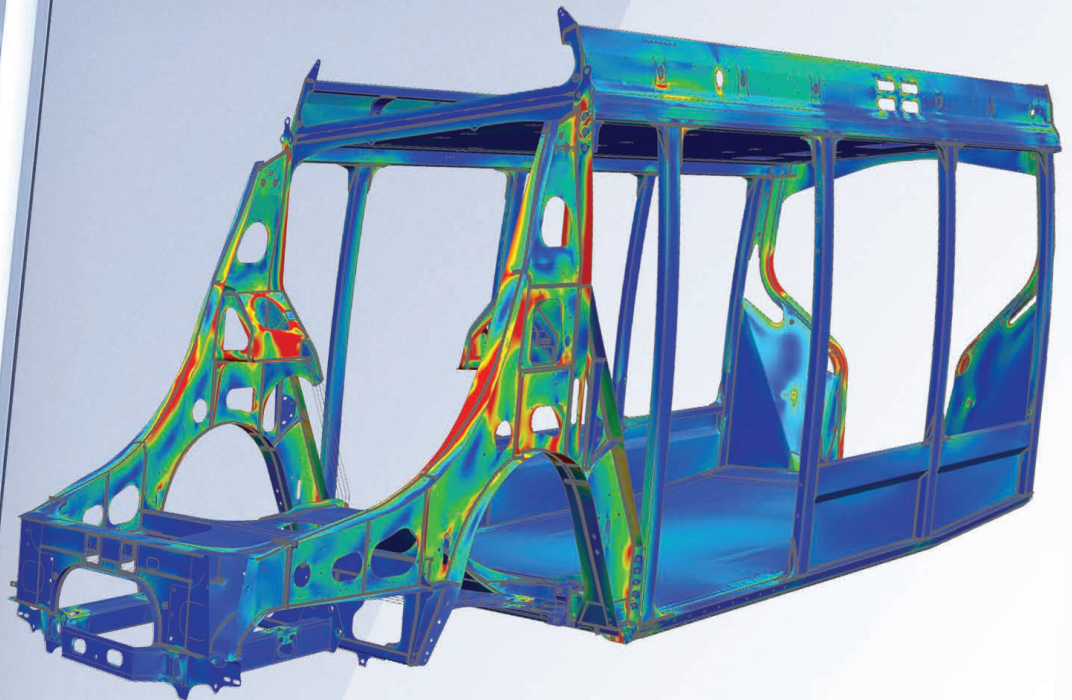


SIEMENS

Ingenuity for life



Siemens PLM Software

Simcenter Nastran

Facilitating the development of
high-performance, reliable and
optimized designs

[siemens.com/simcenter](https://www.siemens.com/simcenter)





Product development challenges

Choosing the right simulation tools

Companies need to consider technology, scalability and integration when evaluating simulation tools:

- The right technology confirms simulation can accurately represent the physical environment
- Scalable solutions can be adjusted to product complexity, high-performance computing resources and a broad range of users' skill levels
- Integrating with other simulation tools and product development applications is important for developing an efficient and effective computer-aided engineering (CAE) solution

“In the aircraft and aerospace business, there is no room for poor quality engineering.”

Ben Terrell
Perth Engineering Manager
Aquila Engineering

The Simcenter Nastran advantage



A premier FEA solver

An industry standard for over 40 years, Nastran is a finite element (FE) solver for stress, vibration, structural failure, heat transfer, acoustics and aero-elasticity analyses. Manufacturers and engineering suppliers in aerospace, automotive, electronics, heavy machinery, medical devices and other industries rely on Simcenter™ Nastran® software for their critical engineering computing needs so they can produce safe, reliable and optimized designs within ever shorter design cycles.

Develop products faster

Using Simcenter Nastran for simulation helps engineers find problems with product designs prior to conducting any costly physical tests. With Simcenter Nastran, engineers can be confident their design will work when the first physical prototype is tested.

Increasing product quality

Simcenter Nastran enables engineers and designers to rapidly evaluate many more design concepts than can be accomplished with physical prototypes. Simulation allows engineers to better understand and optimize design tradeoffs for quality, cost and performance.

Reduce development and warranty costs

Using Simcenter Nastran for simulation is credited with significantly reducing research and development (R&D) costs because building a computer model and digitally testing performance is cheaper, faster and more effective than the physical prototyping processes it replaces. With increased product quality, companies can also save on potential warranty costs.

Siemens' performance engineering vision

Our vision is to deliver engineering simulation solutions that drive product performance decisions across the complete product lifecycle.

Siemens PLM Software has delivered on this vision by building the Simcenter portfolio. Simcenter helps you go beyond simple verification to performance prediction by combining simulation, physical testing and data analytics to spot unforeseen trends.



“Customers in the defense, satellite and commercial aerospace industries are all using Simcenter Nastran, and they provide data to us in the Simcenter Nastran format.”

Kristopher Notestine
Manager, R&D
Damping Technologies Inc.

Multiple solution domains – one solver

Simcenter Nastran can be used to solve most structural analysis problems: linear and nonlinear analysis, dynamic response, rotor dynamics, vibro-acoustics, aero elasticity and optimization. The advantage to having all of these solutions available in a single solver is that input/output file formats are the same for all solution types, greatly simplifying modeling processes.

Linear analysis

Simcenter Nastran features a complete range of structural and thermal linear analysis functionality: linear static, transient and buckling. Distinct material models are available to address material behavior, namely isotropic, orthotropic and anisotropic.

Advanced nonlinear analysis

Simcenter Nastran nonlinear solutions enable you to address problems as simple as a plastic catch and as complex as a car body roof crush using post-buckling analysis. Depending on the rate of loading, you can use either static or transient nonlinear analysis.

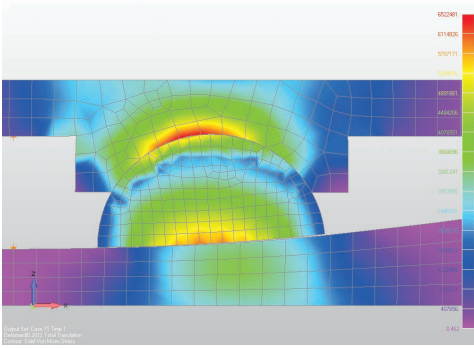
The availability of nonlinear material models realistically characterize plasticity, hyper-elasticity, viscoelasticity and creep behavior of materials. You can also integrate your nonlinear material models with Simcenter Nastran.

