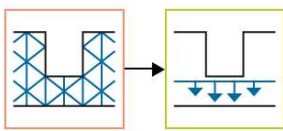
Name	Value
Machine Type	IPMSM
Stator slot ...	48
Pole pair ...	4
Topology	Inner Rotor
Stator phase ...	3
Stator winding...	Single Layer ...
Stator winding...	0.03595 Ohm
Machine total ...	33.38 kg

Plot Machine

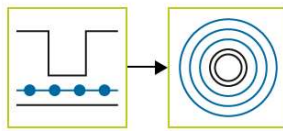
Plot Stator Unit MMF

Quick Campbell

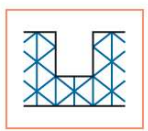
Workflow Selection



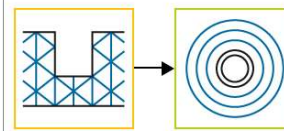
WF1_MLUT_early



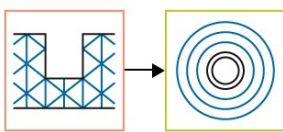
WF2_ABN_early



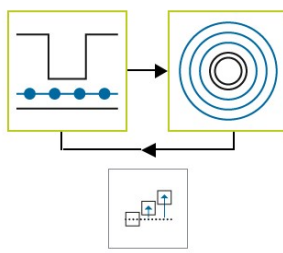
WF3_MLUT_intermediate



WF4_ABN_intermediate



WF5_ABN_advanced



WF6_skew_PS

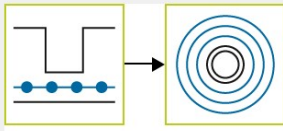
Workflow Description

Description: Calculates AirBorne Noise (ABN) in early design stage along given operating point(s).

Typical use: Quick e-NVH calculation at fixed speed, along torque speed curve or in torque-speed plane when iterating on electromagnetic design parameters.

Requirements: MLUT containing airgap surface forces automatically calculated with fast analytical models or pre-calculated with WF1 using FEA.

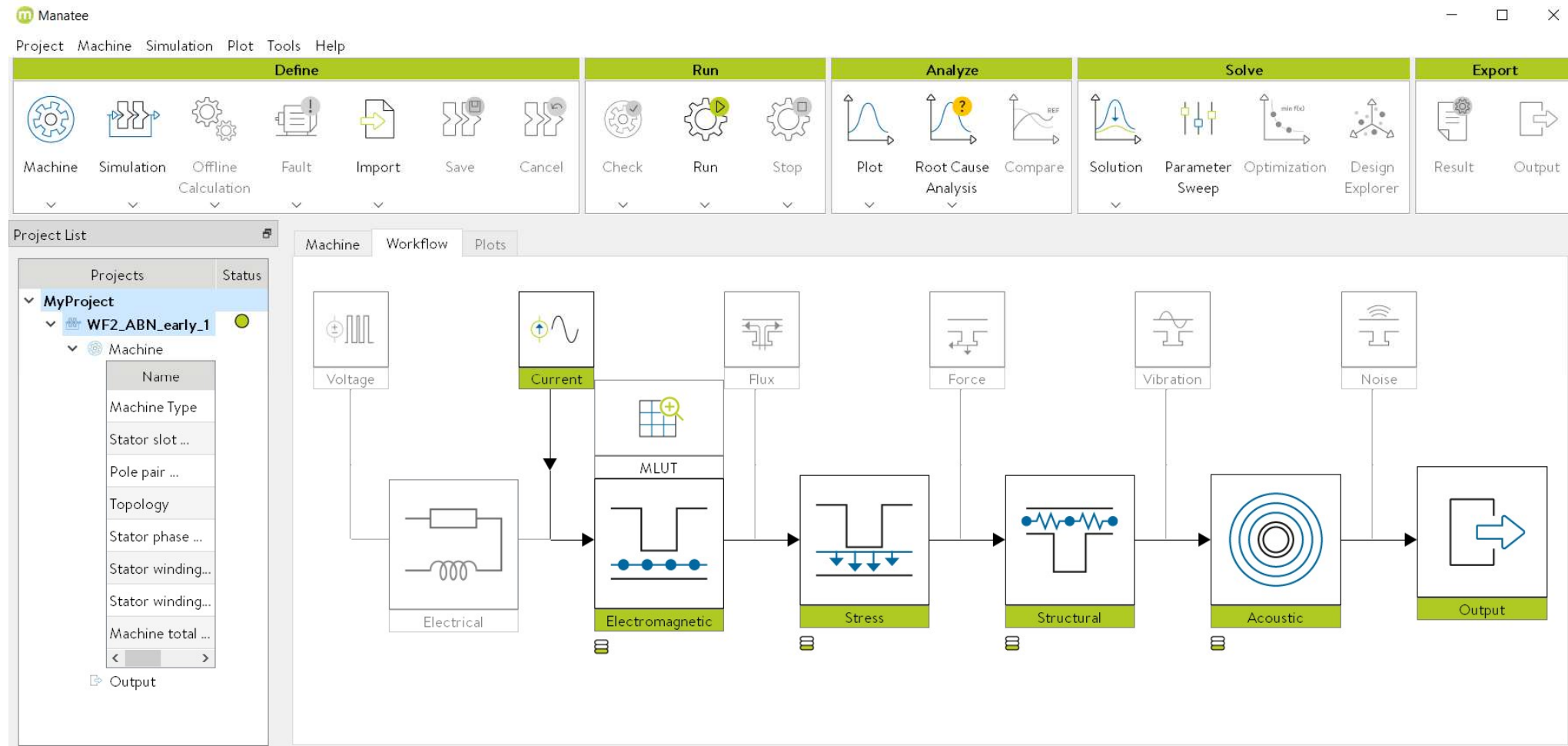
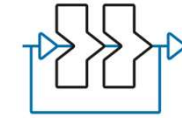
Key assumptions: Semi-analytic vibro-acoustic model of the outer structure responsible for radiated noise, excluding Structure-Borne Noise (SBN).



