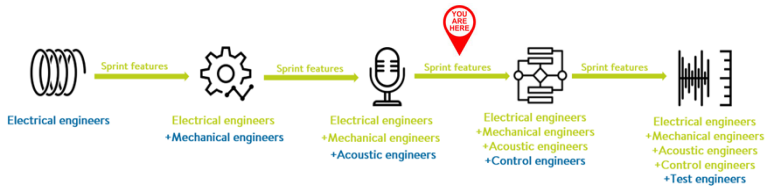
SIMULIA MANATEE

MODULE DESCRIPTION OF 2025X R3

LAST UPDATE: JULY 25, 2025
MANATEE SOFTWARE VERSION 2025X R3

3DEXPERIENCE®



QUICK e-NVH SIMULATION DEFINITION

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION
COLLABORATIVE, USER-FRIENDLY GUI	GUI	Integrated user-friendly GUI made for all engineers involved in the design of electrical systems	Graphical User Interface designed for **acoustic, mechanical and electrical engineers** to ease their collaboration during the development of complex systems involving electric machine operation. Possibility to handle several simulation projects in the same interface.
QUICK e-NVH SIMULATION DEFINITION *Solutions to easily define variable-speed e-NVH calculations including advanced post-processing tools*	SIM.WF	e-NVH pre-defined simulation workflows & post processing along e-machine development cycle	Manatee **pre-defined simulation workflows** combining the modelling level options which are the most adapted to electrical machine topology and different stages of **V-model electrical machine development cycle**, from **early design phase** to **detailed design phase**. Examples of workflows include e-NVH along max torque speed curve using semi analytic electromagnetic & vibroacoustic models in open circuit/full load with sine current, e-NVH along torque speed curve using Load Interpolation Algorithm coupled with FEA magnetic solver, e-NVH along torque speed curve refined with Electromagnetic Vibration Synthesis calling third party FEA structural model. Manatee also provides a dedicated tool to create **user-defined simulation workflows** in few clicks. After calculations, some **predefined post-processing and visualizations** adapted to chosen predefined workflows are run. Includes more than **50 pre-defined plots** (permeance, flux, force, vibration and noise) including FFT in 1D or 2D spaces.

QUICK e-NVH SIMULATION DEFINITION

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION
QUICK e-NVH SIMULATION DEFINITION *Solutions to easily define variable-speed e-NVH calculations including advanced post-processing tools*	SIM.FS	Fixed-speed e-NVH calculations	Calls Manatee on a single Operating Point to compute current / flux / forces / vibration / noise and provide the corresponding post-processing.
	SIM.HARM	Fixed-speed e-NVH calculations with additional stator current harmonics for SM	Calls Manatee on a single Operating Point to compute flux / forces / vibrations / noises and provide the corresponding post-processing by setting a current with additional harmonics specified in DQH frame
	SIM.VS	Quasi-static variable speed e-NVH calculations	Calls **several Manatee fixed-speed steady state simulations** with varying supply based on control strategy (e.g. max torque/speed curve, torque/speed plane). Dedicated variable speed NVH post processing are available (overall SPL/SWL as a function of speed, noise and vibration **waterfalls, order tracking analysis,** force / vibration / noise **spectrograms**, operational deflection shape).
	SIM.MAP	Torque / speed plane e-NVH calculations (acoustic noise maps)	Calls several Manatee simulations based on input Id/Iq maps to characterize the e-motor **NVH behavior in torque/speed plane** on two quadrants (traction / braking), including noise map plots and detailed post processings. Can be combined with ALG.MLUT and ALG.EVS to speed up calculations (using semi analytic NVH models, full map can be obtained in less than 5min of calculation). Only applicable to PMSM.

