SIEMENS
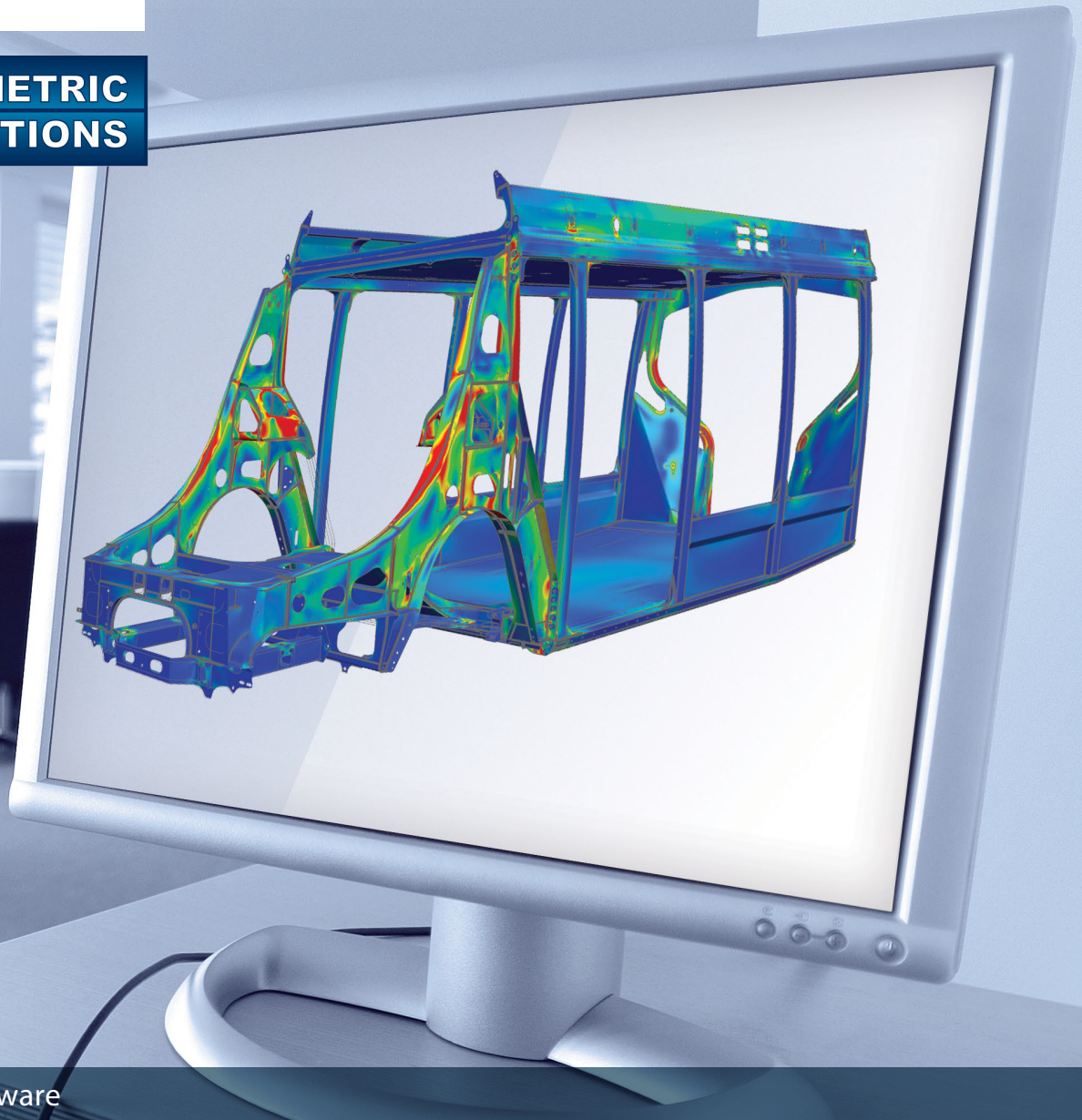
Siemens PLM Software

NX NASTRAN

The premier FEA solver for computational performance, accuracy, reliability and scalability

siemens.com/plm/nxnastran

Product development challenges

Siemens understands your product development challenges
Increasing product and market complexity combined with global development teams and reduced development budgets create challenges for companies in every industry.