OK

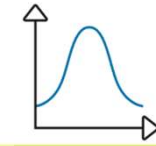
Cancel

e-NVH predefined workflows



[Feature tutorial video](#)

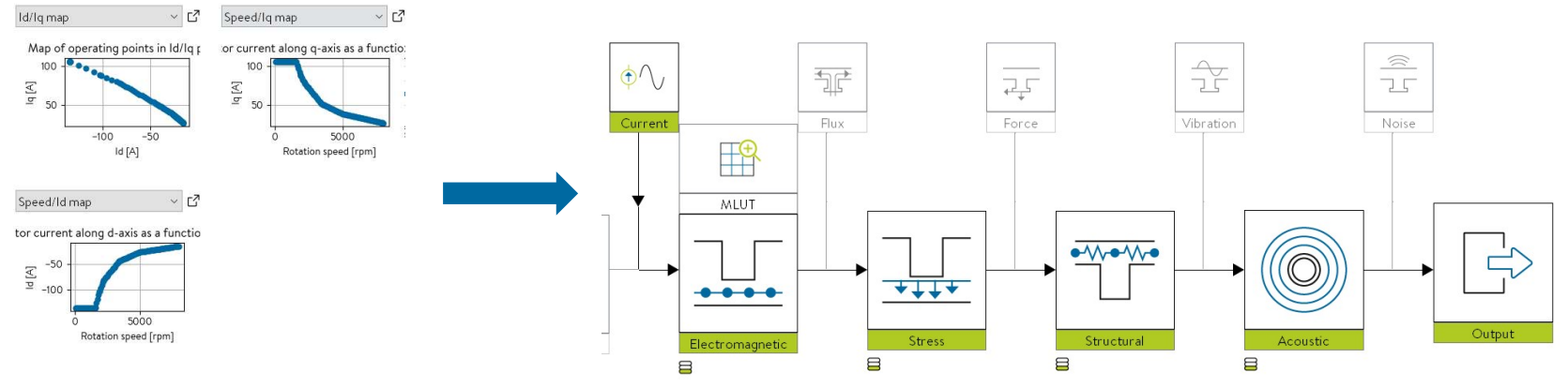
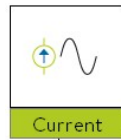
e-NVH predefined graphical post processing



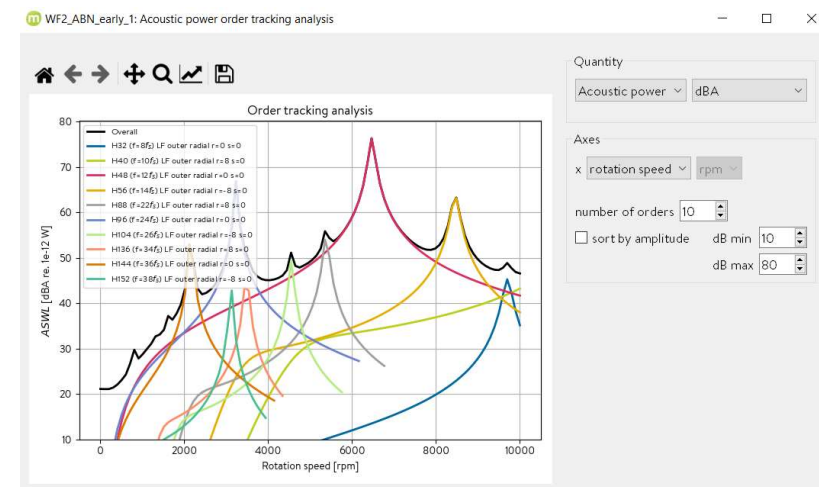
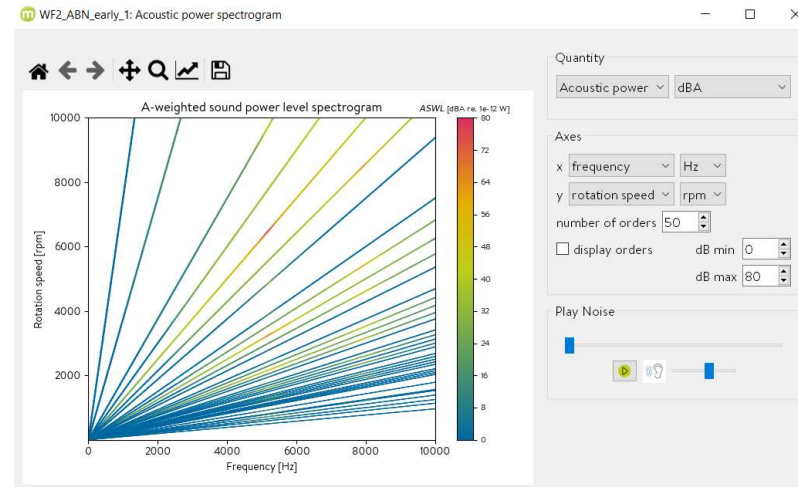
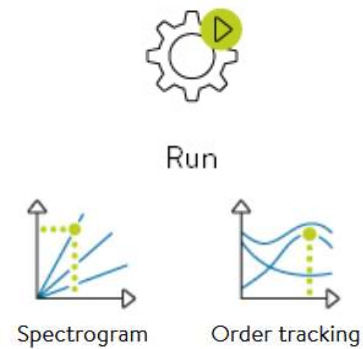
e-NVH calculation along max torque speed curve



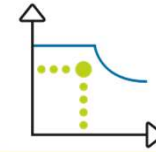
1. Define variable speed current control law



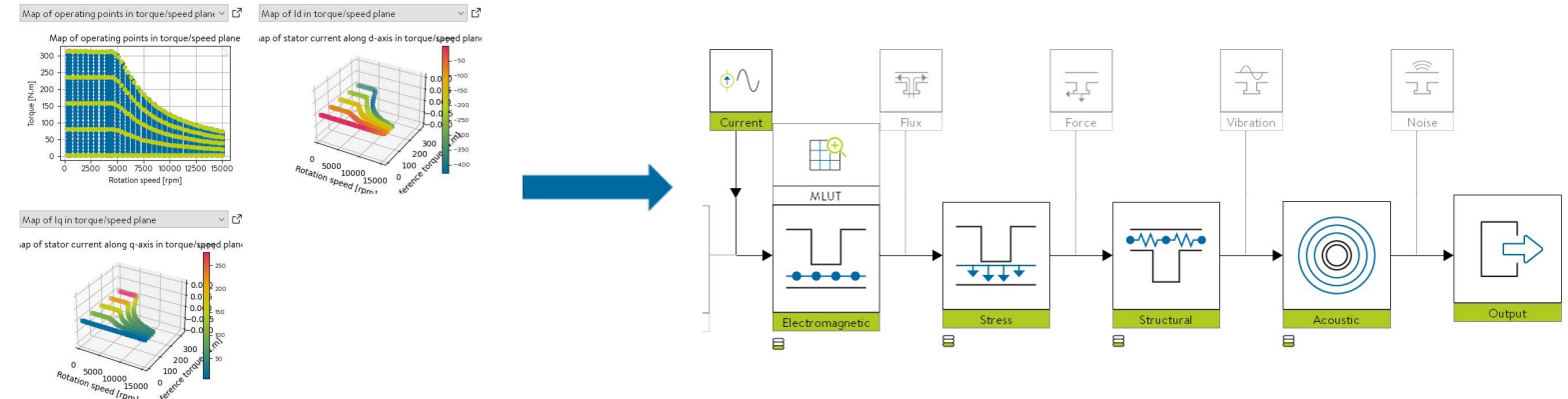
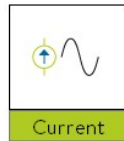
2. Run & plot