FAST & ACCURATE e-NVH CALCULATIONS

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION
FAST AND ACCURATE e-NVH CALCULATIONS *A series of unique, proprietary algorithms to speed-up e-NVH accurate calculations and give more physical insights to design engineers*	ALG.MLUT	Load Extrapolation Algorithm or Load Interpolation Algorithm based on MLUT concept	**Accelerated variable speed magnetic load calculation** based on **force extrapolation or interpolation algorithms**. Depending on topology and supply inputs (e.g. open circuit, constant Id/Iq angle), Manatee automatically shortens the calculation time of variable speed magnetic loads using the concept of air-gap **Magnetic Look Up Table** as a function of operating point. MLUT can be built based on flux import (IO.FLUX), or on magnetic FEA calculation (ex: EM2.PMSM). ALG.MLUT also reduces computing time of skewed PMSM.
	ALG.EVS	Electromagnetic Vibration Synthesis to speed up variable-speed FEA-based vibration calculations, or optimization of electromagnetic excitations with respect to vibration	**Speeds up magnetic vibration calculations** while giving more **physical insights and transfer path analysis** by applying **elementary electromagnetic loads** in radial & tangential directions (wavenumbers identified automatically by Manatee) on the structural model, calculating the **Frequency Response Functions of both rotor and stator**, and synthesizing the overall vibration response under operational loads. Can be used with any type of structural model provided in structural module SM (analytic or FEA). EVS is particularly useful when a high number of operational loads have to be calculated, for instance in variable speed calculations (e.g., NVH maps on torque speed plane) or in optimization mode (e.g., pole shaping).

ACCELERATED e-NVH POST PROCESSING

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION
ACCELERATED e-NVH POST PROCESSING *Solutions to quickly post process multiphysic calculation results*	PLOT.F1D	Spectrum visualization for single operating point spectra	Interface for **1D spectrum**/waveform visualization, includes A-weighting and dB scaling. Possibility to display **frequency, electrical or mechanical orders.**
	PLOT.F2D	Spectrum visualization for variable operating points spectra	Interface for **2D spectrum**/waveform visualization, includes A-weighting and dB scaling. Possibility to display frequency, electrical or mechanical orders.
	PLOT.SPEC	Spectrogram for variable speed operating points	Interface for **Spectrogram visualization**, includes A-weighting and dB scaling and possibility to display main **structural modes and excitation orders.**
	PLOT.OT	Order Tracking analysis for variable speed operating points	Interface for **Order Tracking** visualization, includes A-weighting and dB scaling. Automatically associates to a given frequency the most influent magnetic Load Case. Possibility to switch from rotation speed to frequency axis.
	PLOT.OG	Ordogram for variable speed operating points	Interface for **Ordogram visualization**, includes A-weighting and dB scaling.
	PLOT.OFS	Operational Forces Shape analysis	Interface to visualize the operational forces (radial, tangential or both) on the external structure for each operating points. Possibility to animate the forces.
	PLOT.ODS	Operational Deflection Shape analysis	Interface to visualize and animate how the envelope nodes radiating surface vibrates at a given speed and frequency (**ODS**). Can be used for both analytic or 3D FEA mechanical model.

e-NVH ROOT CAUSE ANALYSIS

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION
ADVANCED e-NVH ROOT CAUSE ANALYSIS *Solutions to carry early-stage e-NVH analysis or identify noise and vibration root cause with advanced post processing*	RCA.MFSA	Magnetic Force Signature Analysis for e-NVH troubleshooting in early design stage	Draws a **Campbell diagram** of magnetic excitations per physical origin with magnitude estimates. Identifies all **main magnetic force harmonics (frequencies and wavenumbers)** based on slot/pole/phase combinations, electrical machine topology and load state using theoretical analytic work (instantaneous calculations). Provides the physical origin of a given force harmonic in terms of **permeance, magnetomotive force, flux waves combinations** as well as in terms of excitation sources (**rotor/stator mmf, slotting, winding or PM** space harmonics). Includes magnetic force harmonics due to Pulse-Width Modulation (PWM). Animates radial and circumferential force harmonics to visualize with an arbitrary magnitude. Available for PMSM/WRSM & SCIM.
	RCA.MCLC	e-NVH investigation based on modal basis, unit-magnitude stress waves, and radiating surface envelope	Projects unit magnetic load cases on the modal basis to calculate vibrations of a specified surface / node to **quickly analyze which structural modes and unit load cases are contributing the most to overall noise and vibration** at resonance (no notion of speed). In particular, this graph identifies key structural modes excited by radial ripple, torque ripple, or UMP when applied to stator or rotor.
	RCA.SPAT	Spatiogram (spectrogram filtered per Load Case)	Draws vibration/noise spectrograms **per magnetic Load Case** when ALG.EVS has been used. This way the contribution of **airborne paths** (e.g. external stator excitation) Vs **structure borne path** (e.g. internal rotor excitation) can be differentiated, as well as the **impact of each force wavenumber** and direction.
	RCA.LCC	e-NVH contribution of Load Case	Draws vibration/noise overall contribution **per magnetic Load Case** when ALG.EVS has been used. Possibility to split between air-borne/structure-borne and radial/circumferential contributions

