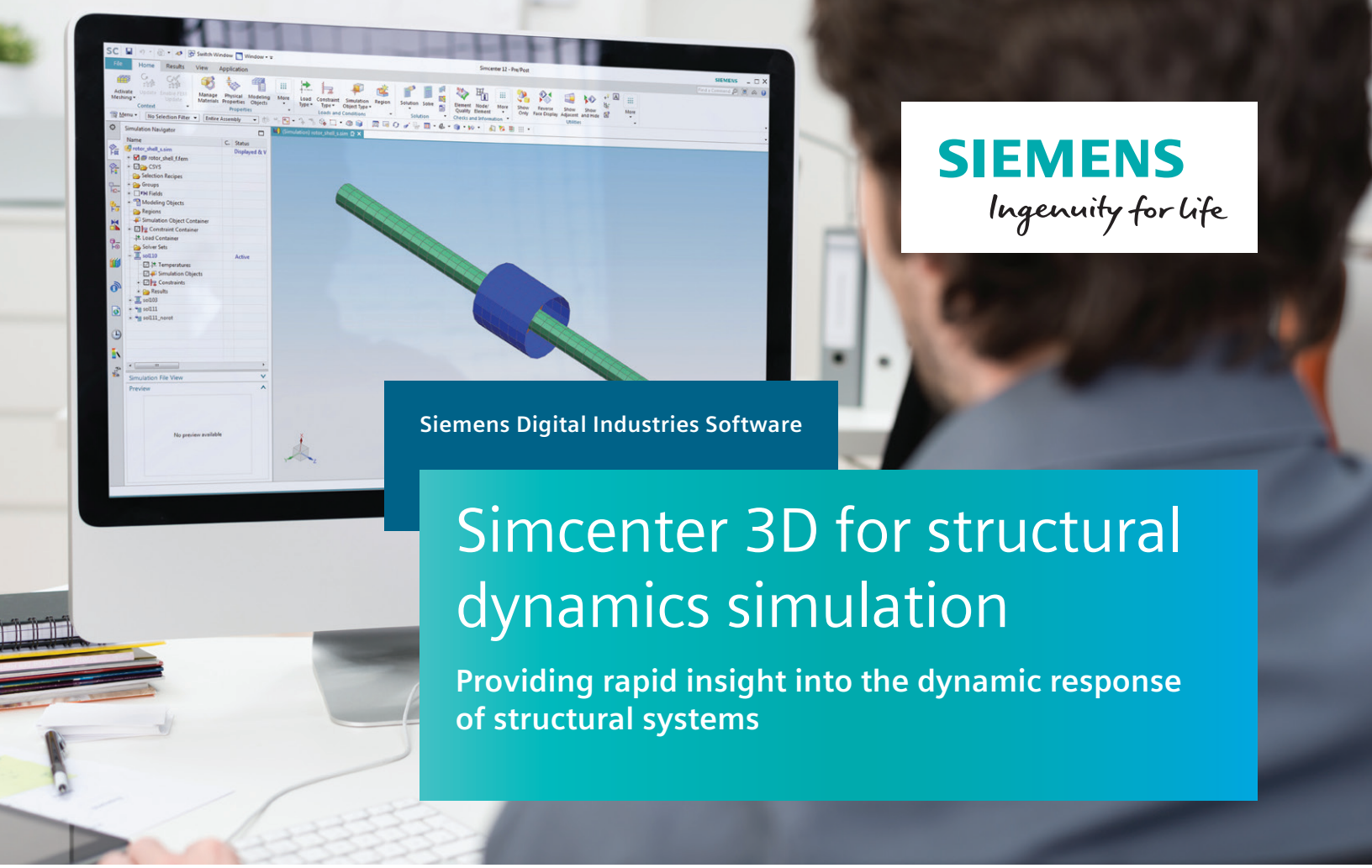


SIEMENS
Ingenuity for life

Siemens Digital Industries Software

Simcenter 3D for structural dynamics simulation

Providing rapid insight into the dynamic response of structural systems

Solution benefits

- Perform comprehensive dynamic analysis and accelerate product time-to-market
- Improve confidence in design by using Simcenter Nastran to investigate the product's performance under dynamic operating conditions
- Get insight and improve NVH performance by dedicated tool set for NVH postprocessing and troubleshooting
- Combine FE with measured data as loading or component's description for more realistic simulations and hybrid assemblies
- Rapidly evaluate and improve the dynamic performance of rotating systems
- Improve accuracy and increase confidence in your FE models by correlating with actual measured data

Simcenter™ 3D software offers a comprehensive solution to understand, analyze and improve the response when a system is subjected to dynamic loading. This includes the industry standard Simcenter Nastran® software for dynamic analysis as well as interactive solutions for general dynamic analysis in order to efficiently understand and avoid excessive vibrations and stresses. Moreover, dedicated capabilities are available for noise, vibration and harshness (NVH) engineering, rotor dynamics and correlation.

Advancing structural dynamics prediction

Starting from the product concept phase, analysts and specialists can rely on Simcenter 3D structural dynamics solutions to analyze design decisions and systematically improve dynamic characteristics of the system. The graphical user interface (GUI) of Simcenter 3D is fully customizable to suit your dynamic analysis processes by creating predefined templates and streamlining the product engineering process.

Simcenter 3D for structural dynamics simulation

NVH and rotor dynamics

Dedicated interactive and solver solutions are available to support industry workflows for NVH and the dynamics of rotating machinery.

Uniquely combine real-world test data in the simulation

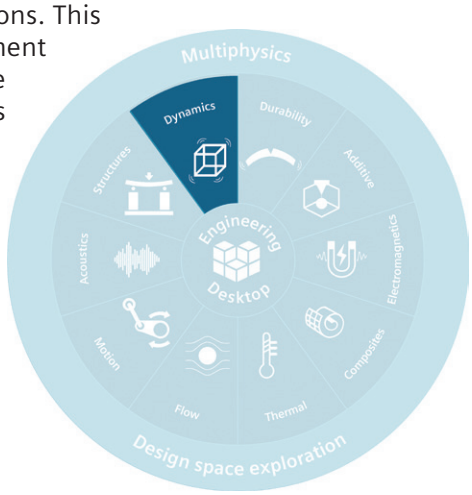
Using Simcenter 3D for structural dynamics solutions enables you to implement a distinctive hybrid simulation approach to leverage measured data as a component representation in a system-level finite element (FE) model, or to apply real-life loading to accurately and robustly accelerate the engineering process.