Contact behavior, a typical nonlinear effect, is a universal phenomenon and almost all users need it to develop a realistic model. Simcenter Nastran offers robust contact algorithms with advanced formulations that include effects such as friction, large sliding, temperature dependence and time variation.

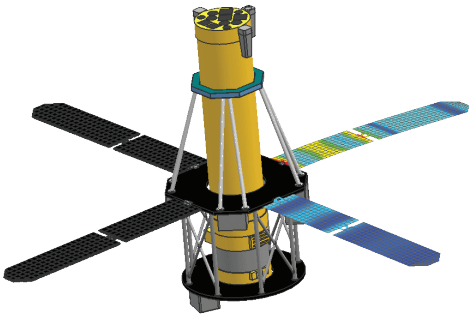
Nonlinear solutions affected by the loading order can be handled by the Simcenter Nastran multistep solution capability, which allows users to sequence a set of loads and boundary conditions.

“Nonlinear dynamics is a core feature of Simcenter Nastran; it has helped us fill a gap in civil and structural engineering.”

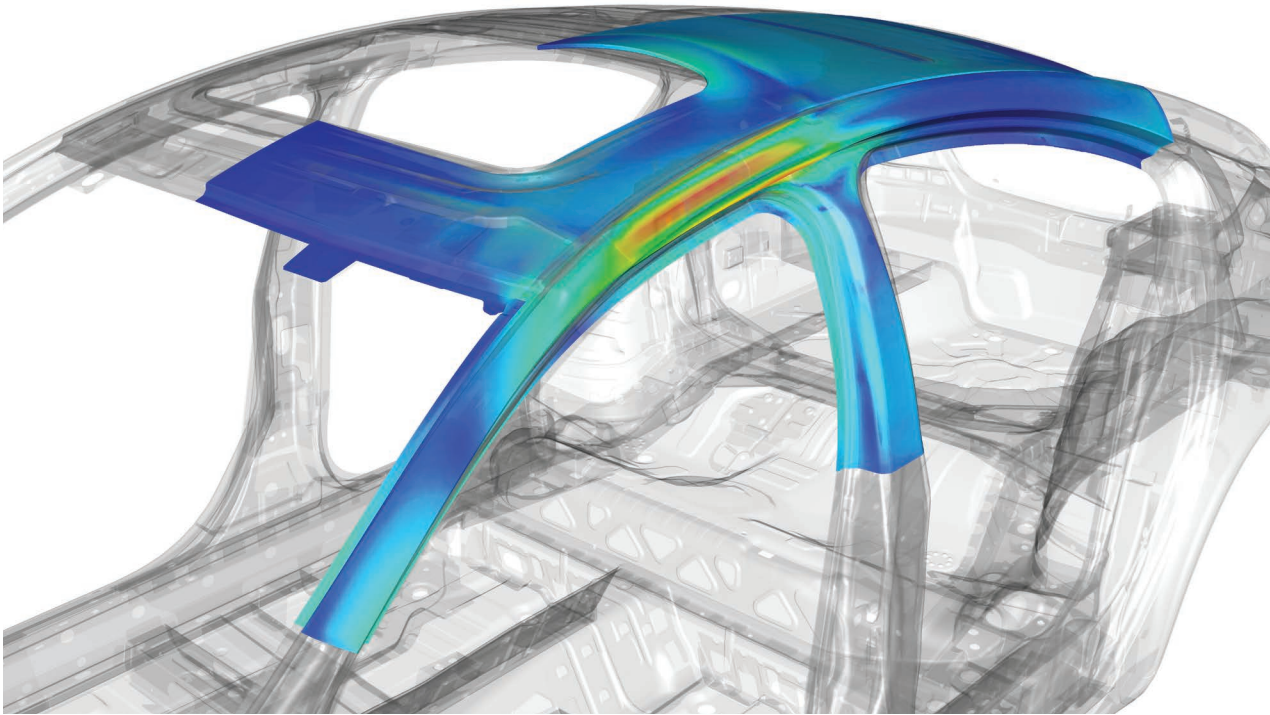
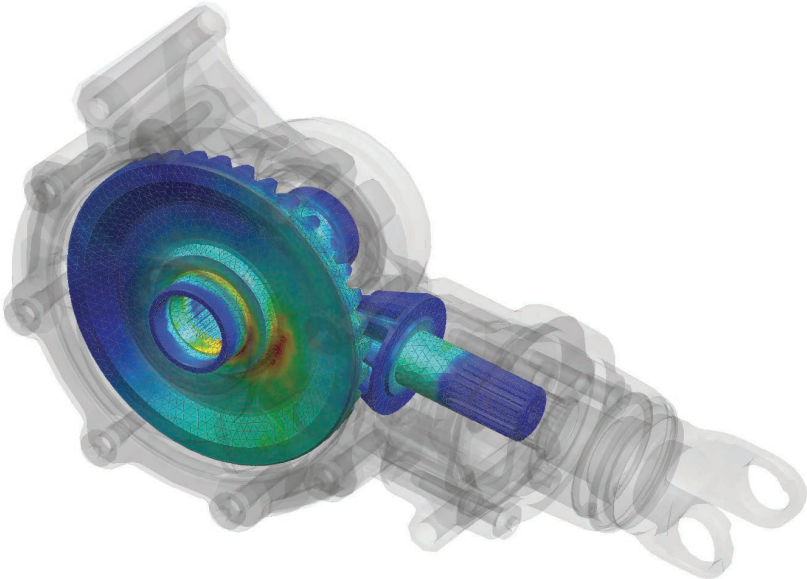
Roberto Nascimbene
PhD Researcher, Structural Analysis Sector Coordinator
Eucentre



Detail of the contact surfaces of a pendulum isolator.



Flexible bodies within a motion analysis.