e-NVH calculation on whole torque-speed plane



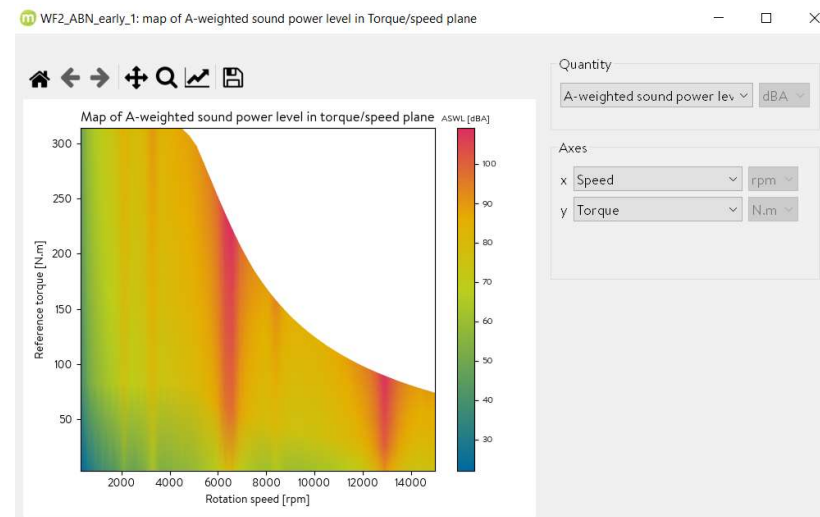
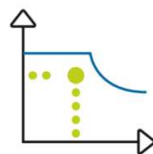
1. Define variable speed current control law