Problems found too late in development
The top development issue manufacturers cite is that they find problems too late in the development cycle. Such problems are extremely costly to fix through late design and manufacturing changes, but they are also costly in terms of lost revenue caused by delays in product introductions.

Top product design challenges

Problems/errors found too late — 47%
Making trade-offs for cost, performance and quality — 41%
Frequent design changes — 36%
Predicting product behavior in a real-world environment — 28%
Workforce reduction/lack of technical experts — 24%

0%   10%   20%   30%   40%   50%

Percentage of respondents (n=157)
Source:
Aberdeen Group
April 2010

Understanding quality vs. cost and performance trade-offs
Another issue companies cite is the need to better understand how design trade-offs affect quality, cost and performance characteristics. The use of physical testing of different prototype designs to understand these trade-offs is time-consuming, costly and ultimately impractical in today's business environment.

Choosing the right simulation tools
Industry pressure to decrease development time and improve quality is driving best-in-class companies to increase use of simulation. However, choosing the right tools is key to achieving the business benefits of simulation. Companies need to consider technology, scalability and integration when considering simulation tools:
- The right technology ensures that simulation can accurately represent the physical environment
- Scalable solutions adjust to product complexity, high-performance computing resources and a broad range of users' skill levels
- Integration with other simulation tools and with product development applications is important to both efficiency and effectiveness of the CAE solution
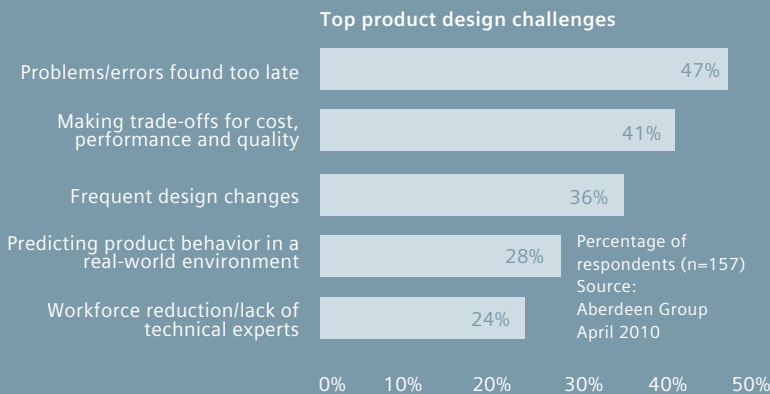
NX Nastran advantage

The premier FEA solver

An industry standard for over 40 years, Nastran is a finite element solver for stress, vibration, structural failure, heat transfer, acoustics and aeroelasticity analyses. Manufacturers as well as engineering suppliers in aerospace, automotive, electronics, heavy machinery, medical device, and other industries rely on NX™ Nastran® software for their critical engineering computing needs so they can produce safe, reliable and optimized designs within increasingly shorter design cycles.

Develop products faster

Simulation with NX Nastran helps engineers to find problems with product designs earlier before conducting any costly physical tests. With NX Nastran, engineers can be confident their design will work when the first physical prototype is tested.

Increase product quality

NX 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 trade-offs for quality, cost and performance.

Reduce development and warranty costs

Simulation with NX Nastran is credited with driving millions of dollars out of 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. And with increased product quality, companies can save on potential warranty costs.

Siemens' CAE vision and heritage

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

Siemens PLM Software delivers on this vision by building upon our simulation heritage which spans over 40 years and encompasses well known CAE brands such as I-deas™, NX CAE and NX Nastran.