Integrating specialized software into the analysis process

Dynamic analysis

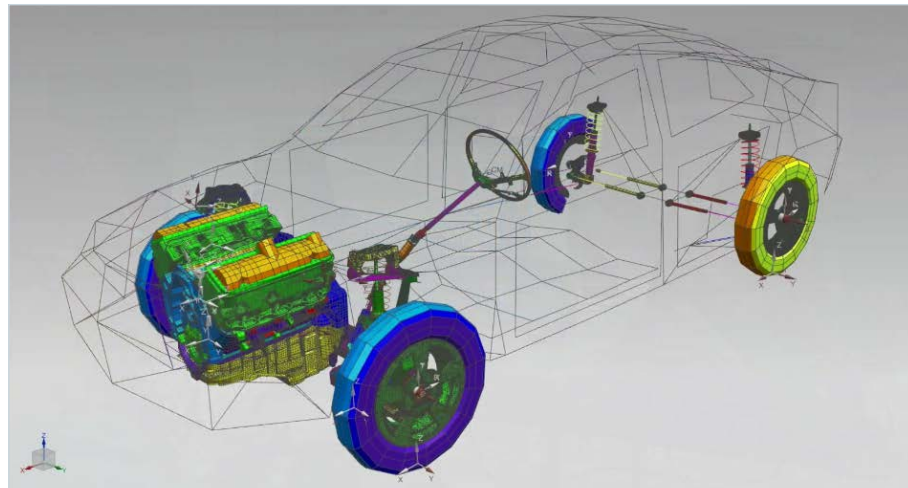
Simcenter Nastran offers complete solutions for problems involving transient, random loading, shock response and more. Dynamics analysis results are often used as input to other types of analyses, such as motion analysis for flexible bodies. Simcenter Nastran provides links to motion simulation tools, such as Simcenter 3D Motion, RecurDyn, Adams, SIMPACK and the MATLAB® environment, to simplify simulation workflows.

Noise and vibration analysis

Simcenter Nastran offers all the solution types needed for analyzing noise and vibration, including normal modes and direct and modal frequency response, such as an effi-

cient coupling method between a structure and acoustic cavity. Simcenter Nastran is well known for being a highly efficient solver for basic and advanced noise, vibration and harshness (NVH) solutions, including solving large modal and fast frequency response computations.

Simcenter Nastran also supports advanced NVH hybrid analysis, which abstracts the dynamics of a component or a subsystem by its matrix representation.



“Today’s advanced NVH analysis applications require seamless integration of special purpose proprietary software tools into the analysis process. Simcenter Nastran has set new standards with access to, and exchange of Nastran finite element data. This enables us to extract maximum benefit from the CAE tools at the heart of the virtual development process.”

*Dr. Otto Gartmeier
Manager, NVH CAE
Daimler AG*

Providing diversified analysis capabilities

Acoustics analysis

Simcenter Nastran enables you to perform a pure radiation analysis or fully coupled vibro-acoustic analysis of both interior and exterior acoustic problems. Porous material law, dedicated acoustic loads and leading functionalities like load-independent acoustic transfer vectors (ATV) and absorbing automatic matched layer (AML) support the creation of efficient and lean simulation models that lead to rapid noise prediction.

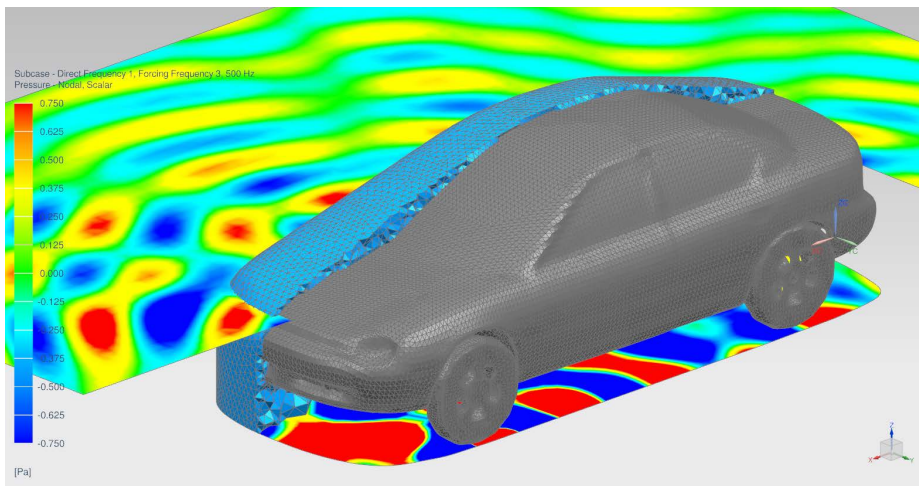
Rotor dynamic analysis

Simcenter Nastran includes capabilities to predict dynamic behavior of rotating systems subject to rotation-induced gyroscopic and centrifugal forces. Rotor dynamic analysis

allows you to predict critical speeds and develop designs that operate safely. Both modal and direct methods can be applied for complex eigenvalues, frequency response and transient response analyses.

Aero-elastic analysis

Aero-elastic analysis enables you to analyze structural models in the presence of an air-stream. With Simcenter Nastran, you can simulate static aero-elastic trim analysis, flutter and dynamic aero-elasticity response applied to a variety of unsteady loadings, including gust. As such, it can be applied to the design of airplanes, helicopters, missiles, suspension bridges and even tall chimneys and power lines.