Increasing confidence in dynamic FE models

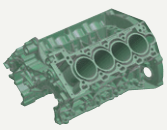
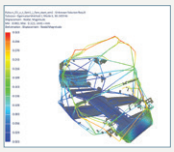
An integral part of making product engineering decisions is having confidence in the simulation models so you can accurately predict reality. Correlation solutions allow you to validate and improve the dynamic behavior of simulation models from physical test data.

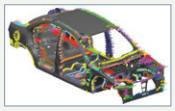
Providing a platform for multidiscipline simulation

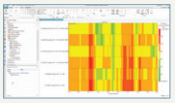
The Simcenter 3D structural dynamics solution is part of a larger, integrated multidiscipline simulation environment with the Simcenter 3D Engineering Desktop at the core for centralized pre-/postprocessing for all Simcenter 3D solutions. This integrated environment helps you to achieve faster CAE processes and streamline multidiscipline simulations that integrate dynamics and other disciplines like computing dynamic loads from motion, flow or electromagnetics solution.



Preprocessing	Pre-test and correlation	Multilevel assembly	Connections modeling	Cavity mesh	Loads	Solution	Postprocessing
Defeaturing, synchronous technology, convergent modeling, multi-CAD support, component meshing, boundary conditions	Senor and exciter locations, Operational deflection shape, modal assurance criterion (MAC), coordinate MAC, modal scale factor (MSF), cross-orthogonality	Component models sub-assembly, hybrid modeling with test modes and FRFs, automatic assembly label resolution	Universal connections, automated weld, joints, spring, damper bolt, and sealing identification	Solid to shell meshing, surface wrap, polygon body	Loads from measured data, dynamic loads from Simcenter 3D motion, mapped dynamic loads electromagnetics, enforced vibration loads	Model reduction techniques -modal, super-elements, FRFs	Modal, grid path, panel and structural model contribution, energy contributions, radiated power



What-if, optimization, feedback to designer

NVH workflow

Industry applications

Since most systems are subjected to loading that is dynamic in nature at some point in the lifecycle, understanding the dynamic behavior of structures is an important topic in many fields. Simcenter 3D provides a complete solution to predict dynamic behavior, be it for a component, subsystem or the complete system.

Automotive and transportation

NVH performance strongly impacts the driving experience and perception of quality. Simcenter 3D offers integrated tools and solvers to predict NVH characteristics and analyze the root cause of noise and vibration problems.

Aerospace and defense

Simcenter 3D helps you identify the structural weaknesses of a given design and optimize the vibration and dynamic performance of aeronautical structures subjected to dynamic loading. Dedicated solutions for rotor dynamics help you assess the performance of aero-engines to avoid instabilities.

Industrial machinery

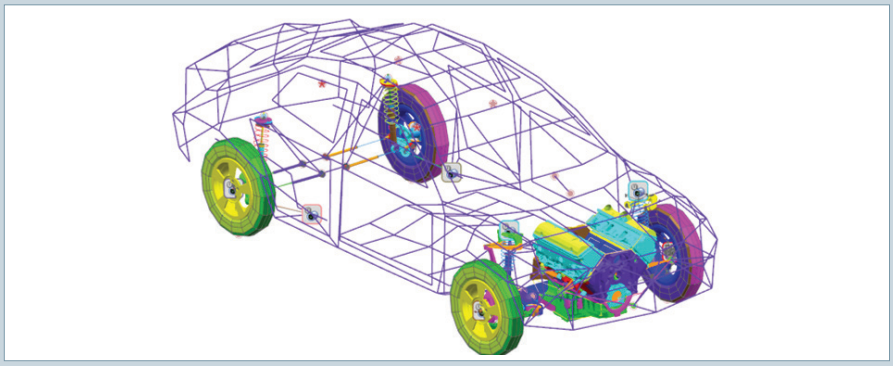
Machines that excessively vibrate during operation directly impact the quality of the manufactured product. Simcenter 3D delivers insights into the possible cause of machine vibrations, including rotating machinery.

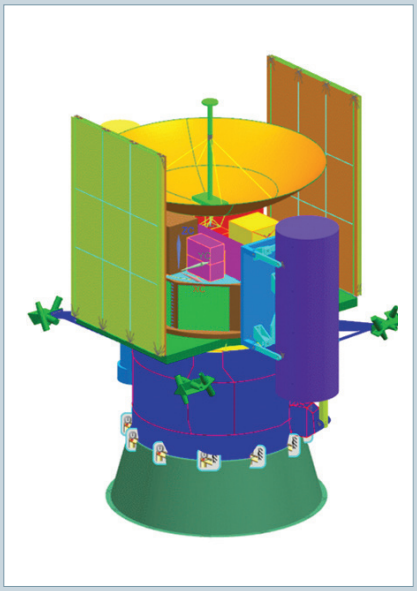
Electronics and consumer goods

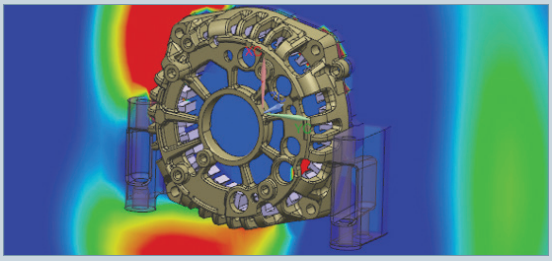
Simcenter 3D helps predict the dynamic characteristics of electronics and consumer goods to avoid excessive vibrations and stresses, which could result in fatigue or catastrophic failure.

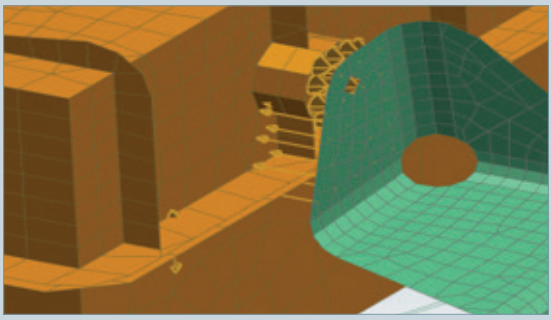
Marine

With an increasing demand for faster and lightweight ships, design engineers can rely on Simcenter 3D to predict the response of the overall structure and its individual components that are subjected to wave and current actions.