SDRC	UGS	SIEMENS
I-deas	NX CAE	
	Teamcenter Simulation Process Management	
	NX Nastran	
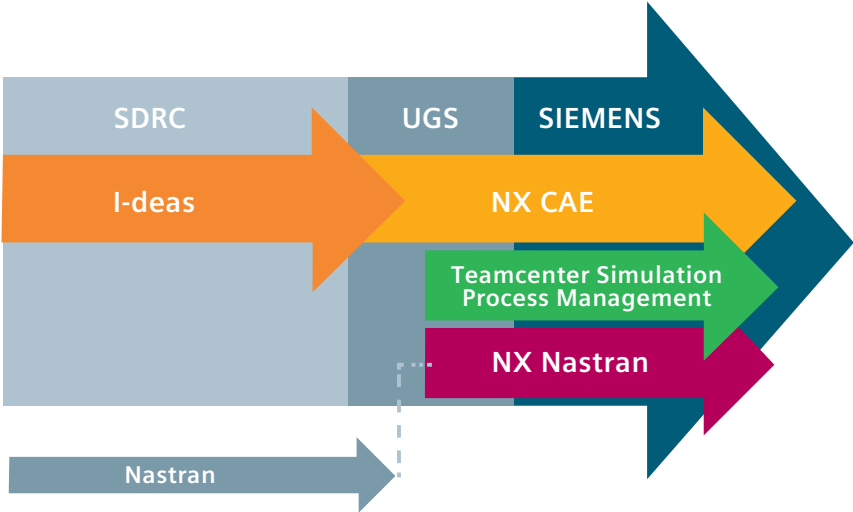
Nastran

Multiple solution domains – one solver

NX Nastran solves most structural analysis problems for linear and nonlinear analysis, dynamic response, rotor dynamics, aeroelasticity 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
Linear analysis assumes that materials are not strained beyond their yield limits and that deformations remain small in relation to overall dimensions. NX Nastran features a complete range of linear analysis functionality. For example, it can solve static problems, such as determining if a structure will fail under a prescribed load. NX Nastran also solves transient problems where loads change over time, like a car driving down a road. In addition, engineers use NX Nastran to solve for buckling load capacities and heat transfer behavior.

Advanced nonlinear analysis
When deformations are large, linear material assumptions are invalid, or contact is a factor, then nonlinear analysis is the appropriate simulation choice. Nonlinear implicit and explicit analysis solvers enable engineers to address problems as simple as a plastic catch and as complex as a car body roof crush and post-buckling analysis.

Advanced material capabilities enable users to simulate the collapse of a rubber mount or the performance of an engine gasket seal. Integrated explicit dynamic capabilities let engineers perform metal forming analysis or evaluate electronic hardware performance during a high impact drop test simulation.

Rotor dynamic analysis
Rotating systems, such as shafts and turbines, are subject to rotation-induced gyroscopic and centrifugal forces that give rise to dynamic behavior not present in stationary systems. In particular, dynamic instability can occur at certain rotation speeds known as critical speeds. Rotor dynamic analysis allows engineers to predict critical speeds for their systems and develop designs that operate away from these unstable speeds.
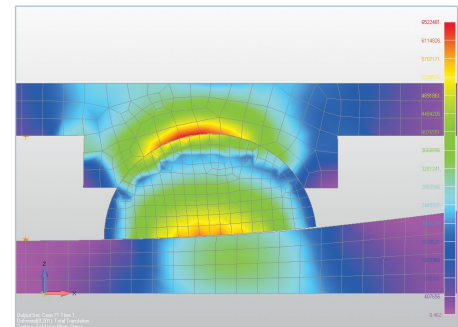
Detail of the contact surfaces of a pendulum isolator
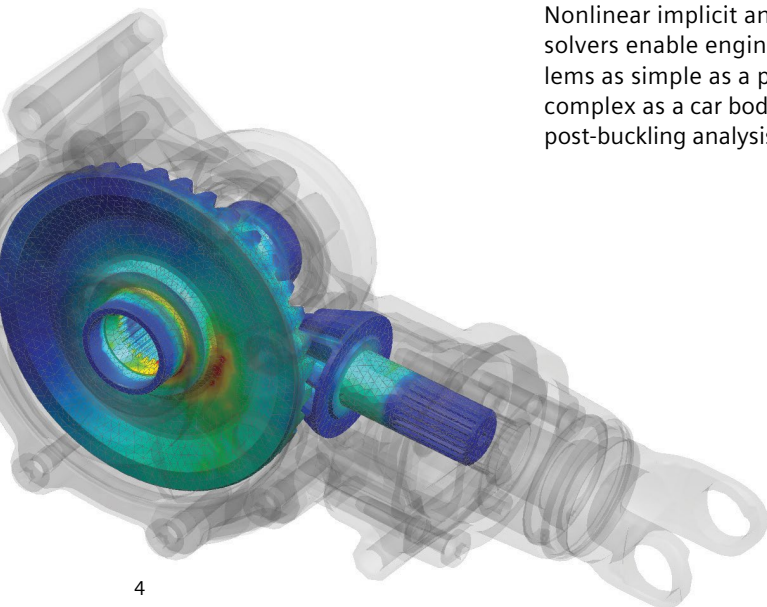
Dynamic analysis

Dynamic analysis is an important known strength of NX Nastran. From transient, to frequency, to random loading, to shock response, NX Nastran covers the full range of dynamic solutions. Dynamic response capabilities play a key role in various applications, such as assessing passenger comfort in aircraft and automobiles under different operating conditions, or evaluating the effect of vibrations on the performance of consumer products and other high-tech electronic devices.