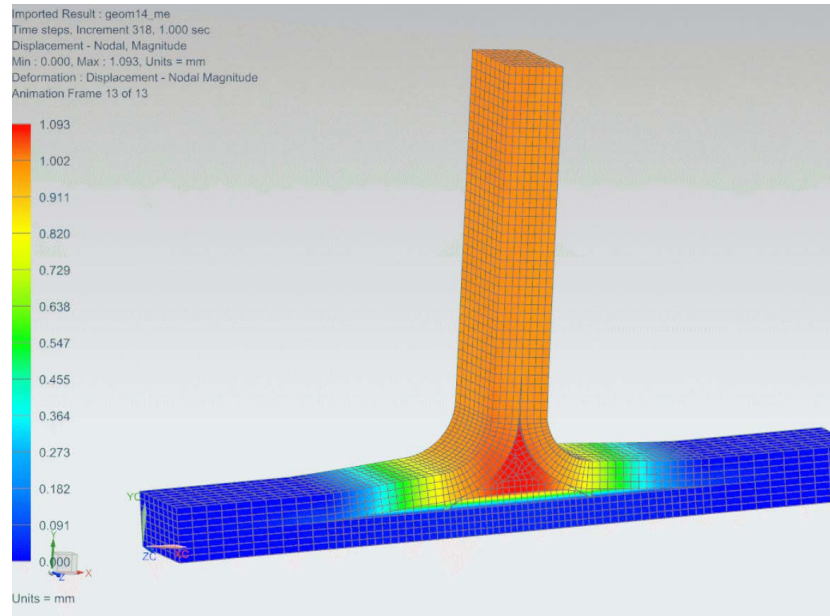
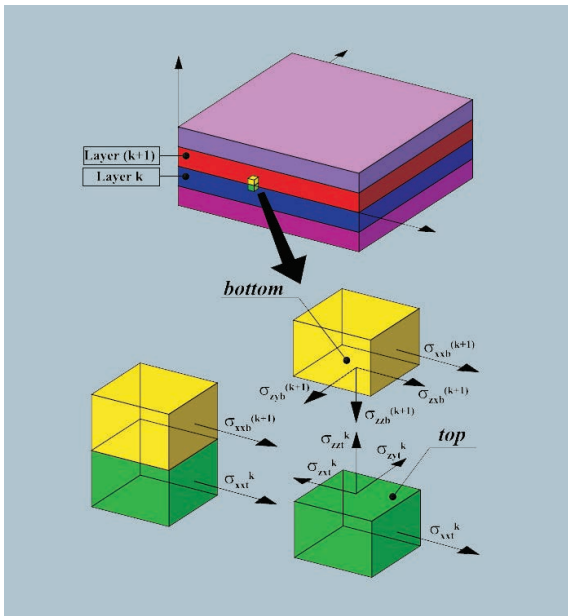
Evaluating composite designs

Composites

Simcenter Nastran is at the leading edge of simulating the behavior of products made of composite materials, and provides capabilities for continuously developing material models and element types. Strength of composite designs can be evaluated using first-ply failure criteria such as Tsai-Wu or Hoffmann, advanced progressive failure methods or composite delamination methods.

Using design optimization techniques, you can essentially develop the optimal ply layout for a design, accounting for thickness, orientation and material stiffness.

Solid composite element



Finding the right combination

Coupled physics

In the real world, product behavior is not determined by a single, isolated physical domain. Instead, effects from one physical phenomenon will simultaneously impact how a product reacts to another physical domain. For example, thermal-mechanical effects are crucial to jet engine engineering. Simcenter Nastran allows you to analyze thermal contact problems that will also impact structural performance. Basic coupling can be achieved with Simcenter Nastran by using its thermal and structural analysis solution sequences. For coupling solutions that need more advanced thermal modeling, engineers can couple the multistep nonlinear solution of Simcenter Nastran with Simcenter 3D Thermal.

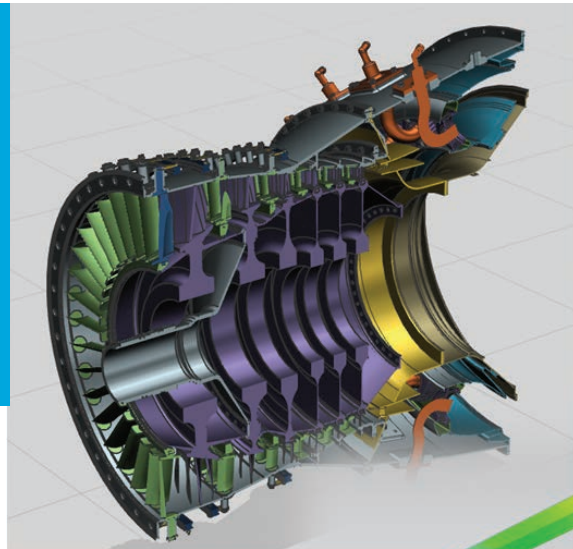
Optimization

Simcenter Nastran offers parameter and topology optimization solutions. The topology optimization algorithm finds an optimal geometric shape to carry loads or meet certain responses and/or manufacturing constraints. The resulting shapes are often described as “organic” and they can be manufactured to fit well with additive manufacturing methods.

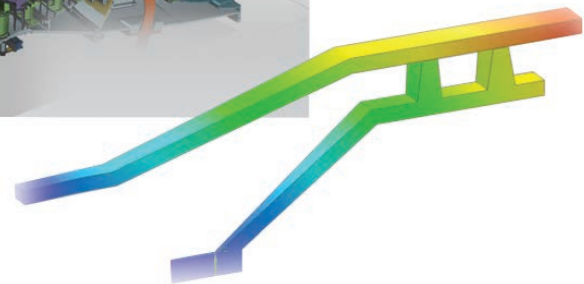
The sophisticated algorithms of Simcenter Nastran facilitate searching the design space and finding the right combination of parameters that will yield optimal performance. Selectable parameters include shell thickness, composite ply thickness, composite ply orientation, material properties and spring stiffness.

“The analysis processes provided unprecedented fidelity with the results, allowing the design to pass the critical design review with flying colors.”