Dynamics

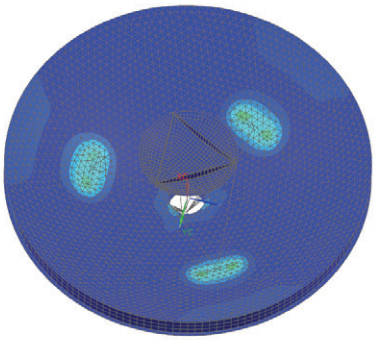
Response dynamics

NVH

Rotor dynamics

Simcenter 3D Response Dynamics

Simcenter 3D Response Dynamics software is an integrated solution that makes dynamic analysis more accessible and efficient for the analyst. It allows you to predict the forced response of structural systems under various loading conditions in a single graphical user environment, thereby eliminating the complexity of setting up and launching analysis and providing rapid insight into dynamic behavior. Analysis information can then be used to perform design studies to enhance the new product development process and confirm the quality of designs prior to physical prototyping and production.

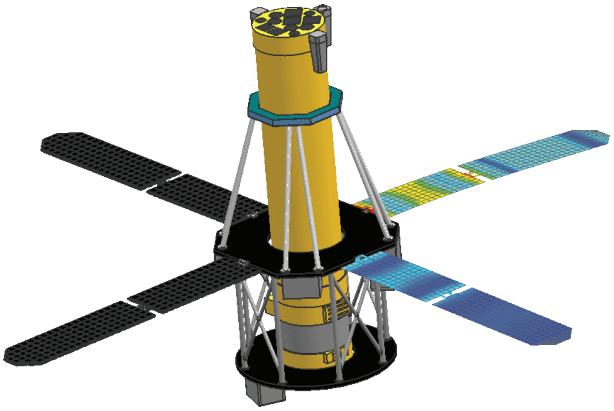


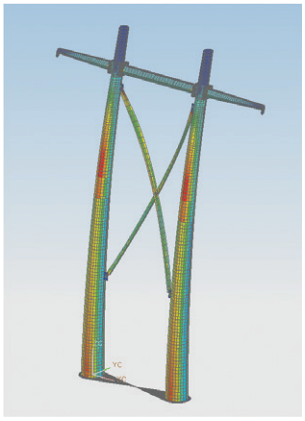
Module benefits

- Gain rapid insight into the dynamic response of structural systems
- Quickly generate and view results graphically
- Leverage all capabilities of Simcenter 3D to make quick design changes and provide rapid feedback on dynamic performance

Key features

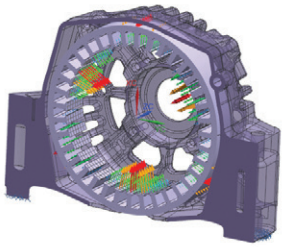
- Predict model response to transient, frequency (harmonic), random vibratory, shock spectrum, dynamic design analysis method (DDAM)(ship's shock loads) and quasi-static loads
- Efficiently calculate responses using a modal formulation starting from a priori solved set of Simcenter Nastran mode shapes
- Import, generate and edit the excitation information from computer-aided engineering (CAE) analysis and test data, including force, enforced motion and distributed loads (for example, dynamic pressure)
- Seamlessly interface analytical models with measured test data for instance-measured accelerations used for base-excitation loading

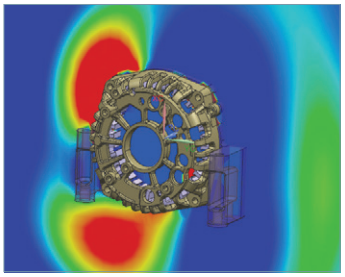


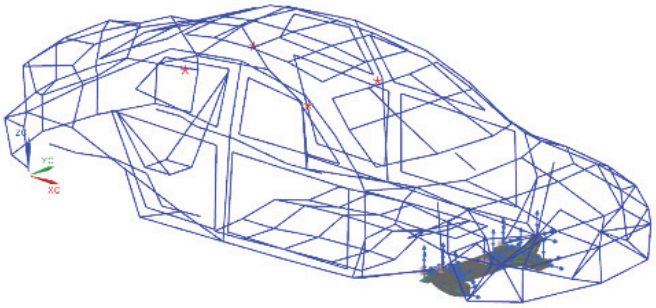


Simcenter 3D Noise and Vibration Modeling

Simcenter 3D Noise and Vibration Modeling offers a comprehensive set of noise and vibration pre/post capabilities addressing your need to build, understand, evaluate and optimize the noise and vibration performance of complete system and assembly models.





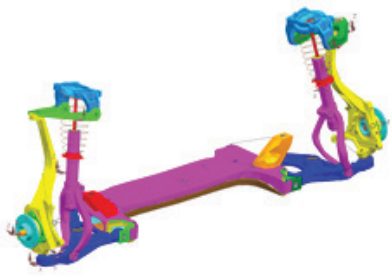


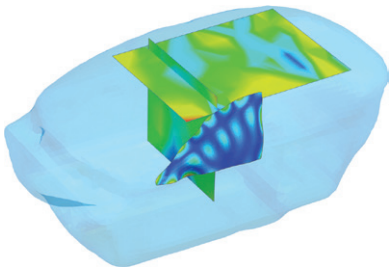
Module benefits

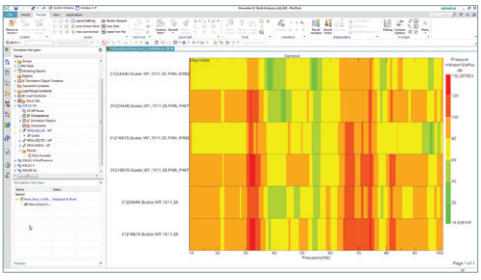
- Gain valuable insight into the noise and vibration performance of your design
- Use data from measurements and previous simulations to create relevant load cases
- Use dynamically equivalent, reduced component representations in your assembly model to speed up response analysis

Key features

- Intuitive noise and vibration diagnostics with support from modal, grid, panel, energy and path-contribution analysis
- Map test data and predecessor simulation data – multibody, electromagnetics (EM), computational fluid dynamics (CFD) – onto the vibro-acoustic simulation model, including time-to-frequency domain conversion for obtaining realistic loads
- Include frequency response function (FRF) and modal representations for structural components in assembly context using either simulation or test data
- Include acoustic transfer vectors (ATV) or vibro-acoustic transfer vectors (VATV) representations for acoustic or vibro-acoustic components, which are re-usable for multiload case scenarios for powertrain noise or cabin wind noise







Simcenter 3D Load Identification

Simcenter 3D Load Identification enables you to get accurate dynamics loadings of a structure. Operational loads are very important for accurate response prediction but are often impossible or difficult to measure directly. This product offers several ways of identifying the operational forces from measured data, either by mount stiffness method or inverse matrix method. For instance, in an inverse matrix method the operational vibration data can be measured in operational conditions and the transfer functions (FRFs) can be measured in controlled lab conditions or be obtained from simulations. These data are then combined in an inverse load identification case.