2. Run & plot

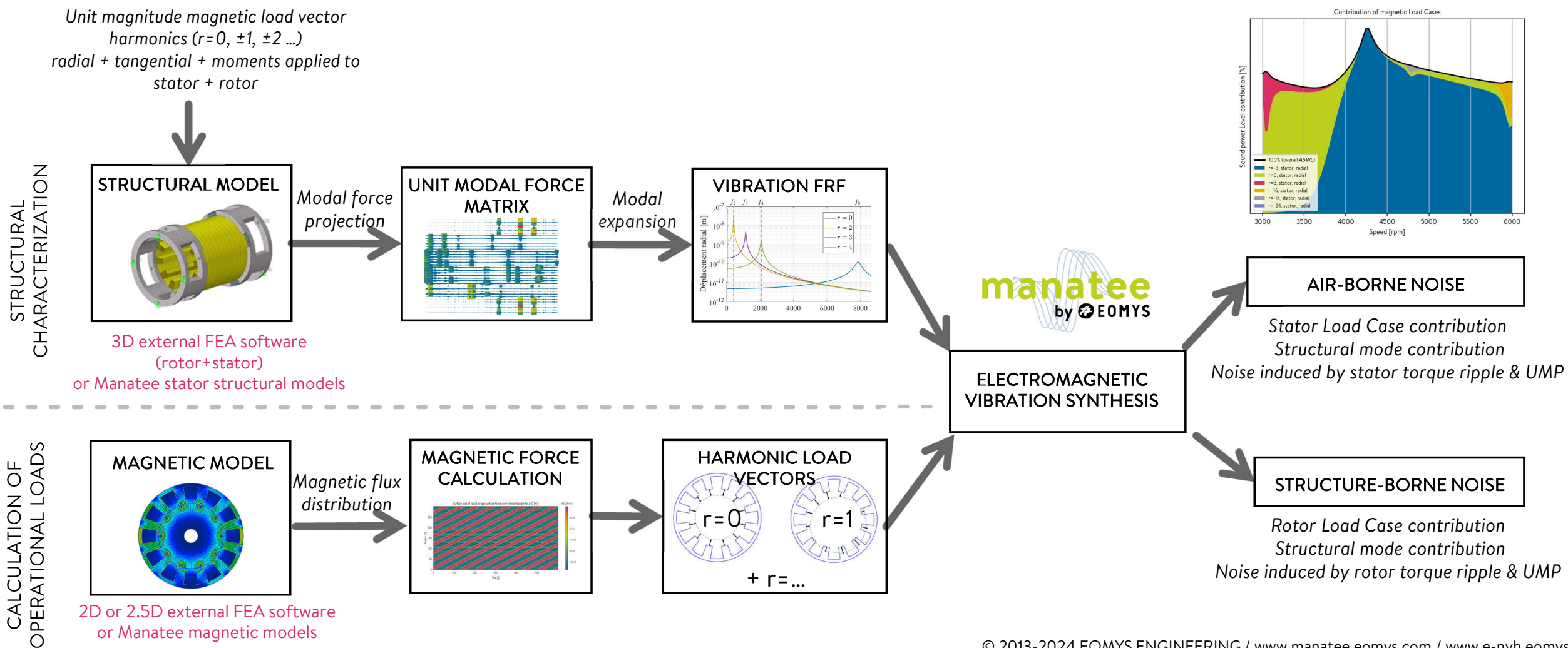


Run



Electromagnetic Vibration Synthesis

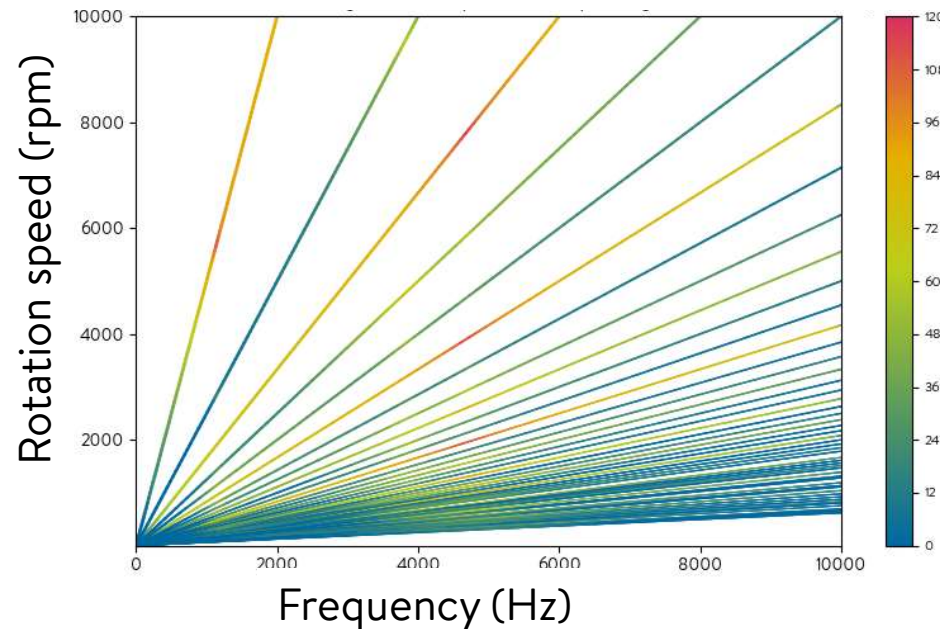
- Faster than direct vibration calculation at variable speed/torque, with more physical insights



Accelerated e-NVH calculations based on MLUT

Calculation along torque speed curve

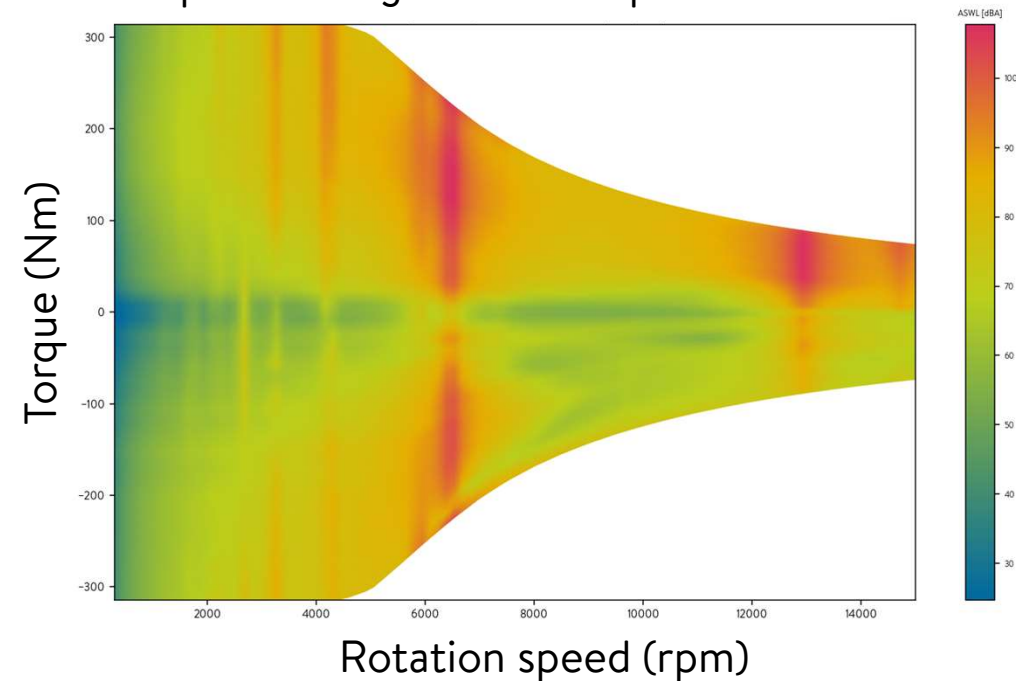
A-weighted sound power level spectrogram



- ~ 100 Operating Points
- Early design stage: <1 min
- Advanced design stage: ~30 min using 4 CPU (depending on machine symmetries and OP)

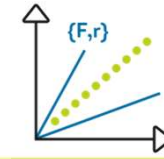
Calculation on torque speed plane

Map of A-weighted sound power level



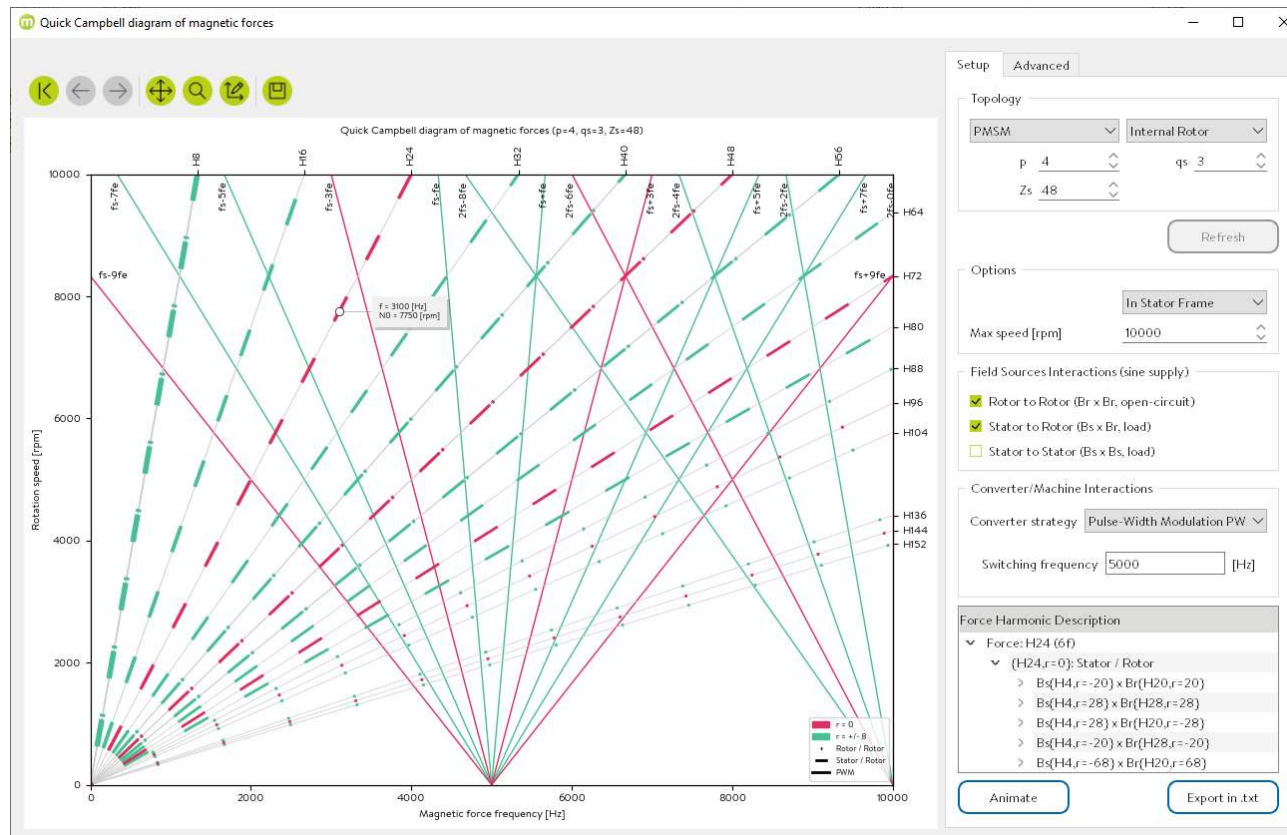
- ~ 1000 Operating Points
- Early design stage: ~2min
- Advanced design stage: ~2-3hrs using 4 CPU (depending on machine symmetries and OP)