Sean McAllister
Principal Mechanical Engineer
BAE Systems, IEWS



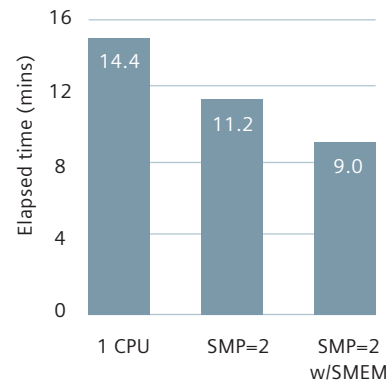
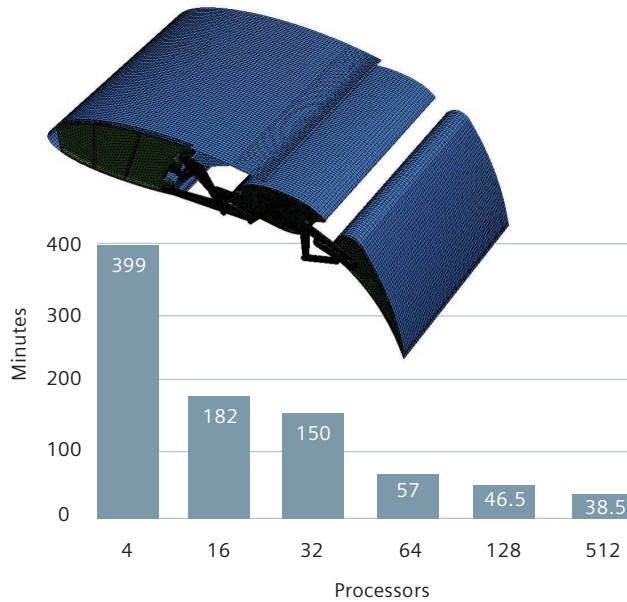
Thermo-mechanical coupling between Simcenter Nastran and Simcenter 3D Thermal



Computational performance and numerical accuracy

Finite element analysis (FEA) models have consistently grown in size as engineers continue to tackle complex problems. Today, complex models with millions of degrees-of-freedom (DOF) have become the norm. At the same time, computers have also evolved and multicore processors have become the de facto standard.

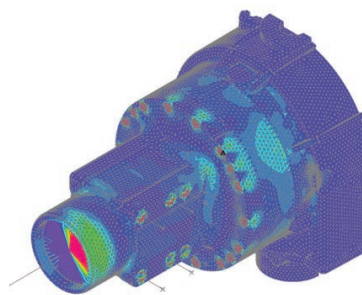
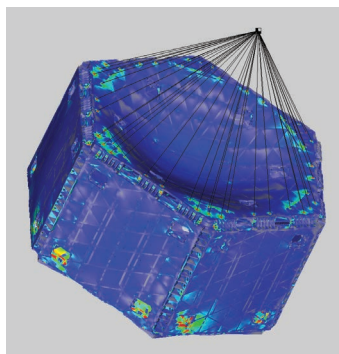
Taking advantage of multiple parallel processors can significantly reduce solution runtimes compared to traditional serial solutions that use one processor. Shared memory parallel processing (SMP) uses multithreading, and can be used to compute intensive operations, such as matrix factorization, forward backward substitution and matrix multiplication. Since every solution sequence involves matrix multiplications or matrix factorization, SMP can be activated in all solution sequences as long as the hardware supports it.



DMP with recursive domain partitioning example:

- Modal solution of simulated airplane wing model
- 50 million degrees of freedom
- 1,521 modes below 200 Hz
- Each node: dual quad-core Intel Nehalem 2.67GHz, 24GB RAM

SMP performance for a model with 68K nodes solved on a laptop with Intel Core 2 Duo processor and 8GB RAM.



Distributed memory parallel processing

Simcenter Nastran distributed memory parallel processing (DMP) solutions can be run on a single node or across multiple compute nodes. When running in DMP mode, Simcenter Nastran spins off multiple processes that communicate via the Message Passing Interface (MPI) within or across nodes. Simcenter Nastran offers the following methods for distributed processing:

Geometric domain partitioning is available for static and dynamic solutions. The system-level matrices are automatically partitioned and distributed to different MPI processes.

Frequency domain partitioning is available for dynamic solutions. The frequency range of interest for eigenvalue computation as well as frequency response is automatically partitioned into segments that are distributed to different MPI processes.

Hierarchic domain partitioning is a hybrid of geometric and frequency domain methods. This approach is used for modal solutions and allows scalability to higher levels than could be obtained with either method individually.

Load domain partitioning is useful when there is a large number of load cases in a linear static analysis problem. Instead of partitioning the finite element model (FEM), the load matrix is partitioned among MPI load domain partitioning, which does not need communication between processors, and is nearly linearly scalable.

Recursive domain normal modes

Recursive domain normal modes (RDMODES) is a high-performance eigen solution technique that significantly reduces the cost of eigenvalue analysis for large FE models. In combination with RDMODES, Simcenter Nastran offers several options for calculating fast frequency responses, and is able to handle large structural and vibro-acoustic models typically used in NVH.

Simcenter Nastran also supports CDH/AMLS software to drastically accelerate Simcenter Nastran modal and frequency response calculations. RDMODES supports both SMP and DMP for greater solution scaling.

Scalability for this method has been achieved with up to 512 central processing units (CPUs). The recursive DMP solution can solve

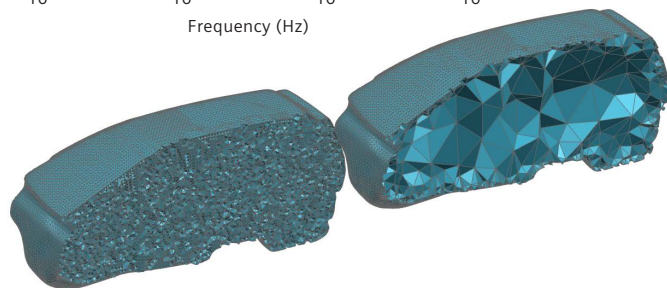
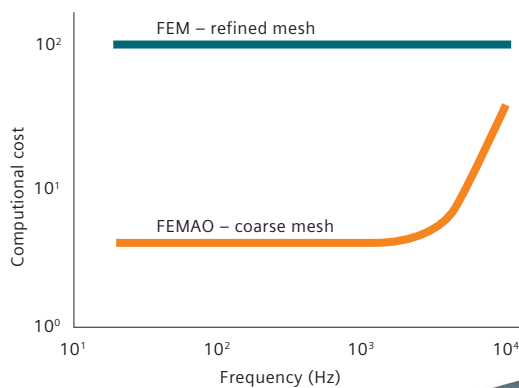
large problems more than 100 times faster than the Lanczos method on a single processor.