Module benefits

- Determine operational forces which is difficult or impossible to measure directly
- Get more realistic simulation by applying more accurate loading
- Combine measured loading data with FE simulations

Key features

- Mount method to estimate mount forces by combining operational vibration data at each side of the mount and mount stiffness data
- Inverse matrix method by combination of operational measurements and transfer functions
- Based on all measured data or a combination or operation measurements and simulation data
- Straightforward application and reuse of the identified forced to the simulation model

Test

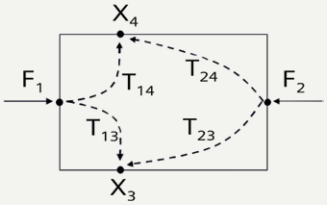
Mount stiffness method

- Operational vibrations on both ends of the mounts are measured
- Mount stiffness FRFs measured in lab

$$F(\omega)=K(\omega)[X_s(\omega)-X_t(\omega)]$$

Inverse matrix method

- Operational vibrations are measured
- FRFs measured in lab



$$\begin{bmatrix} F_1 \\ F_2 \end{bmatrix} = \begin{bmatrix} T_{13} & T_{23} \\ T_{14} & T_{24} \end{bmatrix}^{-1} \begin{bmatrix} X_3 \\ X_4 \end{bmatrix}$$

Simcenter 3D NVH Composer

The Simcenter 3D NVH Composer is a streamlined product to create full vehicle level FE models for NVH starting from subassembly models (BIW, Door, Suspension...).

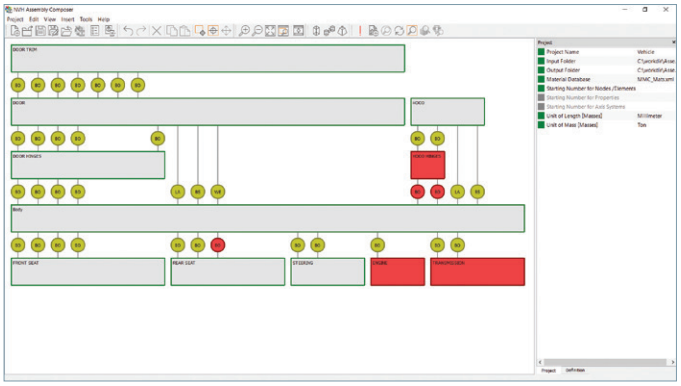
The product offers an interactive network display to define the topology of the full vehicle assembly by defining components, connectivity information and lumped mass trim information. Once the full vehicle layout is defined, the assembly is automatically created in Simcenter 3D and syncs it with the network display which is a simplified way to interact with the full vehicle assembly. All typical connections between full vehicle subsystems are available and the modeling is done for Simcenter Nastran.

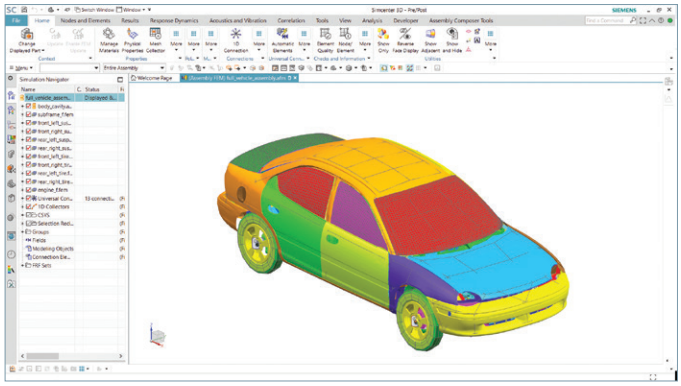
Module benefits

- Increase productivity and speed up full vehicle creation time
- Decrease human error by capturing assembly topology in layout files
- Take out the complexity of full vehicle assembly model creation
- Rerun easily in case of component changes

Key features

- Interactive network display to define full vehicle topology starting from subsystem FE models
- All typical full vehicle connections are supported (bolt, bushing, weatherstrip/sealing,...)
- Support of lumped mass trimming
- Automatic assembly from the defined full vehicle topology
- Integrated checking functionality
- Automatic synchronization between Simcenter 3D NVH Composer and resulting Simcenter 3D assembly

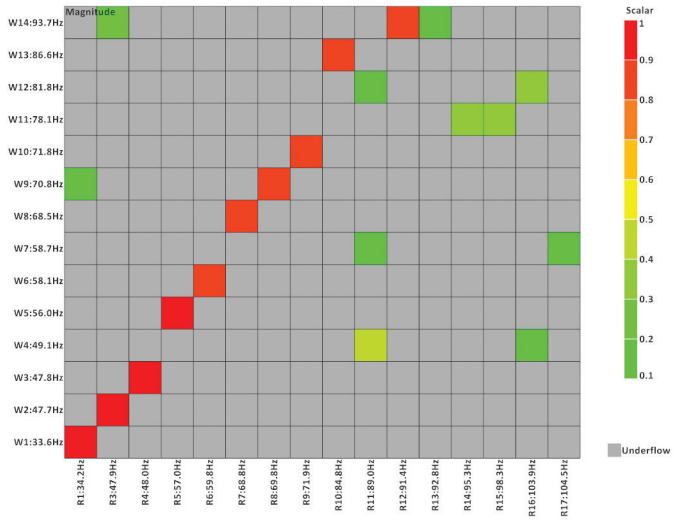




Simcenter 3D FE Model Correlation

Simcenter 3D FE Model Correlation software enables you to quantitatively and qualitatively compare simulation and test results, as well as two different simulations. It provides the tools needed to geometrically align the models, pair the modes from both solutions, view mode shapes and frequency response functions and calculate/display correlation metrics.