e-NVH root-cause analysis with Campbell diagrams

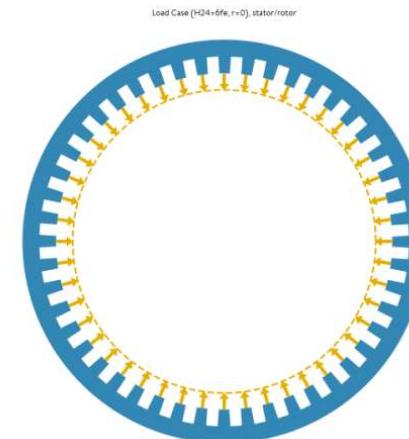


- Automated offline Campbell diagram based on load state, topology and slot/pole combination:

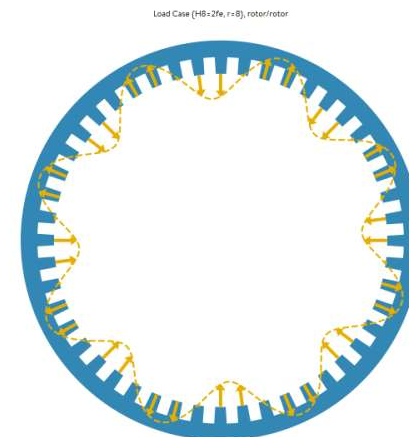
Example of a 48s8p PMSM ($Z_s=48$, $p=4$)



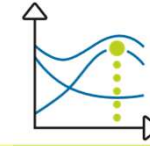
[Feature tutorial video](#)