e-NVH CONTROL SOLUTIONS

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION
PREDEFINED NOISE CONTROL TECHNIQUES *A series of dedicated noise control environments for the design optimization of control, magnetic or structural-based e-NVH mitigation techniques*	SOL.SKEW	Skew pattern application	Dedicated GUI to automatically define a parameter sweep to find the optimal skew pattern (linear, step-skew, zig-zag, V-shape) with the best tradeoff between noise and torque. The vibroacoustic model can be of any type depending on Manatee inputs (semi-analytic, numerical, or with imported FRF).
	SOL.HCI	Harmonic Current Injection	Dedicated GUI to automatically define an optimization to find the optimal harmonic current to inject on the noisiest operating point to reduce the noise without altering the torque.

e-NVH ROBUST DESIGN

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION
ROBUST DESIGN INCLUDING TOLERANCES *Solutions to carry robust e-NVH design of electric motors*	ROB.ECC	Manufacturing tolerance simulation of eccentricities	Handles **static and dynamic 2D or 3D eccentricities due to manufacturing tolerances** when calculating magnetic loads. **Eccentricity** can be modelled even when importing flux density with IO.FLUX without the need to carry electromagnetic calculations without symmetry. Healthy electromagnetic calculations are perturbated at first order to estimate the impact of eccentricities, assuming saturation unchanged.
	ROB.UAG	Manufacturing tolerance simulation of uneven stator bore radius	Handles **stator uneven roundness (such as ovalization) due to manufacturing tolerances** when calculating magnetic loads **and uneven airgap**. **Uneven roundness** can be modelled even when importing flux density with IO.FLUX without the need to carry electromagnetic calculations without symmetry. Healthy electromagnetic calculations are perturbated at first order to estimate the impact of uneven airgap, assuming saturation unchanged.
	ROB.UMAG	Manufacturing tolerance simulation of uneven magnetization	Handles **uneven magnetization** on each magnet when calculating magnetic loads, when using non-linear FEA magnetic solver (not compatible with PMMF model or perturbation model). Contrary to ROB.ECC and ROB.UAG, magnetic model does not use a perturbation method (direct non linear magnetostatic calculations).

e-NVH IMPORT EXPORT SOLUTIONS

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION
SMOOTH INTEGRATION INTO CAE WORKFLOW *Solutions to ease Manatee integration within existing CAE workflow, including use of Manatee post processing on experimental data*	IO.CURRENT	Import of currents	**Import currents from a third-party software** at single speed or variable speed to perform simulation with non-sinusoidal currents. For PMSM only.
	IO.FLUX	Import of airgap magnetic field distribution	**Imports the airgap flux density distribution calculated with third party electromagnetic software** at single speed or variable speed or using MANATEE Magnetic Look Up Table (MLUT) format, and projects the airgap Maxwell stress on the inner and outer structures to calculate magnetic forces and resulting e-NVH behavior. Handles variable speed import and skewed machines.
	IO.MODAL	Import of measured or calculated modal basis	**Import of structural modal basis** (.disp/.fem/.op2, .rst, .inp/.op2/.csv/.rpt, .dat/.op2, other formats can be added upon request) to perform nodal vibration, modal expansion, modal force and modal participation factors calculation. The modal basis can come from numerical simulation or experiments.
	IO.EXTN	External (non magnetic) noise source import	Possibility to import external noise harmonics (gear, aerodynamic noise for instance) - compatible with Manatee acoustic post-processing (PLOT.OT and PLOT.SPEC for instance). Includes a template to ease import of gear whine from Romax.
	IO.DXF	Import of slot, notch, magnet, uneven bore shape or cooling channel shape from .DXF file	Imports a .DXF file to draw the electrical machine magnetic circuit.