Correlation modal assurance criteria (MAC) results

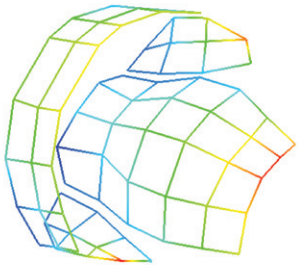


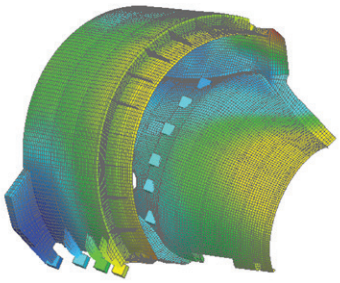
Module benefits

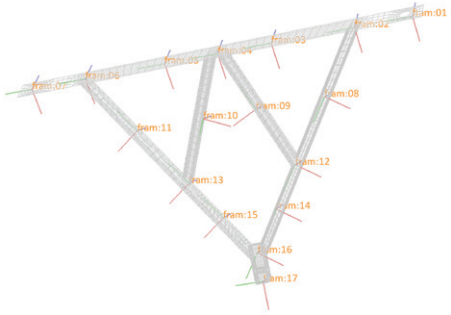
- Validate the accuracy of the finite element model for dynamic analysis
- Determine optimal sensor and exciter locations before performing physical modal tests
- Increase productivity by enabling model validation in the same environment as used for model creation and analysis

Key features

- Supports Simcenter Nastran, Simcenter Samcef® software, Abaqus, ANSYS and MSC Nastran results
- Test solution import using universal files or Simcenter Testlab™ software files
- Pretest planning for optimal number and location of sensors and exciters
- Intuitive and powerful test model alignment
- Automatic and manual mapping of FE model nodes and test sensors
- Variety of mode-pairing options and correlation criteria
- Interactive correlation with matrix and mode-shape displays



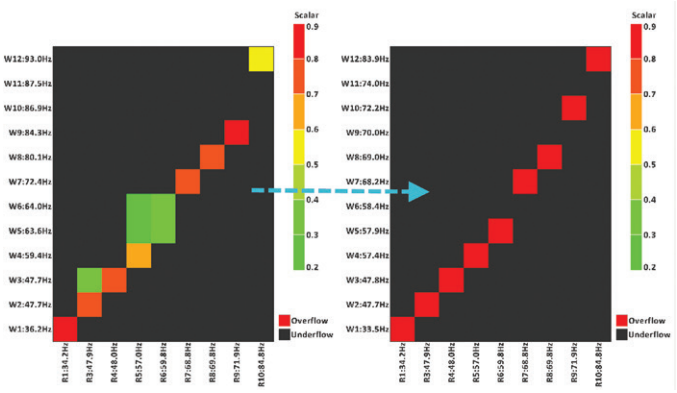




Simcenter 3D FE Model Updating

Simcenter 3D FE Model Updating software is an advanced correlation tool designed to automatically update FE models to match real-life test data. The tool is fully integrated with Simcenter 3D structure modules, making the updating process efficient, intuitive and productive.

Correlation modal assurance criteria (MAC) results



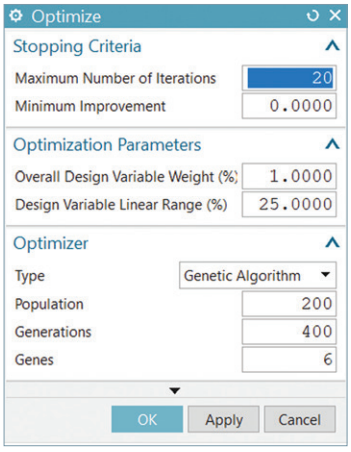
Before and after update.

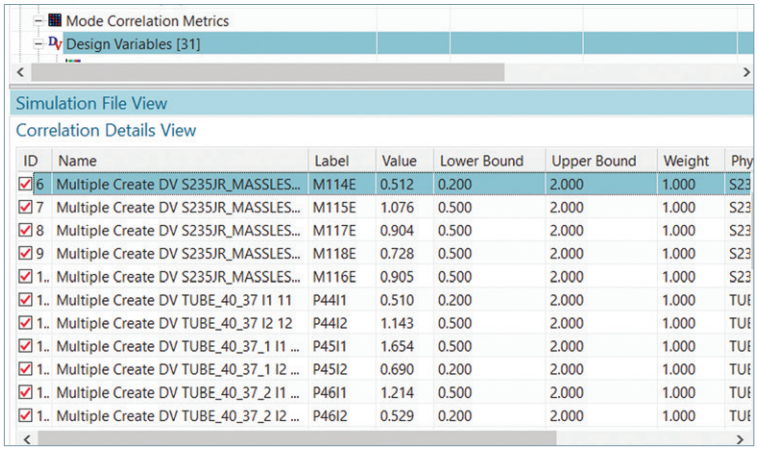
Module benefits

- Improve accuracy and increase confidence in your FE models
- Increase productivity by performing model updating in the same environment used for model creation and analysis
- Provide quick sensitivity-based approach

Key features

- Support material and physical property design variables such as beam section areas, shell or laminate ply thickness and Young's modulus
- Automatic generation of multiple design variables
- Automatic and manual design variable management
- Targets include modal frequencies, mode shape modal assurance criterion (MAC) and mode shape cross-orthogonality
- Simcenter Nastran or MSC Nastran SOL 200 licenses not required
- Embedded eigenvalue solver to achieve accurate updating of results in few iterations
- Automatic update of finite element method (FEM) that can be easily cascaded to all simulations





Simcenter Nastran Dynamic Response

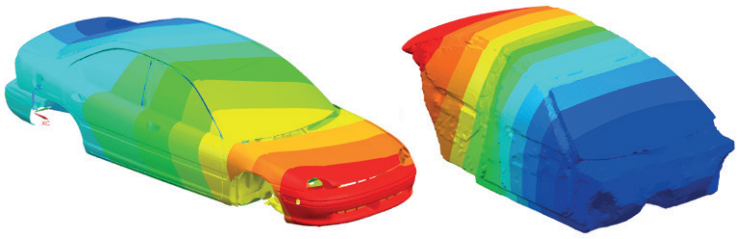
Simcenter Nastran Dynamic Response software is the core solver for dynamic finite element analysis (FEA). It enables the forced response analysis of a component or assembly subject to time- or frequency-varying excitations. Assessing dynamic response under different operating conditions is critical to industries such as automotive, aerospace, consumer products and other sectors that rely on electronic devices. It is possible to perform numerous what-if studies by virtually investigating the product's performance in various dynamic operating conditions by using the rich analysis tool set supported by Simcenter Nastran Dynamic Response.

