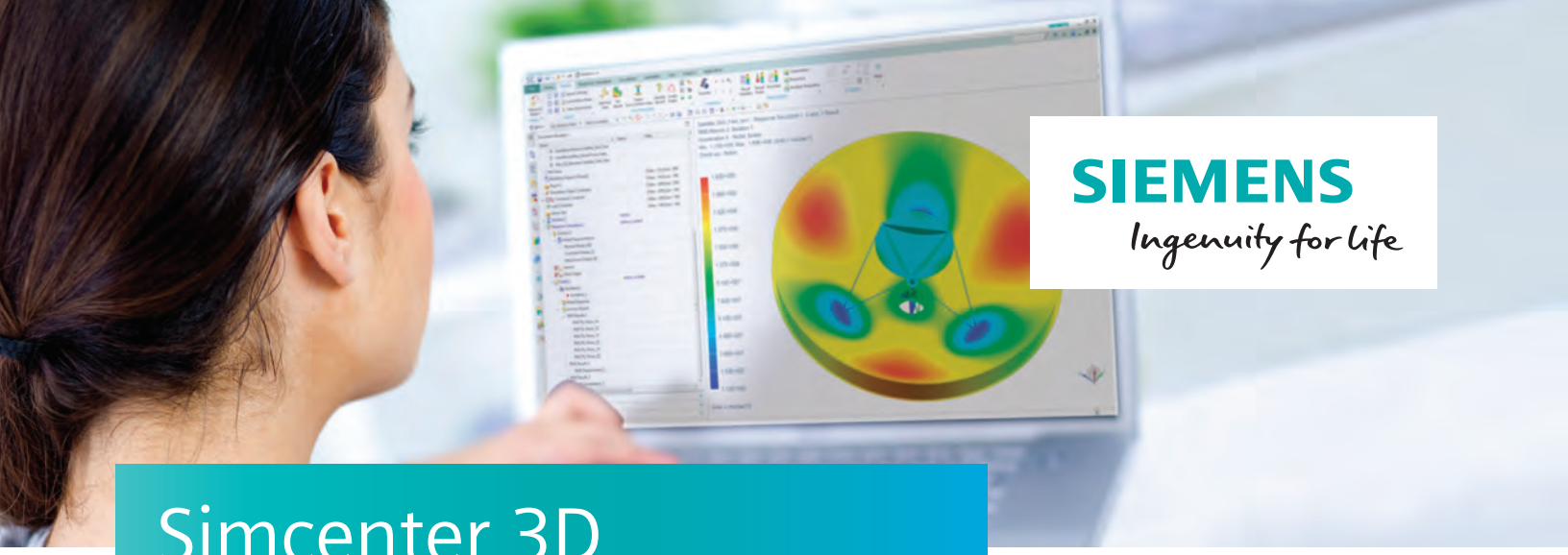

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Simcenter 3D Response Dynamics

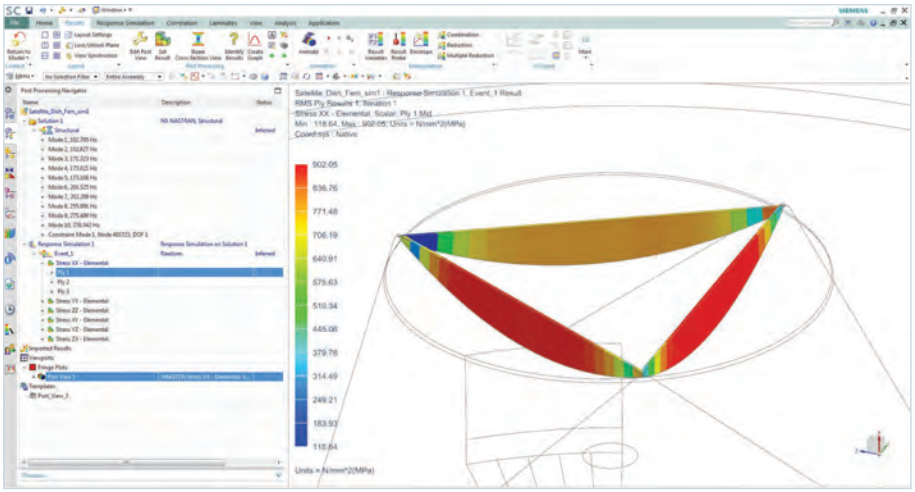
Interactively analyzing structural dynamic response