EFFICIENT e-NVH DESIGN EXPLORATION

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION
EFFICIENT e-NVH DESIGN EXPLORATION *Solutions to carry parameter sweep, multi-objective optimization and simulation comparison*	LAB.PS	Parameter Sweep	Calculates e-NVH **responses with respect to design variables** (e.g., to study the effect of +/- 5% pole width or slot numbers on noise). Design variables can be chosen among geometrical templates of magnetic circuit geometry. Skew, Eccentricity (ROB.ECC), uneven stator bore radius (ROB.UAG), Current harmonics (SIM.HARM) and Magnet temperature are available as design variables as well. User defined response variables can be added to track and visualize flux / forces / vibration / noises harmonic amplitude for each design.
	LAB.OPTI	Multi-objective optimization	Multi-objective optimization with constraints using Non-dominated Sorting Genetic Algorithm (NSGA-II) algorithm to calculates e-NVH **responses with respect to design variables**. Design variables can be chosen among geometrical templates of magnetic circuit geometry. Skew and Current harmonics (SIM.HARM) are available as design variables as well. User defined response variables can be added to track / optimize / constraint and visualize flux / forces / vibration / noises harmonic amplitude for each design.
	LAB.DE	Multidimensional design space explorer	Dedicated GUI to visualize all the design of a parameter sweep solution on 5D graph (X, Y, Z, point colour and point size) to find the design with the best trade-off between design and response variables.
	LAB.BAT	Batch mode	Manatee simulation (previously defined in the GUI) can be run in batch mode to enable integrating Manatee within external optimization loops. Input are set with an xlsx/csv file and output are exported in csv. Windows only.

e-NVH ELECTROMAGNETIC MODELS (semi-analytical models)

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION
e-NVH ELECTROMAGNETIC MODELS *Electromagnetic models for magnetic field calculation in both early and detailed design phase for all electrical machine topologies*	EM1.PMSM	Fast electromagnetic analytical module based on permeance / mmf and winding functions for permanent magnet synchronous machines	Calculates the airgap rotor and stator radial flux density time and space distribution based on permeance / mmf model. Includes rotor skewing, any winding type (**star of slot** method included). Hybridation with FEA magnetic solver to calculate rotor mmf of PMSM. Assumes infinitely deep slots, but any shape of surface/interior magnet, and infinite permeability of magnetic materials. Most suitable for early design phase to capture the main airborne resonances due to radial forces.
	EM1.SCIM	Fast electromagnetic analytical module based on permeance / mmf and winding functions for inner rotor induction machines, including squirrel cage induction machine (SCIM)	Calculates the airgap rotor and stator radial flux density time and space distribution based on permeance / mmf model. Includes rotor skewing, any winding type (**star of slot** method included). Full load PMMF model is simulated in the frequency domain to avoid any spectral leakage problems. Most suitable for early design phase to capture the main airborne resonances due to radial forces in induction machines. NL= no load FL = full load

e-NVH ELECTROMAGNETIC MODELS (numerical finite element models)