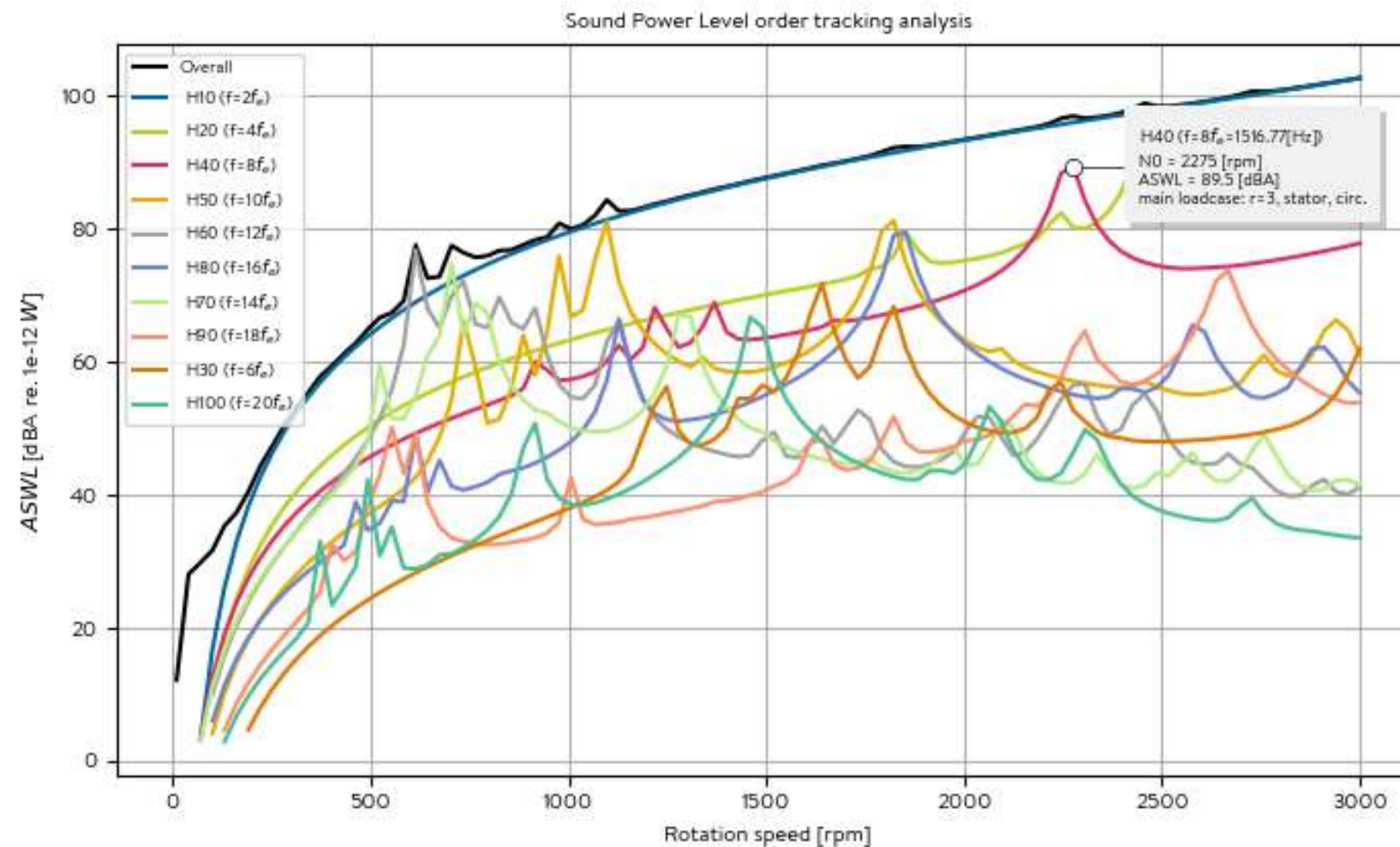
wavenumber
 $r=0$



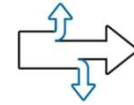
wavenumber
 $r=+/-8$



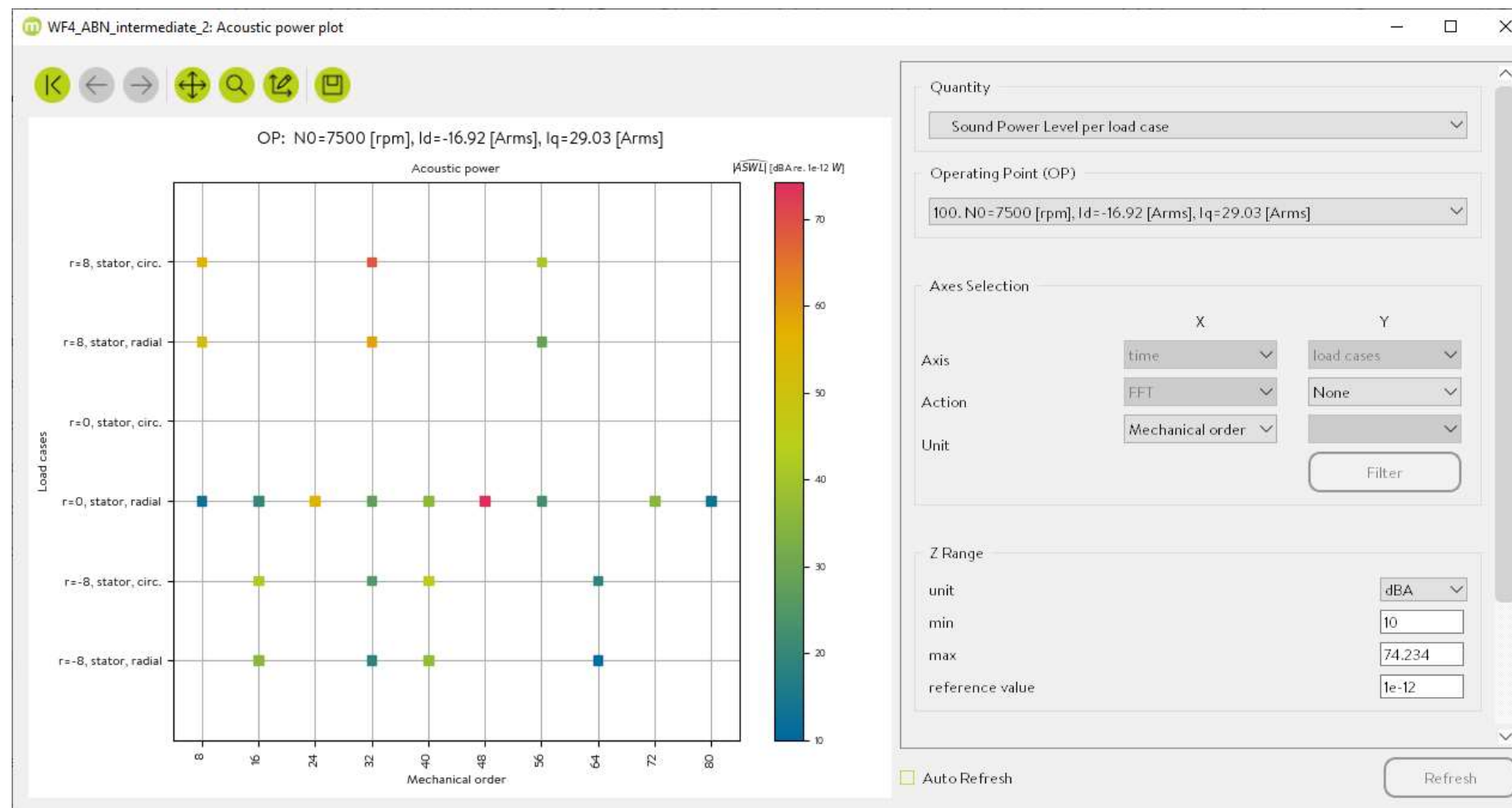
- Order Tracking based on automated identification of main force wavenumbers



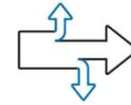
e-NVH root-cause analysis with advanced plots



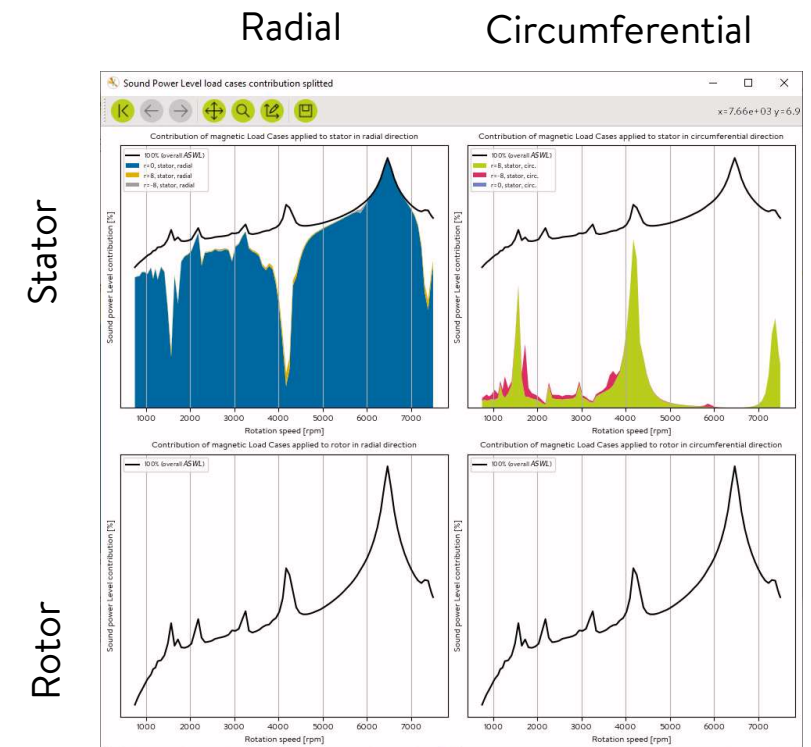
- Automated Load Case contribution at fixed operating point