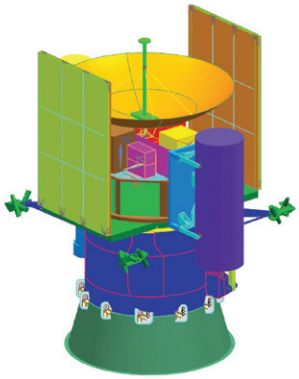
Module benefits

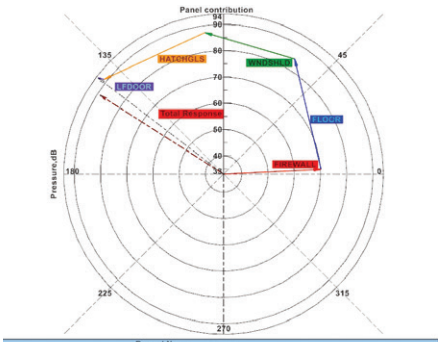
- Assess dynamic performance of your physical model
- Apply to all applications, industries and model sizes
- Save time and cost compared to physical build-test-break cycles

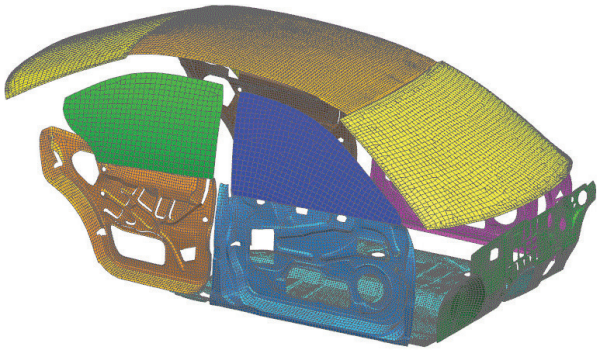
Key features

- Comprehensive dynamic response set. Supports frequency, transient, complex eigenvalue, random response, shock spectrum and other analysis
- Includes a list of eigenvalue solvers such as Lanczos, Householder, Hessenberg, etc.
- Supports numerous types of dynamic loading in time and frequency domain
- Fast frequency response solvers applicable to large models



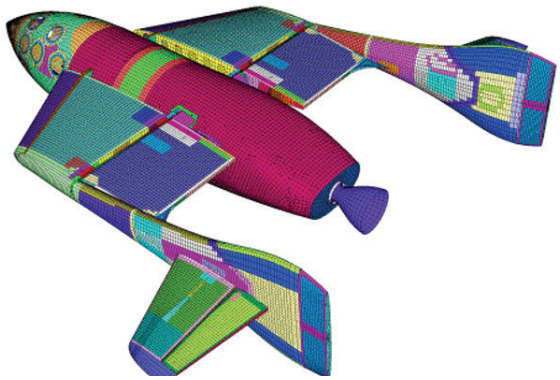


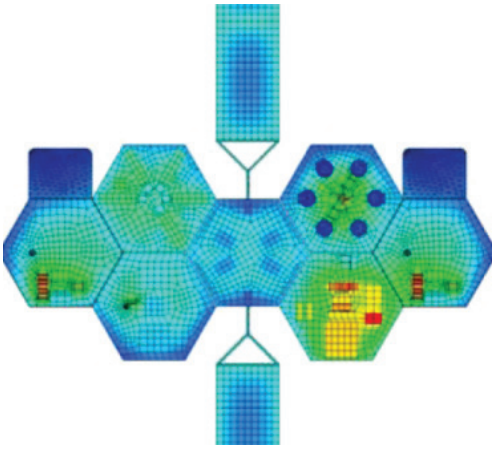




Simcenter Nastran Advanced Dynamics bundle

Simcenter Nastran Advanced Dynamics is a cost-effective bundle that provides a set of commonly used and advanced dynamics functionality, which includes Simcenter Nastran Dynamic Response, Simcenter Nastran FRF representations, Simcenter Nastran superelement analysis, Simcenter Nastran recursive domain (RD) modes, Simcenter Nastran DMP (distributed memory processing), Simcenter Nastran aeroelasticity and Simcenter Nastran direct matrix abstraction program (DMAP).





Module benefits

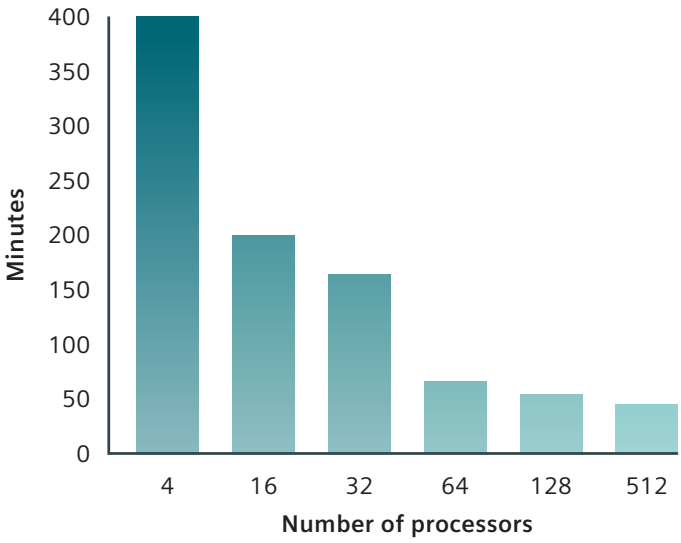
- Use cost-effective bundle to perform comprehensive dynamic analysis and accelerate product time-to-market
- Build system assembly models using a hybrid assembly of components based on finite elements and test measurements or reduced order models

Key features

- Includes all capabilities of Simcenter Nastran Dynamic Response
- Includes Simcenter Nastran FRF representation
- Computes the forced response of a product subject to time or frequency varying excitations
- Represents a component in the form of frequency response function, an alternate form of matrix representation of a component
- Large models consisting of more than 300 modes can be efficiently solved using recursive domain normal modes (RDMODES)
- Analyze structural models in the presence of an airstream using aeroelastic analysis
- Modify and adapt out-of-the-box (OOTB) solution sequences using DMAP

Simcenter Nastran DMP

Simcenter Nastran DMP facilitates a significant reduction in computing time by using multiple processors and computing resources. Simcenter Nastran DMP enables a higher level of parallelism and provides better scalability than shared memory processing (SMP).