Dynamics analysis results are often used as input into other types of analyses, such as motion analysis for flexible bodies. NX Nastran facilitates links to motion simulation tools, such as NX Motion, RecurDyn, Adams, SIMPACK and MATLAB to simplify simulation workflows.

Aeroelastic analysis

Aeroelastic analysis enables analysis of structural models in the presence of an airstream. With NX Nastran, engineers can simulate static aeroelastic trim analysis, flutter and dynamic aeroelasticity response applied to a variety of unsteady loadings including gust. As such, it is applicable in the design of airplanes, helicopters, missiles, suspension bridges and even tall chimneys and power lines.

Optimization

Designing and producing innovative products that meet performance criteria is a goal of every manufacturer. Using optimization techniques, engineers can improve a proposed design, resulting in the best possible product for minimum cost. Because your designs may have hundreds of variable parameters with complex interrelationships, finding an optimal design through manual iterations is hit-or-miss at best. NX Nastran's optimization capabilities streamline and automate that process by using sophisticated algorithms to search the entire design space and find the right combination of parameters that will yield optimal performance.

"We have set ourselves up with an advanced solution that lets us perform a complete range of structural and thermal analyses."

Nicolas Étienne
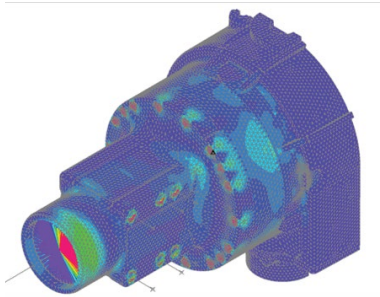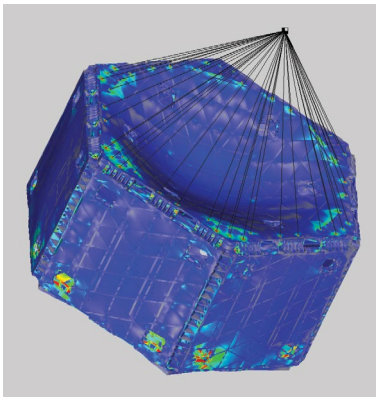Mechanical Group Leader
ABB Analytical Business Unit
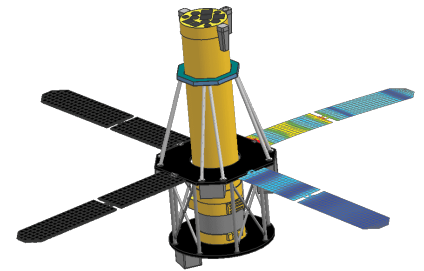
Flexible bodies within a motion analysis
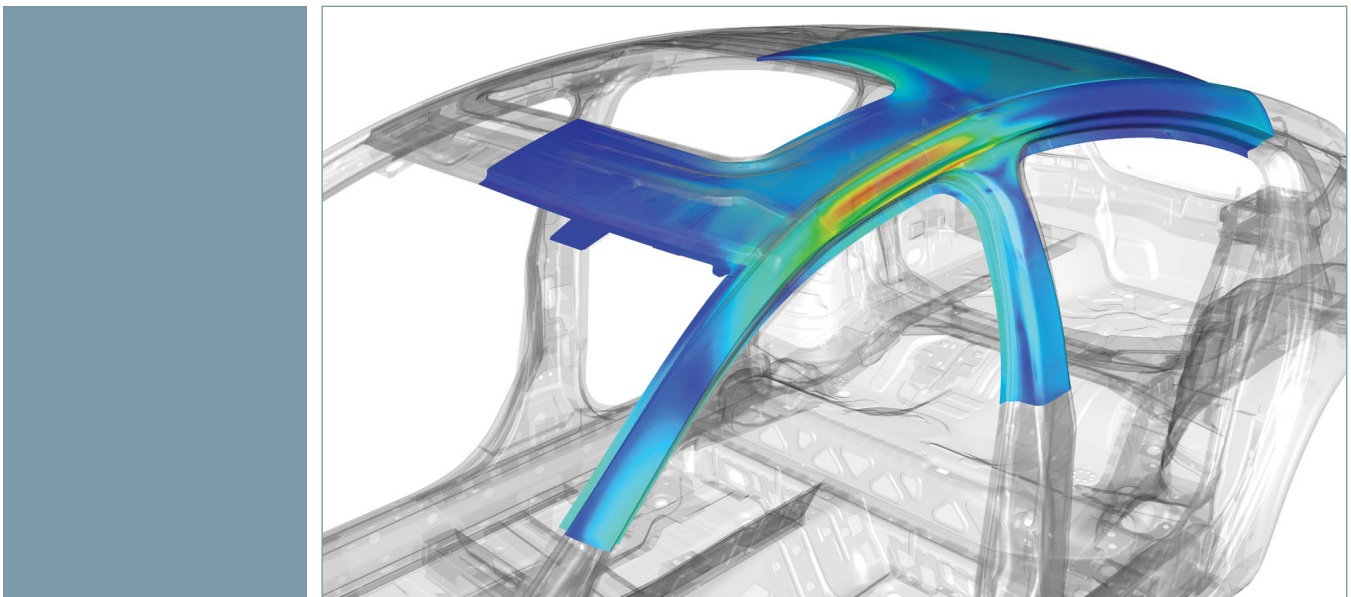
Computational performance and numerical accuracy