Benefits

- Reduce costly physical prototypes by using response simulation to improve product performance
- Gain insight into the dynamic response of structural systems
- Interactively evaluate the dynamic forced responses of a structural model
- Quickly generate and view results graphically
- Leverage the associative geometry environment to make quick design changes and provide rapid feedback on dynamic performance

Summary
Simcenter™ 3D Response Dynamics software is an add-on module to the Simcenter 3D Engineering Desktop environment that predicts the dynamic responses of structural systems under various loading conditions. Augmenting the capabilities of Simcenter 3D Structures, Simcenter 3D Response Dynamics produces a broad range of XY plot results and color contour results that aid the user in determining the integrity and suitability of product designs subject to dynamic loads. Analysis information can then be used to perform design studies to enhance the new product development process and ensure the quality of designs prior to physical prototyping and production.

A flexible way to predict responses
Simcenter 3D Response Dynamics enables users to interactively evaluate the dynamic forced responses of a structural model. A set of flexible tools allows you to predict response of a model to a set of applied transient, frequency (harmonic), random vibratory or shock spectrum loads. A modal formulation is used to very efficiently calculate response using a prior solved set of mode shapes. The Simcenter™ Nastran® solver is used for solving mode shapes which are stored in a standard OP2 file format. Both normal modes and static modes for advanced

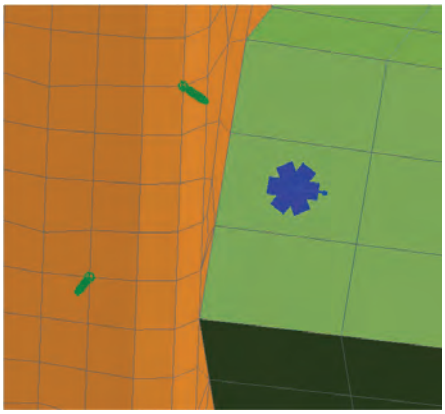


Calculate root mean square (RMS) stress results for each ply in a laminate composite structure.

Simcenter 3D Response Dynamics

Data processing tools

- Export data to universal files, RPC III files (MTS), DAC files (nCode), mat files (MATLAB®) and spreadsheet text files
- Import data from spreadsheet text files
- Perform mathematical and statistical processing and calculations
- Manage, sort and edit an extremely high volume of functions in multiple files
- XY graphics for display and probing
- Convert functions between time domain and frequency domain (for example PSD functions)



Model with sensors and strain gages.

methods are computed using the standard Simcenter Nastran Basic package. Response Simulation attaches the OP2 file and extracts mode shape data as needed for simulating the wide range of dynamic analyses.

Simcenter 3D Response Dynamics enables you to import, generate and edit the excitation information from CAE analysis or test data, including force, enforced motion and distributed loads (for example dynamic pressure). The user can then apply excitations to the structure, controlling dynamic modes, static corrections and damping assumptions to define an event for analysis. Motion, force and stress responses can be predicted as either XY plots at specific locations or as contour results over sections of the model or the complete model. Strength and peak results can be generated for elements by sorting through all time points or all frequencies for the maximum values. Extensive plotting and contour display capabilities allow results to be reviewed and compared with other data or allowables.