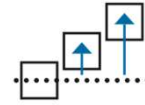


e-NVH root-cause analysis with advanced plots



- Automated Load Case contribution at variable operating point

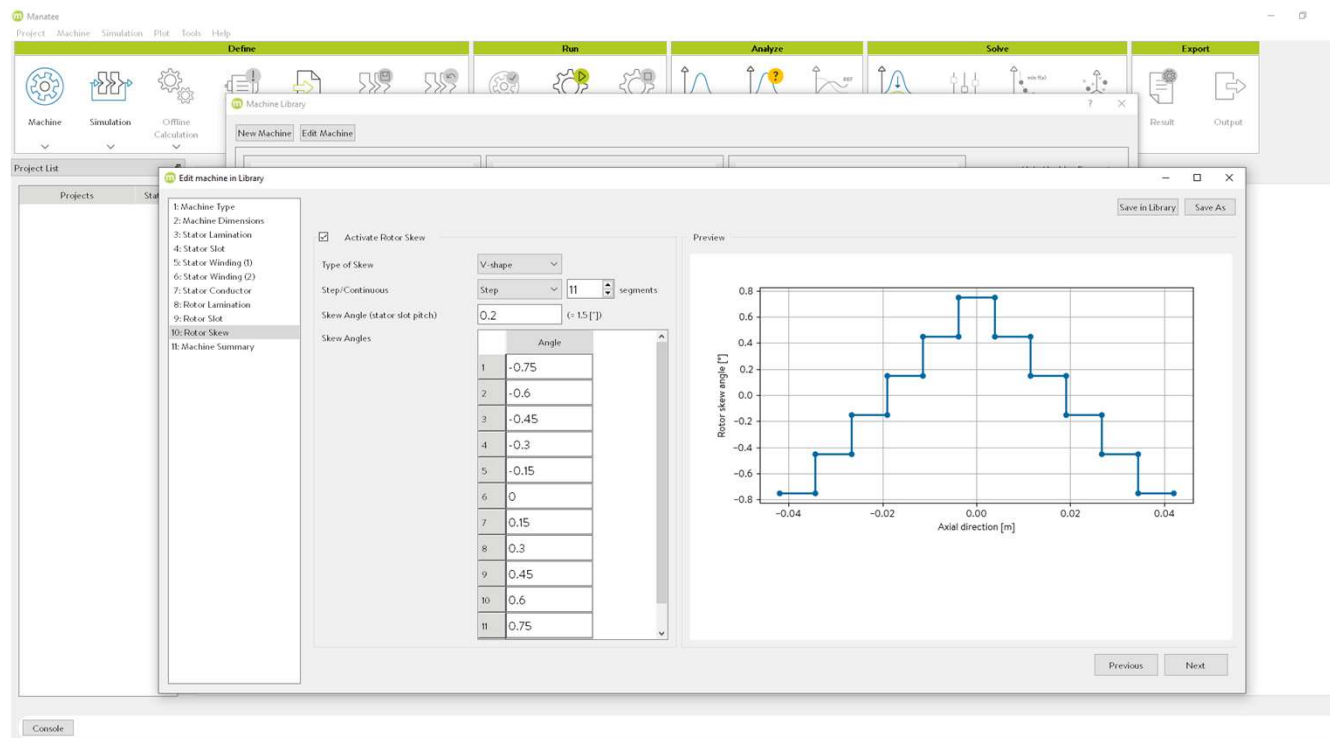




e-NVH mitigation with rotor skew

Manatee includes built-in design environment of **skewing technique**

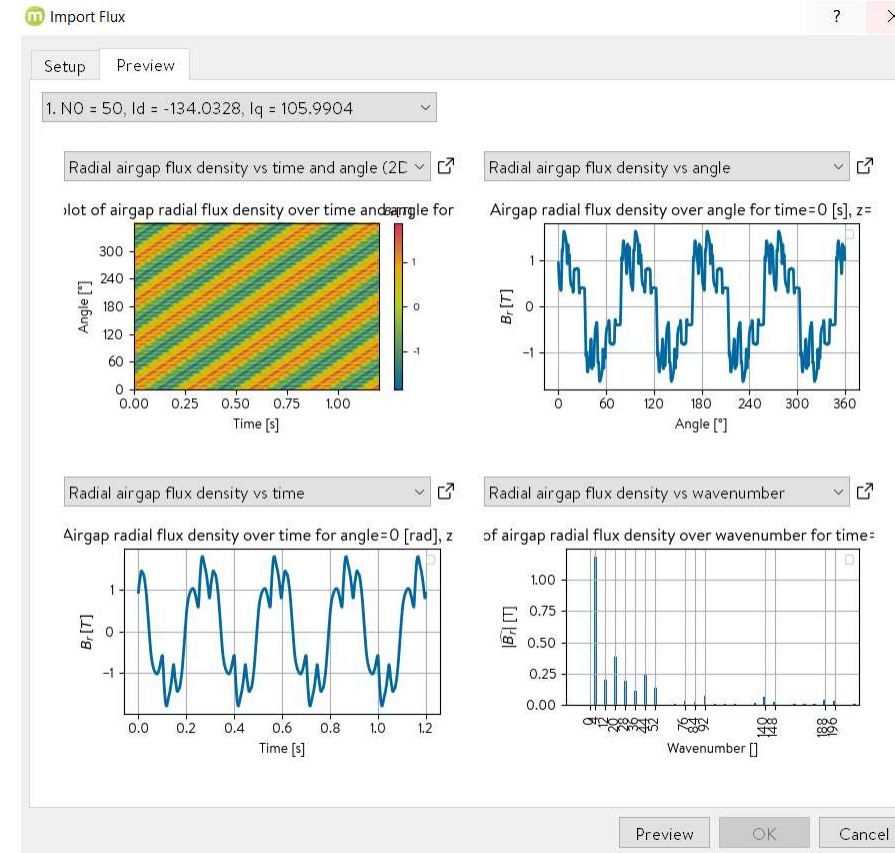
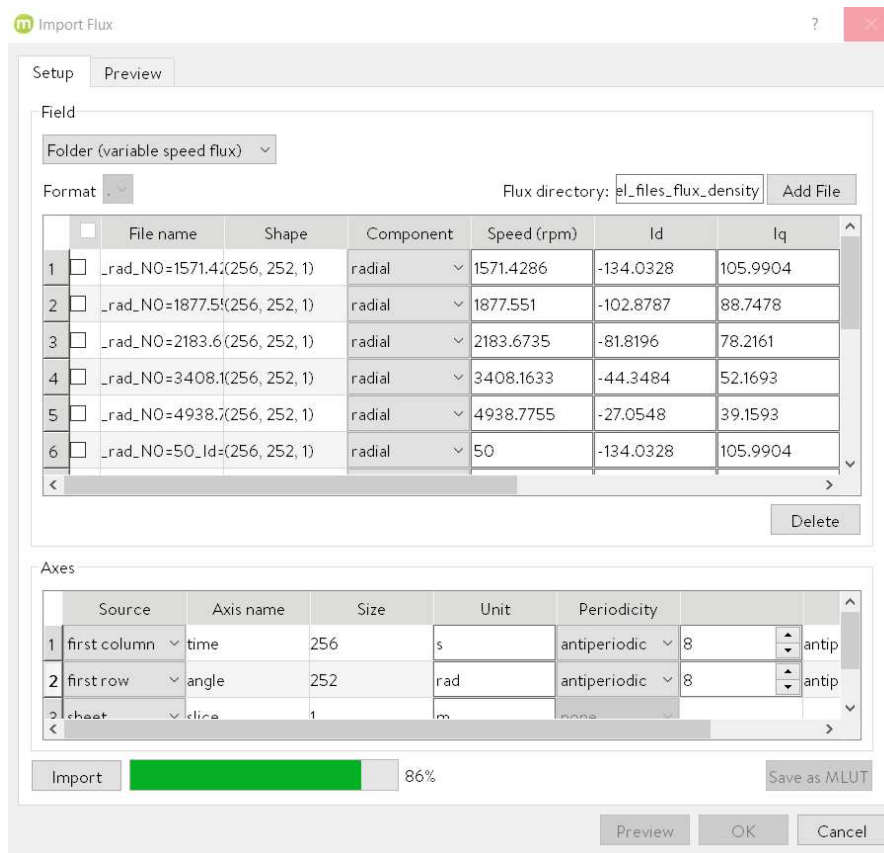
- Possibility to define any rotor skew shape
- Automated **parameter sweep** of NVH & torque ripple function of **skew angle**