Finite element analysis models have consistently grown in size as engineers continue to tackle more complex problems through the increase in computing capacity. Today, complex models with tens of millions of node points and elements are common. Performance is what makes NX Nastran the solution of choice for users who need to solve today's increasingly large problems.

Shared memory parallel processing (SMP)

Using multiple processors in parallel can significantly reduce solution run times compared to more traditional serial solutions that use one processor. Shared memory parallel processing (SMP) is the preferred technology on multiprocessor nodes with shared memory or with processor nodes with multiple cores. SMP is used for lower level operations, such as matrix decomposition and matrix multiplication. Since every solution sequence involves matrix multiplications, SMP can be activated in all solution sequences as long as the hardware supports SMP.

Distributed memory parallel processing (DMP)

Large system-level static and dynamic analyses, often seen in the automotive and aerospace industries, are a major computational challenge, and much higher levels of scalability can be obtained with distributed memory processing (DMP) compared to shared memory processing (SMP). NX Nastran uses DMP to achieve faster solution speed by dividing the finite element solution into smaller pieces that can be solved simultaneously.

DMP solutions are typically run on a cluster with multiple nodes and multiple I/O channels communicating over a network. Each node has its own memory and one or more disks. Users only need to specify the number of processors, and the partitioning of the solution is done internally.
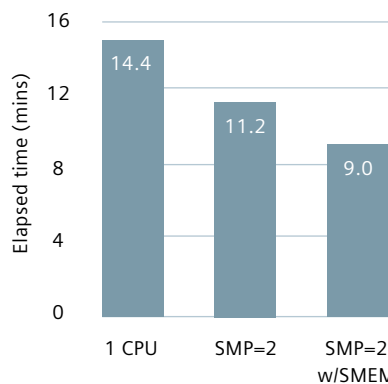
SMP performance for a model with 68K nodes solved on a laptop with Intel Core 2 Duo processor and 8GB RAM.

DMP can also be operated on a single node that has multiple processors. If adequate memory and I/O channels are available the processors run the same as if they are configured on a cluster system.

Whether running NX Nastran with DMP on a cluster or a multiprocessor workstation, each processor operates on its own partition of the geometry or frequency range and communicates with the other processsors to share information. Once the solution is complete, the results are merged, creating a single results file.

NX Nastran has many options for partitioning of the solution domain:

Geometric domain partitioning is available for static and dynamic solutions. The physical model is automatically divided into geometry partitions that are solved on different processors.

Frequency domain partitioning is available for dynamic solutions. The frequency range of interest is automatically partitioned into frequency range segments that are solved separately. Each processor solves the full model within its frequency segment.