Fast frequency response

Modal methods are often used in forced response dynamic analysis because they reduce the model size considerably, and the modes can usually be treated as uncoupled, which facilitates fast solutions. But for full vehicle NVH, damping and vibro-acoustic coupling effects lead to modal coupling, which makes for more computationally expensive solutions. Simcenter Nastran has exceptional frequency response methods that can be used to efficiently solve such problems.

Finite element method adaptive order for acoustics

The finite element method adaptive order (FEMAO) is a higher-order polynomial technique that provides accurate and faster solutions for acoustic and vibro-acoustic analyses. You can use the FEMAO method for one-way coupling of vibro-acoustic analysis, two-way coupling of vibro-acoustic analysis, and uncoupled acoustic analysis. You can use the FEMAO method for predicting acoustic transfer functions for pass-by noise, aircraft engine fan noise, perfecting transmission loss for a large volume industrial muffler, etc.

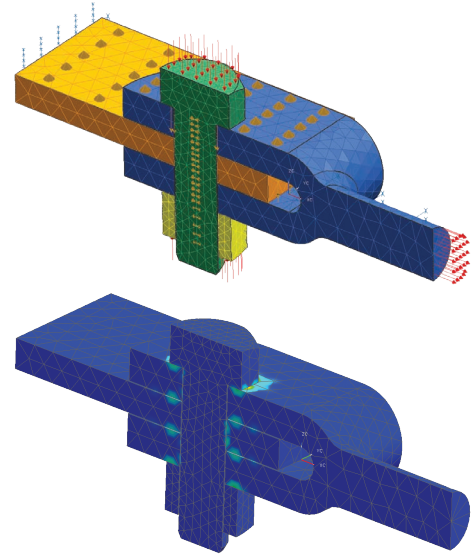


Ease of modeling and engineering workflow

Engineers can create Simcenter Nastran models with a number of available FEA pre-processors that support Simcenter Nastran. But to simplify the modeling process even more, Simcenter Nastran includes features that enable engineers to connect complex components and speed process time.

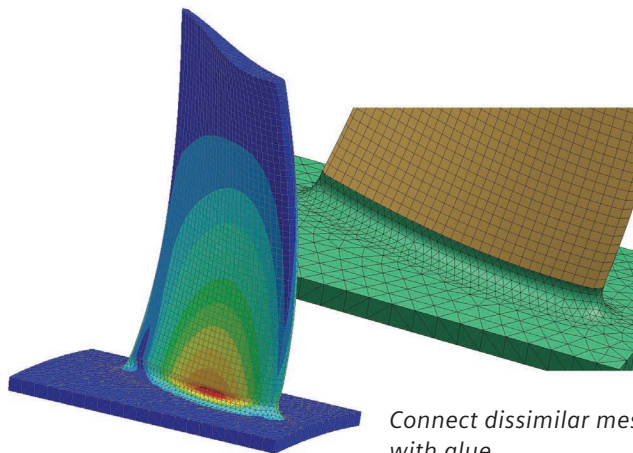
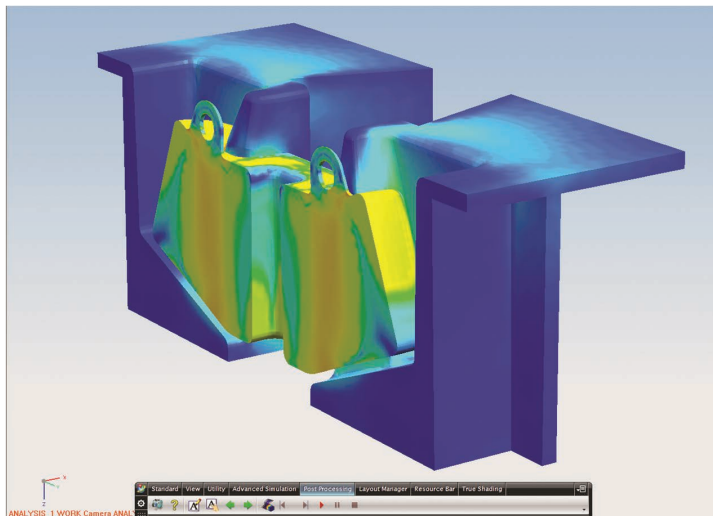
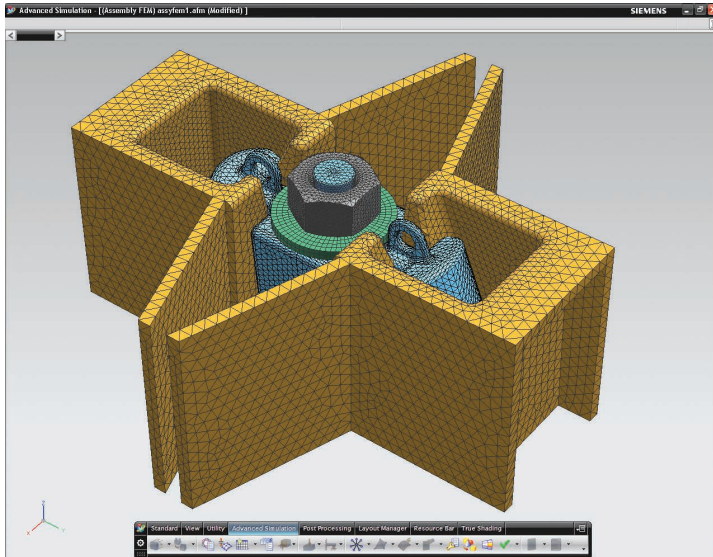
Integrating Simcenter 3D and Femap

Siemens' strategy is to develop Simcenter Nastran for the most advanced and demanding users. The same robust capabilities are then integrated with Simcenter 3D and Femap™ software tools to benefit a wider user community. Solver and graphics teams work closely, making sure enhancements to Simcenter Nastran capabilities are rapidly supported by corresponding advances in Simcenter 3D and Femap.



Linear contact in a bolt application

...robust capabilities are then integrated with Simcenter 3D and Femap software tools to benefit a wider community.