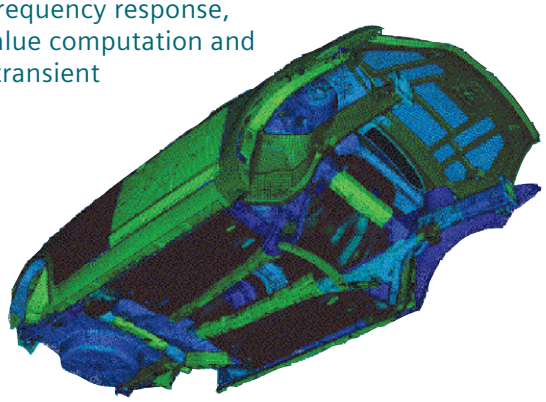


Module benefits

- Rapidly solve complex large problems
- Use the DMP solution to solve large problems more than 100 times faster than the Lanczos method on a single processor

Key features

- Simcenter Nastran has many options for partitioning solution domains, such as geometric, frequency, hierarchic, load and recursive domain partitioning
- DMP can also be operated on a single node that has multiple processors
- Supported dynamic solution types are modal and direct frequency response, eigenvalue computation and modal transient



Simcenter Nastran Rotor Dynamics

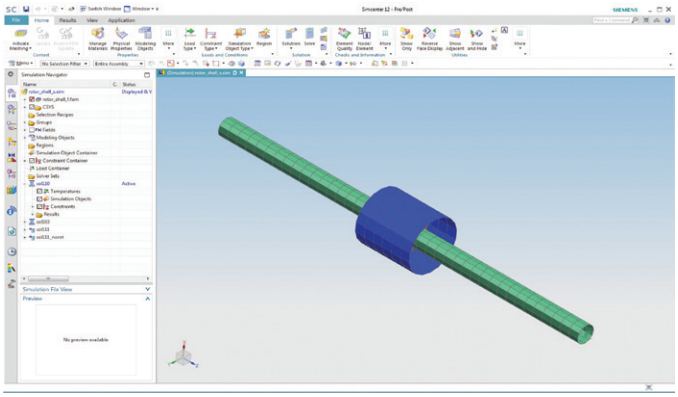
Rotating systems are subject to gyroscopic forces such as Coriolis and centrifugal forces that are not present in stationary systems. Simcenter Nastran Rotor Dynamics software provides the capability to predict the linear dynamic behavior of rotating systems. Users can simulate rotating system loads, perform synchronous and asynchronous analysis to generate Campbell Diagram data, predict whirl frequencies and critical speeds and detect instability in rotating components.

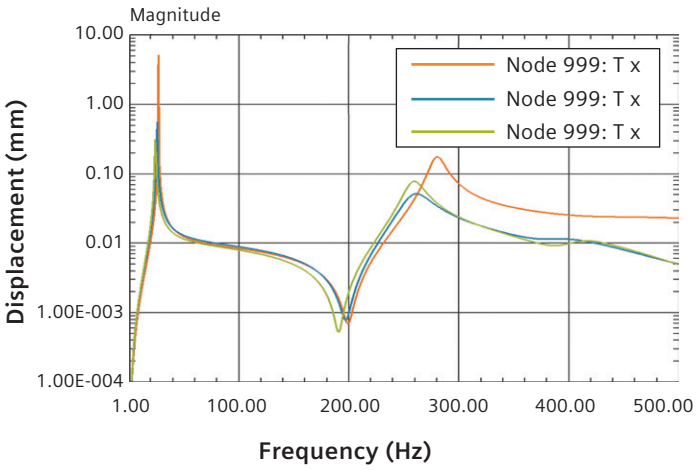
Module benefits

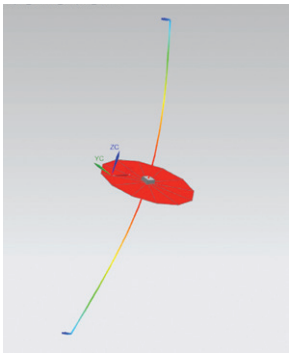
- Rapidly evaluate and improve the dynamic performance of rotating systems prior to physical prototyping and production commit in a fully integrated CAE environment
- Evaluate and develop optimal in-service design modifications to increase production process throughput of rotating equipment systems

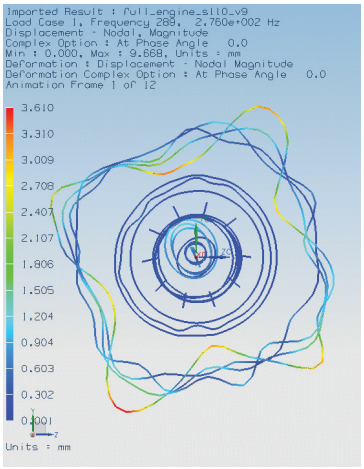
Key features

- Compute critical speeds and whirl frequencies from Campbell diagrams
- Study the linear dynamic behavior of the rotating system under rotor imbalance or any frequency-dependent (synchronous or asynchronous) or time-dependent excitation
- Analyze symmetric and asymmetric rotor models, as well as multiple rotors with different rotation speeds and orientations
- Include differential stiffness to compute centrifugal softening effects
- Solve the model in the fixed or rotating coordinate reference system



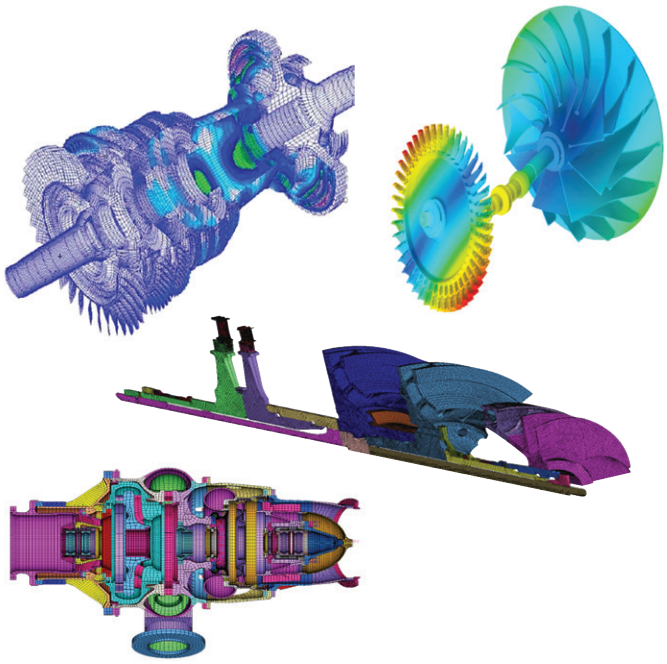






Simcenter Samcef Rotor

Simcenter Samcef® software, rotor module is a solution for simulating the behavior of high-speed rotating machines such as turbo machines, aero-engines, propellers, fans, etc. The solution is tailored specifically for rotor dynamics specialists and more generally for engineers focusing on global dynamics of rotating machines. Simcenter Samcef Rotor is a standalone solution that includes a dedicated pre-post environment, and solver modules for linear and nonlinear computations as well as superelement creation and recovery.