Hierarchic domain partitioning combines the 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, the load matrix is partitioned among the processors as evenly as possible, and the linear solution is calculated within each of the respective processors for its own load cases. Like frequency domain partitioning, load domain partitioning, which does not need communication between processors, is nearly linearly scalable.

Recursive domain partitioning is the newest and most scalable DMP solution yet for modal solutions. It operates on multilevel partitions of the finite element matrices by

performing automated matrix reduction (not just mass and stiffness). As a mathematical reduction method, the resulting solution is approximate when compared to the other DMP methods. However, the user has the ability to control the accuracy of the approximation, and experience has shown that the default approximation is very good and is very close to the computationally exact solution.

Scalability for this method has been achieved up to 512 CPUs. The recursive DMP solution can solve very large problems more than 100 times faster than the Lanczos method on a single processor.
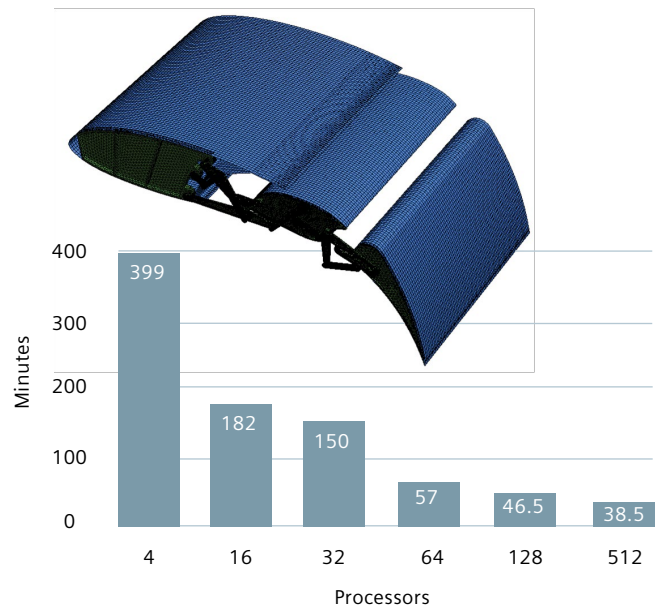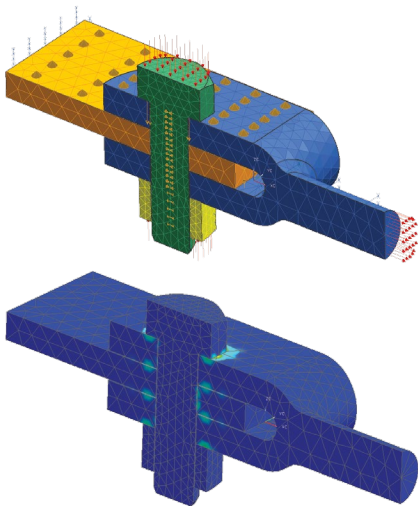

DMP with Recursive Domain Partitioning example:
Modal solution of simulated airplane wing model
50 million degrees of freedom
1521 modes below 200 Hz
Each node: dual quad-core Intel Nehalem
2.67GHz, 24GB RAM

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Ease of modeling and engineering workflow

Linear contact in a bolt application

Engineers can easily create NX Nastran models through a number of available FEA preprocessors that support NX Nastran. But to simplify the modeling process even more, NX Nastran includes unique features that enable engineers to quickly connect complex components together and speed process time.

Integration with NX CAE and Femap
Siemens strategy is to develop NX Nastran for the most advanced and demanding users. The same robust capabilities are then integrated with NX CAE and Femap™ software tools to enable a wider user community to benefit. Solver and graphics teams work closely together ensuring that enhancements to NX Nastran capabilities are rapidly supported by corresponding advances in NX CAE and Femap.