Generating a dynamics model

The first step is to develop a Nastran finite element model of the structure in review. Simcenter Nastran models can be prepared using Simcenter 3D Engineering Desktop or any other FE pre/postprocessing solution such as MSC.Patran™, HyperMesh®, etc. Model setup is consistent with standard Nastran modal solutions with the addition of parameter settings to output binary result (OP2) files from the Simcenter Nastran solution, which are used as the basis of the interactive solution. Both normal modes and static modes for advanced methods are computed using the Simcenter Nastran Basic package. The OP2 result files are imported into Simcenter 3D Engineering Desktop and used in the response simulation.

Function tools

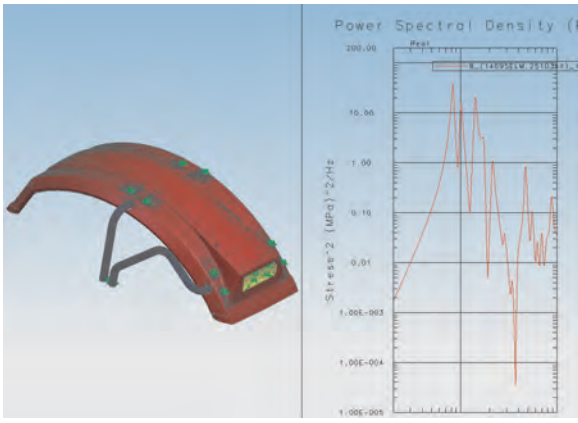
The function toolkit is part of the Simcenter 3D Engineering Desktop package and is used by Simcenter 3D Response Dynamics both to define input loads and to store output results. Function tools are used for plotting, managing and performing math operations and include scaling, offsetting, Fourier transform and interpolation. In addition to these tools, Simcenter 3D Response Dynamics provides a set of operators that are specific to Simcenter 3D Response Dynamics in a Java®-based toolkit. These can be used, for example, to convert frequency domain PSD data to time domain transient (and vice versa). One of the strengths of the Java application is that it is open so that users can define their own function operator if needed.

Interface to test

Simcenter 3D Response Dynamics can be used to interface your analytical models with measured test data. With the toolkit function you can import test data. The measured test data can then be used as an input load. For example, measured accelerations could be used for a base excitation load. Another interaction with test is to compare analytical response predictions with measured responses. This verifies the accuracy of the model. To facilitate comparison of analytical responses with test data, Simcenter 3D Response Dynamics has virtual sensors and strain gages. Analogous to accelerometer measurements from a test, virtual sensors predict motion responses (acceleration, displacement or velocity) at specified locations with orientations. Similarly, virtual strain gages are used to predict strain (or stress) response analogous to test measurements from strain gage rosettes. With both sensors and gages, it is possible to compute responses at many locations with one request. Sensor and gage responses can be computed for transient, frequency, PSD or quasi-static inputs. The virtual results can then be viewed overlaid with the corresponding test measurements.

A wide range of analysis types

Event type	Description
Transient	Calculates the dynamic response of a structure to a set of excitations that vary over time. A transient excitation is either a point load (force or enforced motion) applied to a nodal degree of freedom (DOF) or a distributed load applied over regions of the model. The software calculates the response at each instant in time. Examples of transient excitations are base accelerations on a structure to represent earthquake loads or road surface inputs for a vehicle driving on a test track.
Frequency	Calculates the steady-state responses of a structure to a set of oscillatory excitations. A frequency excitation can be either a point load (force or enforced motion) applied to a nodal DOF or a distributed load. The software calculates the response at each frequency. An example of frequency analysis is predicting automobile steering wheel vibration from engine vibration or wheel imbalance.
Random	Calculates the power spectral density (PSD), root mean square (RMS) and level crossing rate (LCR) results of a structure to fully or partially correlated random excitations. A random excitation can be a nodal force PSD function, an enforced motion PSD function (displacement, velocity, acceleration) or a distributed load. An example of a random simulation is predicting the vibration response of a satellite payload on a rocket during launch.
Response spectrum (also called shock response spectrum)	The response spectrum method is an approximate, efficient means for predicting response to transient shock excitations. It calculates the peak response of a structure to base excitations or applied forces defined by response spectrum functions. The peak response is computed by one of several modal combination methods such as the square root of the sum of squares. An example of a shock spectrum analysis is predicting the peak responses of a structure due to an earthquake excitation.