Connect dissimilar meshes with glue

Simplifying component connectivity

The Simcenter Nastran connectivity modeling features enable analysts to model contact problems for simulations that are otherwise linear, as well as more easily connect dissimilar FE meshes, thus saving modeling time. Connectivity features in Simcenter Nastran include:

- Linear contact
- Glue connections for joining dissimilar meshes, including edge-surface and surface-surface connections
- Bolt preloading
- Thermal expansion for rigid elements

Shorten simulation process time

Beyond simplifying the modeling process, Simcenter Nastran includes capabilities that can help you speed simulation process time:

- Easier-to-use external superelements simplify complex FE assembly modeling and speed solution time
- Automatic resolution of dependency conflicts saves remodeling time when dependency conflicts exist
- Direct interfaces to multibody dynamic (MBD) solutions like Simcenter 3D Motion, RecurDyn, Adams and SIMPACK enables motion simulation with flexible bodies

Third-party preprocessors provide support

Siemens understands each analyst's engineering processes and preferences are different. A number of available third-party FEA preprocessors also support Simcenter Nastran bulk data and results files.

Flexibility and openness



In keeping with Siemens' philosophy of developing open products, Simcenter Nastran gives you the flexibility to add your custom analysis modules. Siemens also works with solution partners that wish to integrate their products with Simcenter Nastran.

Direct matrix abstraction program

The direct matrix abstraction program (DMAP) allows you to expand Simcenter Nastran capabilities by writing your own applications and installing custom modules. DMAP can be used to compute additional measures of structural response, transfer intermediate data to and from Simcenter Nastran (for example, externally generated system matrices), incorporate the latest software enhancements without waiting for a major software release and access more than just the standard results output sets.

Solution partners

Many customers have invested in tools developed by third parties that leverage Simcenter Nastran. Siemens is committed to maintaining the open and productive nature of our relationships with a wide variety of independent developers that are working to develop customer- and industry-specific functionality on top of Simcenter Nastran.

Coupling with third-party solver force results

Analysts can combine Simcenter Nastran with third-party solvers for coupled analysis by taking externally generated force field results as a load to a Simcenter Nastran structural model. For example, this functionality is frequently applied when analyzing structural components of electric motors. In these applications, the surface load resulting from an electromagnetic simulation conducted using an external product is integrated into a Simcenter Nastran solution. Responses of the structure to the combined structural and external electromagnetic field loads are then computed.

Scalable licensing and bundling

Small engineering firms to large, multinational manufacturers use Simcenter Nastran for their simulation needs. This is made possible due to the flexible and scalable licensing and bundling options for Simcenter Nastran.

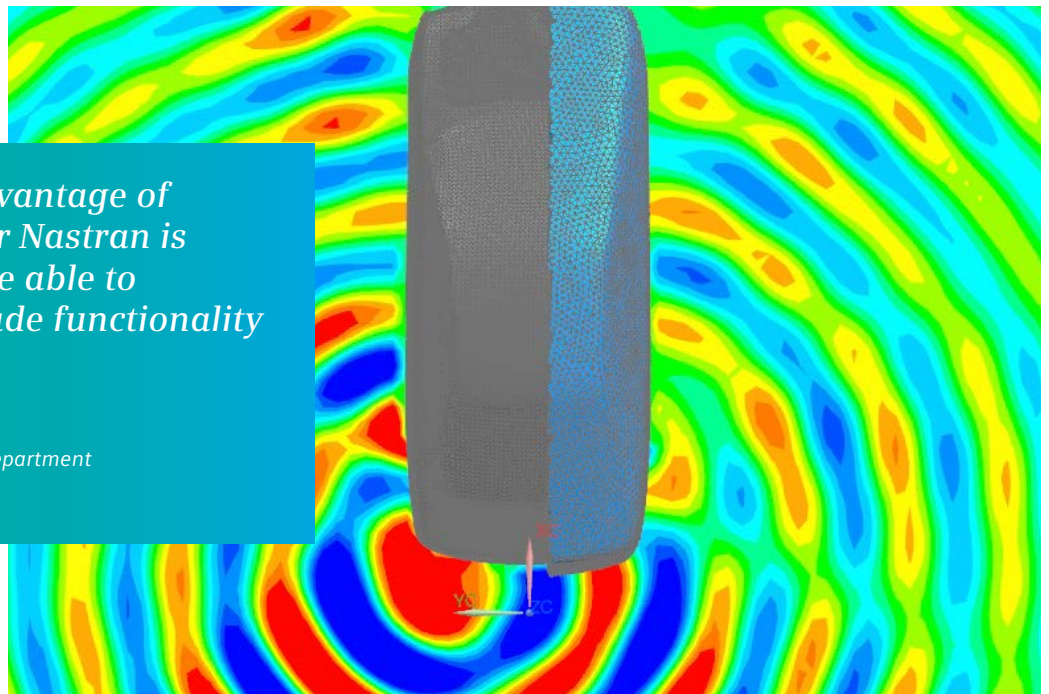
Simcenter Nastran Enterprise

Simcenter Nastran Enterprise licensing gives you the most flexibility to deploy the solver that suits your simulation needs. Enterprise licensing enables Simcenter Nastran to solve any valid Nastran input file from any preprocessor (Simcenter 3D, Femap, MSC Patran, Altair HyperMesh and others). Additionally, the Simcenter Nastran solver can be located on a different CPU from the preprocessing system, such as on a separate server or cluster.

A value-based licensing model called token licensing gives you full flexibility to access most Simcenter 3D and Simcenter Nastran products. The licensing works as follows: Each product has a predefined set of tokens and each usage of a module consumes predefined tokens from the existing pool. Contrary to module-based licensing, by diminishing the license cost you can use several instances of the same application or a different application depending upon the needs of your product development cycle.

“An additional advantage of NX and Simcenter Nastran is scalability. We are able to provide tailor-made functionality to the users.”