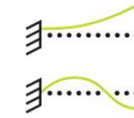
Import of flux density distribution



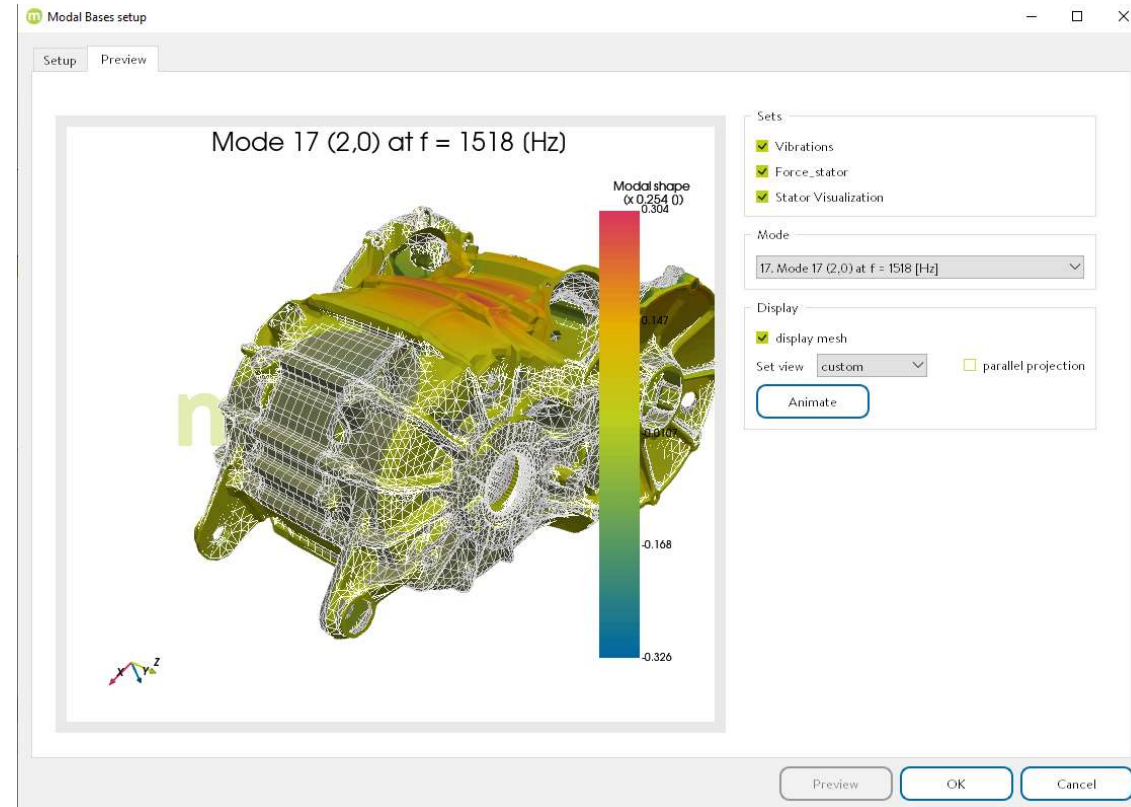
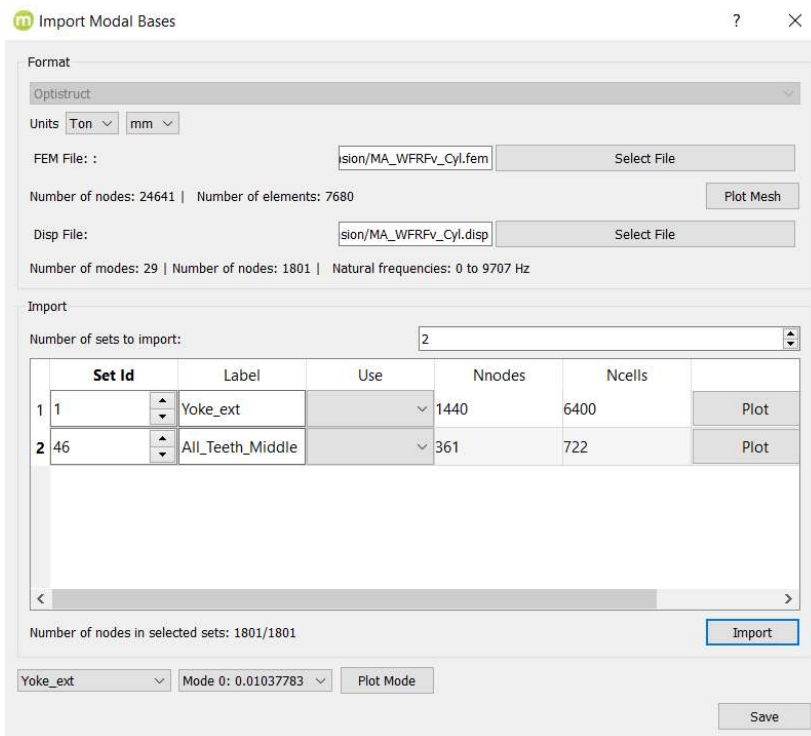
- Import of third party flux density distribution (fixed speed, variable speed, multi slice) in Excel format



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.



CONCLUSION

Manatee software

- 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 development time 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



Contact details

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