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION
e-NVH ELECTROMAGNETIC MODELS *Electromagnetic models for magnetic field calculation in both early and detailed design phase for all electrical machine topologies*	EM3.PMSM	Electromagnetic finite element module for surface, inset or interior permanent magnet synchronous machines	Couples Manatee with SIMULIA FEA magnetic solver for nonlinear magnetostatics problem (automatic drawing, meshing and post processings). Calculates the airgap radial and tangential flux density time and space distribution, as well as torque, and flux linkages. Includes skewing and any winding type, inner and outer rotor. Can be used to calculate the flux density look up tables of ALG.MLUT.
	EM3.WRSM	Electromagnetic finite element module for wound rotor synchronous machines	Couples Manatee with SIMULIA FEA magnetic solver for nonlinear magnetostatics problem (automatic drawing, meshing and post processings). Calculates the airgap radial and tangential flux density time and space distribution, as well as torque, and flux linkages. Can be used to calculate the flux density look up tables of ALG.MLUT.
	EM3.SCIM	Electromagnetic finite element module for inner rotor induction machine at no-load and load conditions, including squirrel cage induction machines (SCIM)	Couples Manatee with SIMULIA FEA magnetic solver for **non-linear magnetostatics** problem (automatic drawing, meshing and post processing). Stator and rotor currents are calculating using enforced Equivalent Electrical Circuit. Calculates the airgap radial and tangential flux density time and space distribution, as well as torque, and flux linkages. Includes skewing and any winding type, inner rotor. NL= no load FL = full load

e-NVH STRUCTURAL MODELS

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION
e-NVH STRUCTURAL MODELS *Structural models for vibration calculation in both early and detailed design phase*	SM.MEXP	Structural Mechanics finite element module based on modal expansion	Performs **modal expansion techniques** based on a **modal basis** to calculate **dynamic vibrations** of radiating envelope or specific user-defined nodes. Can be used when performing ALG.EVS under unit-magnitude stress waves or using an operational magnetic force loading.
	SM.ANLR	Structural Mechanics analytical module for radial flux machines	Calculates the natural frequencies of the outer structure (rotor or stator) based on an **equivalent cylinder** for radial flux machines. Calculates dynamic radial deflections of the outer structure under magnetic forces with an equivalent 2D ring model. Possibility to enforce modal parameters.
	SM.BEMR	Structural Mechanics Beam Element Model of radial flux stators	Calculates the natural frequencies of a stator tooth-yoke system based using a structural **Beam Element Model** suitable for radial flux machines. Calculates dynamic radial deflections of the outer structure under tangential & radial forces. Possibility to enforce modal parameters.
	SM.FBL	Structural Mechanics blocked force computation	Calculates the blocked forces at connection points defined by the user. Requires user to define blocked force sets in the 3D FEA modal basis.

e-NVH ACOUSTIC MODELS

SOLUTIONS	MODULE NAME	FUNCTION	DETAILED DESCRIPTION
e-NVH ACOUSTIC MODELS *Acoustic models for noise calculation in both early and detailed design phase*	AC.ANLR	Acoustics semi-analytical model for radial flux machines	Calculates analytically the **sound power level** radiated by the machine based on **analytic models of cylindrical shells** radiation factors (infinite cylinder or pulsating sphere) – only compatible with SM.ANLR
	AC.ERP	Acoustic model based on Equivalent Radiated Power	Calculates the **sound power level** radiated by the machine based on **Equivalent Radiated Power** - compatible with 3D FEA mechanical model.
	AC.SPL	Sound Pressure Level computation based on monopole source	Calculates the equivalent **sound pressure level** radiated by the machine using a monopole model based on directivity coefficient, distance to the source and equivalent absorption area.
	AC.SYN	Sound synthesis as .wav file	Synthesis the Sound Pressure Level as a normalized .wav file to listen the simulated noise (from SQ.SPL)
	AC.SQM	Sound Quality metrics	Loudness (Zwicker method for stationary signal), Specific loudness (Zwicker method for stationary signal), Sharpness (DIN 45692), Roughness (Daniel & Weber method), Specific Roughness (Daniel & Weber method) are available as post-processing of .wav generated by SQ.SYN.

DASSAULT SYSTEMES

DISCOVER MORE ON 3DS.COM

DASSAULT SYSTEMES