*Don Hoogendoorn
Project Engineer, Research Department
Aquila Engineering*



Simcenter Nastran products and capabilities

Simcenter Nastran Basic bundle*

- Linear static analysis
- Normal modes analysis
- Buckling analysis
- Heat transfer analysis (steady-state and transient)
- Basic implicit nonlinear analysis
- Accelerated acoustic coupling

Simcenter Nastran Advanced Dynamics bundle – add-on

- Dynamic response analysis module
- RDMODES and fast frequency response
- Distributed memory parallel processing
- Direct matrix abstraction programming
- Superelements analysis module
- Frequency response functions (FRF) representations
- Aero elasticity analysis module

Simcenter Nastran Dynamic Response – add-on

- Normal modes analysis and complex eigenanalysis
- Frequency and transient response
- Response and shock spectrum
- Component mode synthesis and random vibration

Simcenter Nastran DMP – add-on

Simcenter Nastran Multistep Nonlinear – add-on

- SOL 401 Static
- SOL 402 Static and Dynamic

Simcenter Nastran Rotor Dynamics – add-on

- Rotor dynamics

Simcenter Nastran Advanced Acoustics – add-on

- Uncoupled, weakly, or strongly coupled acoustics
- Radiated noise analysis
- ATV representations
- Acoustic transmission loss analysis

Simcenter Nastran Optimization – add-on

- Parameter optimization

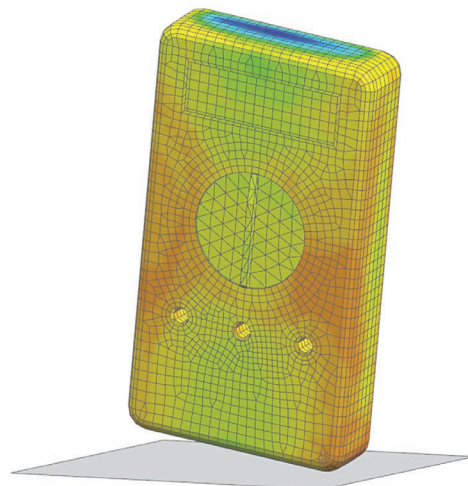
Simcenter Nastran Topology Optimization – add-on

- Topology optimization

Simcenter Nastran Advanced Nonlinear – add-on

- Implicit solver (SOL 601)
- Explicit solver (SOL 701)

*Basic bundle is a prerequisite for all add-on modules and the advanced bundle. Other bundles are also available. Please contact Siemens for the latest product bundles/pricing information.



World-class support and documentation

Simcenter Nastran specialists are located in every region of the world because Siemens believes it is important to have access to a live support engineer or specialist. Therefore, Siemens measures all aspects of support to make sure it provides world-class quality and responsiveness.

GTAC

Siemens is recognized for the dedication, professionalism and efficiency of our world-wide support team. The Global Technical Access Center (GTAC) is the focal point for software support. GTAC provides both application and operating systems software support via telephone and the website. GTAC is organized into specialized teams that support product disciplines.

Documentation

Simcenter Nastran documentation is effective in helping new users get up to speed quickly, and is a key factor in its reputation as a leading solver.

Online help library

The Simcenter Nastran online help library contains electronic (pdf) versions of all the manuals available for Simcenter Nastran. An html-based virtual bookshelf allows you to easily access all documentation.

Quick reference guide

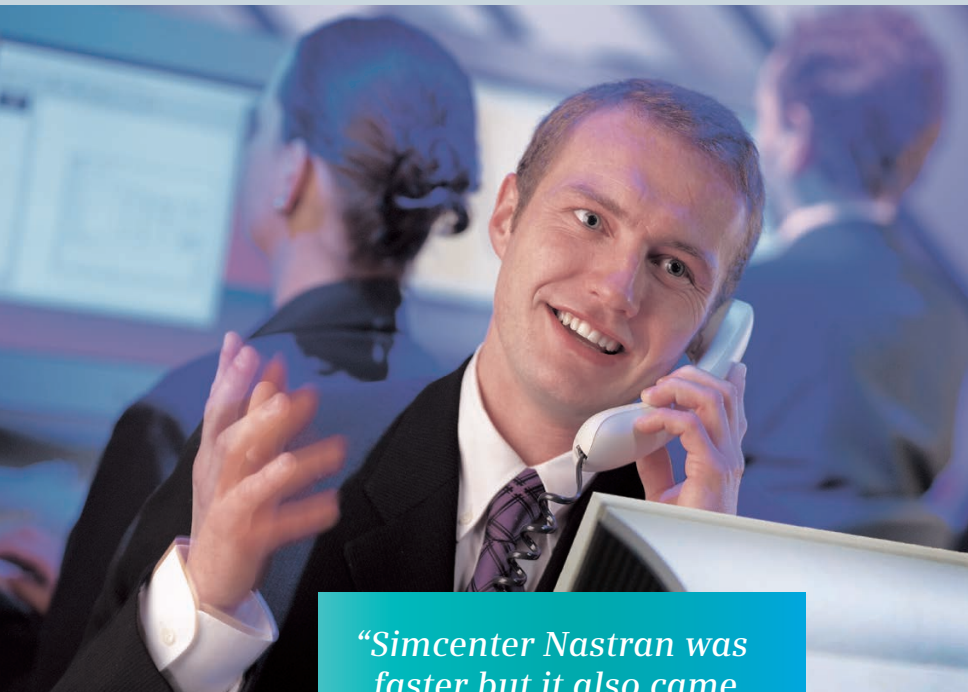
The Simcenter Nastran quick reference guide is available as a digital and printed two-volume guide that provides comprehensive information on using Nastran executive control, case control and bulk data entries.

Training

Siemens PLM Software delivers both instructor-led and online training for Simcenter Nastran. Courses are available for a variety of Simcenter Nastran topics for beginners and expert level users.

Community

With the thriving Simcenter community, passionate Simcenter Nastran engineers help each other through forums and information exchanges.



“Simcenter Nastran was faster but it also came with the best support.”

*Kristopher Notestine
Manager, R&D
Damping Technologies Inc.*

About Siemens PLM Software

Siemens PLM Software, a business unit of the Siemens Digital Factory Division, is a leading global provider of software solutions to drive the digital transformation of industry, creating new opportunities for manufacturers to realize innovation. With headquarters in Plano, Texas, and over 140,000 customers worldwide, Siemens PLM Software works with companies of all sizes to transform the way ideas come to life, the way products are realized, and the way products and assets in operation are used and understood. For more information on Siemens PLM Software products and services, visit www.siemens.com/plm.

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