Simplifying component connectivity
NX Nastran connectivity modeling features let analysts model contact problems for simulations that are otherwise linear, as well as more easily connect dissimilar FE meshes together – thus saving modeling time. Connectivity features in NX 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, NX 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 multi-body dynamic (MBD) solutions like NX Motion, RecurDyn, Adams and SIMPACK enables motion simulation with flexible bodies

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

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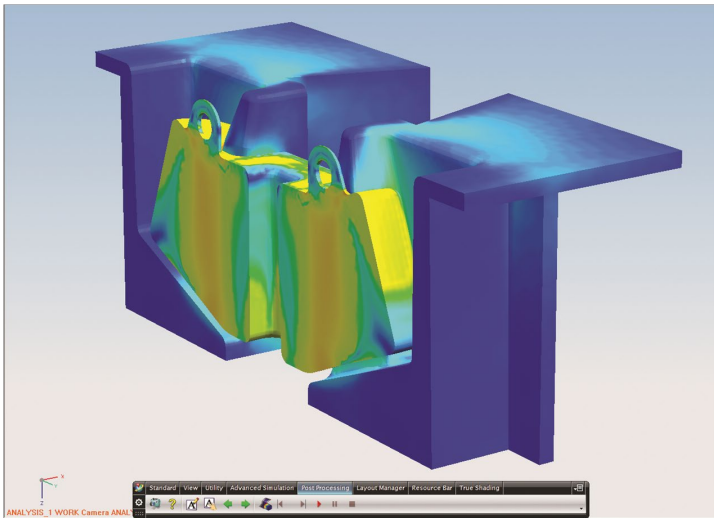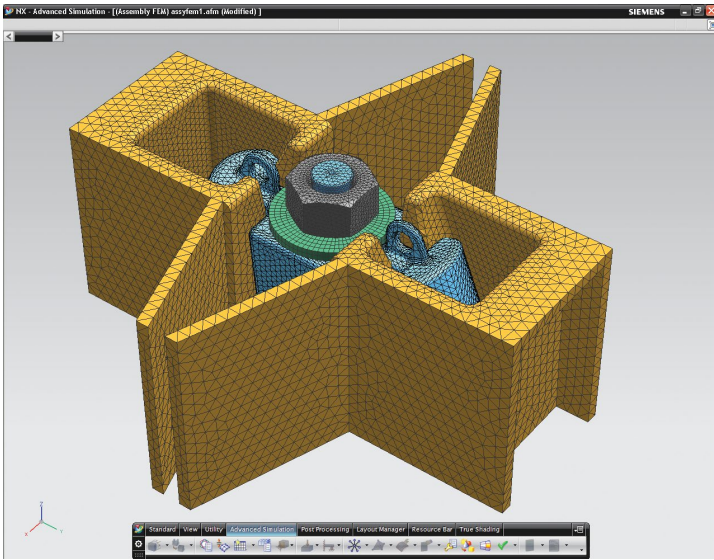
"*The integration of NX Nastran into the NX CAE environment enables the user to increase the fidelity of analysis by using very detailed geometric and finite element models. NX Nastran's ability to solve these, sometimes hundreds of millions degree-of-freedom problems, in the shortest time frame possible provides a capability to the engineering analysts to positively impact design decisions and is an ongoing focus of Siemens research and development.*"

Dr. Louis Komzsik
Chief Numerical Analyst
Office of Architecture and Technology
*Siemens PLM Software*
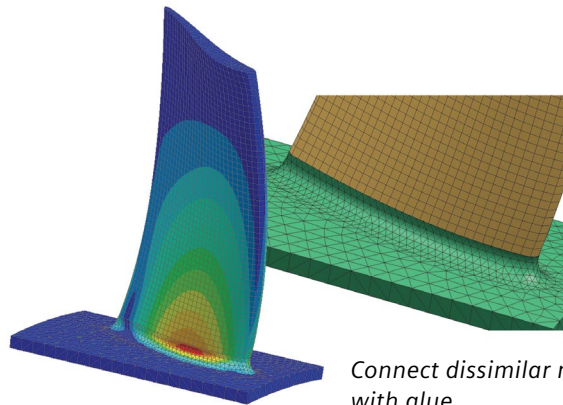
Connect dissimilar meshes with glue

Advanced applications

Engineers today are using NX Nastran to solve a variety of advanced applications, such as NVH (noise, vibration and harshness) problems in the automotive industry, composites analysis in the aerospace industry and complex coupled-physics problems in electronics and a number of other industries.