A wide range of analysis types *continued*

Event type	Description
DDAM (dynamic design analysis method)	Calculates the dynamic response of a ship's components to shock loads. You can apply DDAM excitations for surface ships or submarines. Loads can be applied in vertical (Y), athwartship (Z) and fore/aft (X) directions. Components can be located at ship's hull, deck or plate mountings, and elastic or elastic-plastic response can be specified. DDAM was developed by the United States Navy. The implementation in Simcenter 3D Response Dynamics supports use of either the U.S. Navy specification DDS-072-1 or NRL-1396. You can use the program's default DDAM coefficients or read coefficients from a text file. If confidentiality is needed, the software allows you to enter the DDAM coefficients at run time.
Quasi-static	Calculates the response of a structure to a set of excitations that vary over time. The response is computed as a linear combination of time-scaled static load responses. Therefore it is not based on modes, and dynamic effects are not included. A quasi-static excitation is either a point load (force or enforced motion) applied to a nodal degree of freedom or a distributed load applied over regions of the model. An example of quasi-static excitation includes transient loads that vary slowly relative to the frequencies of the structure and hence can be treated as static loads.

Surface vessel tower stress result from DDAM analysis.

Type of excitation	Type of response analysis
Distributed load	Transient, frequency, random vibration, quasi-static
Nodal force	Transient, frequency, random vibration, quasi-static
Base excitation and enforced motion (displacement, velocity, acceleration)	Transient, frequency, random vibration, response spectrum, quasi-static

Result output

Response format	Type of analysis	Where generated	Response types
Response function (for XY plots)	Transient, frequency, random vibration, quasi-static, FRF, transmissibility	At nodes, at nodes on elements, at element centroids	Displacement, velocity, stress, strain, acceleration, reaction force, shell stress resultants, element force and sensor
Response results datasets (for contour displays)	Transient, frequency, quasi-static	At given points in time: whole structure, selected nodes, selected elements. At given points in frequency: whole structure, selected nodes, selected elements	Displacement, velocity, acceleration, stress, strain energy, shell stress resultants and element force
Strength results datasets (for contour displays)	Transient, frequency, random vibration, response spectrum, DDAM, quasi-static	For the whole event: whole structure or selected elements	Maximum dynamic stresses normalized by allowable values
RMS and level-crossing results* (for contour display)	Random vibration	Whole structure, selected nodes, selected elements	Displacement, acceleration, stress, shell stress resultants and element force
Peak value results** (for contour display)	Transient, frequency, response spectrum, DDAM, quasi-static	Whole structure, selected nodes, selected elements	Displacement, acceleration, stress, shell stress resultants and element force

* Also calculates RMS and level-crossing rate of the von Mises stresses for dynamic stress analysis.
** Also calculates peak von Mises stresses for dynamic stress analysis.

Product availability

Simcenter 3D Response Dynamics is an add-on capability in the suite of Simcenter 3D applications. It requires a core seat of either Simcenter 3D Engineeering Desktop or Simcenter 3D Structures as a prerequisite. If used with Simcenter 3D Engineering Desktop, a license of Simcenter Nastran Basic is also required. Simcenter 3D Structures already includes the Simcenter Nastran Desktop solver.

Simcenter 3D Response Dynamics is available on most widely used hardware platforms and operating systems including Windows and Linux.

Siemens Digital Industries Software
siemens.com/plm

Americas +1 314 264 8499
Europe +44 (0) 1276 413200
Asia-Pacific +852 2230 3333

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