Module benefits

- Enable the study of large problems in complex and realistic scenarios
- Perfectly simulate the global dynamics of the rotor and stator assembly
- Achieve accurate simulations by taking nonlinear effects into account in connection elements
- Reduce the vibration level and avoid harmful resonances by predicting them
- Improve product performance and reduce costly physical prototypes

Key features

- Build the most accurate rotor dynamic models thanks to a large library of elements (1D, 3D, 2D Fourier multi harmonics, cyclic symmetry, etc.), taking advantage of symmetry with maximum flexibility
- Powerful model reduction by superelements to include reduced representations in larger assembly models
- Library of bearings and seals (rolling element, hydrodynamic, squeeze film dampers, gears, etc.) to model assembly connections
- Symmetric or asymmetric rotor and stator can be computed, as well as multiple rotors with different rotation speeds and orientations
- Enable different analysis types: critical-speed analysis, harmonic-response analysis and transient analysis
- Dedicated postprocessing tools according to industrial standards

Capabilities chart

General capabilities	Specific capabilities	Simcenter 3D Response Dynamics	Simcenter 3D Noise and Vibration Modeling	Simcenter 3D Load Identification	Simcenter 3D NVH Composer	Simcenter 3D FE Model Correlation	Simcenter 3D FE Model Updating	Simcenter Nastran Dynamic Response	Simcenter Nastran Advanced Dynamics bundle	Simcenter Nastran DMP	Simcenter Nastran Rotor Dynamics	Simcenter Samcef Rotor bundle
	Structural dynamics											
Structural linear dynamics	Modal transient response	•						•	•			
	Modal frequency response	•						•	•			
	Direct transient response							•	•			
	Direct frequency response							•	•			
	Cyclic direct frequency response							•	•			
	Complex modal analysis							•	•			
	Shock spectrum	•						•	•			
	Random vibration	•						•	•			
	Dynamic design analysis method	•						•	•			
Advanced dynamic analysis	Superelements								•			
	Coupled fluid-structure (vibro-acoustic) analysis							•	•			
	Frequency transfer functions (FRF)								•			
	Recursive domain normal modes (RDMODES)								•			
	Fast frequency response (FASTFR)							•	•			
	Direct matrix abstraction programming (DMAP)								•			
	Aero-elasticity								•			
Parallel processing	Shared memory parallel (SMP)							•	•	•		
	Distributed memory parallel (DMP)								•	•		

General capabilities	Specific capabilities	Simcenter 3D Response Dynamics	Simcenter 3D Noise and Vibration Modeling	Simcenter 3D Load Identification	Simcenter 3D NVH Composer	Simcenter 3D FE Model Correlation	Simcenter 3D FE Model Updating	Simcenter Nastran Dynamic Response	Simcenter Nastran Advanced Dynamics bundle	Simcenter Nastran DMP	Simcenter Nastran Rotor Dynamics	Simcenter Samcef Rotor bundle
	Noise and vibration (NVH)											
NVH model creation	2D full vehicle topology definition from subassemblies				•							
	Full vehicle assembly automation				•							
	Bolt				•							
	Spring and bushing				•							
	Weatherstrip/sealing				•							
	Seam weld				•							
	Kinematic (e.g. latch and bumpstop)				•							
	Lumped mass trimming				•							
NVH post-processing	Modal contribution		•									
	Panel/grid contribution		•									
	Path contribution		•									
	Energy contribution		•									
System level NVH (hybrid)	Modal representations (modal coupling preprocessing)		•									
	FRF representations (FRF coupling preprocessing)		•									
	FRF analysis case		•									
Additional NVH	Transfer path analysis		•									
	Load identification analysis (mount method, inverse force)			•								
	Principal component analysis											
	Rotor dynamics											
Rotor models	1D (line models), 2D, 3D models										•	•
	2D multi-harmonics models											•
	Mixed modeling representation											•
	Multiple rotors										•	•
	Cyclic symmetry											•
	Multi-stage cyclic symmetry											•
Symmetry and superelements	Symmetric rotor with symmetric stator										•	•
	Symmetric rotor with unsymmetric stator										•	•
	Unsymmetric rotor with symmetric stator										•	•
	Unsymmetric rotor with unsymmetric stator											•
	Superelement for the nonrotating parts										•	•
	Superelement for the rotating parts											•
Bearing models	Springs, dampers and bushings										•	•
	Linear bearings										•	•
	Hydrodynamic bearings											•
	Roller bar bearings											•
	Gears											•
	Magnetic bearings (digital controller)											•
	Squeeze film dampers											•
Dynamic rotor analysis	Campbell diagram and stability analysis										•	•
	Modal analysis (normal/complex)										•	•
	Harmonic response										•	•
	Linear transient response										•	•
	Nonlinear transient response											•
	Direct or modal computations										•	•

General capabilities	Specific capabilities	Simcenter 3D Response Dynamics	Simcenter 3D Noise and Vibration Modeling	Simcenter 3D Load Identification	Simcenter 3D NVH Composer	Simcenter 3D FE Model Correlation	Simcenter 3D FE Model Updating	Simcenter Nastran Dynamic Response	Simcenter Nastran Advanced Dynamics bundle	Simcenter Nastran DMP	Simcenter Nastran Rotor Dynamics	Simcenter Samcef Rotor bundle
	Correlation											
Pretest and correlation	Pretest planning					•						
	Test model alignment and geometry mapping					•						
	Test-analysis, analysis-analysis correlation					•						
	Modal correlation (MAC, COMAC, X-orthogonality, etc.)					•						
	FRF correlation					•						
	Local coordinate systems					•						
	Mode pairing and visual comparison					•						
	Correlation with Simcenter Testlab					•						
Model updating	Design variable definition						•					
	Dedicated DESOPT 200 - model update solution						•					
	Design variable sensitivities						•					
	Frequency, mode shape (MAC and X-orthogonality)						•					
	Embedded eigenvalue solver						•					
	Multiple optimization algorithms						•					
	FEM and SIM update						•					
	Model updating for Simcenter Nastran						•					

Note: Simcenter 3D Engineering Desktop is a minimum prerequisite for all Simcenter 3D products. Other dependency or prerequisites may apply for individual products.

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