Composites
In the quest to make products lighter yet stronger, manufacturers are increasing their use of composite materials. NX Nastran is at the leading edge of simulating the behavior of products made from composite materials through continuous development of material models and element types, such as a solid composite element which gives a more geometrically precise representation of a composite material.
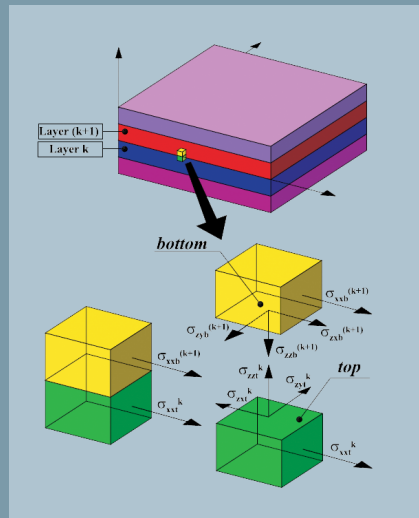
Coupled physics
In the real world, product behavior is not determined by a single, isolated physical domain. Instead, effects from one physical phenomenon will simultaneously impact how a product reacts to another physical domain. For example, thermal-structural effects are crucial to jet engine engineering. NX Nastran allows you to analyze thermal contact problems that will also impact structural performance. Coupling can be achieved within NX Nastran using its thermal and structural analysis solution sequences. For more advanced thermo-mechanical problems, engineers can easily couple NX Nastran with NX Thermal.

NVH
NVH analysis, commonly used in the automotive industry, quantifies noise and vibration characteristics of vehicles. NX Nastran offers all the solution types needed for analyzing noise and vibration, including linear static (with inertia relief), normal modes, direct and modal frequency response, and direct and modal transient response. Accurate NVH analysis can require large models and be computationally intensive, so NX Nastran is ideal for NVH engineers due to its ability to efficiently solve large models.

Solid composite element
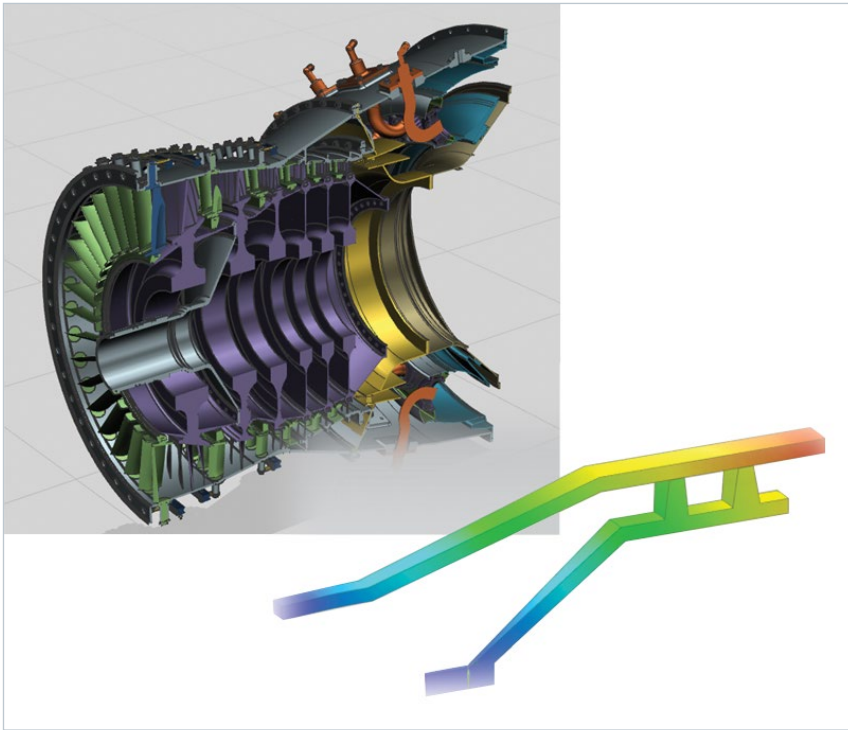
Thermo-mechanical coupling between NX Nastran and NX Thermal

Acoustic structural coupling

"Today's advanced NVH analysis applications require seamless integration of special purpose proprietary software tools into the analysis process. NX Nastran has set new standards in 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

Flexibility and openness

In keeping with Siemens' philosophy of developing open products, NX Nastran gives engineers the flexibility to add their own custom analysis modules. Siemens also works with solution partners who wish to integrate their products with NX Nastran.
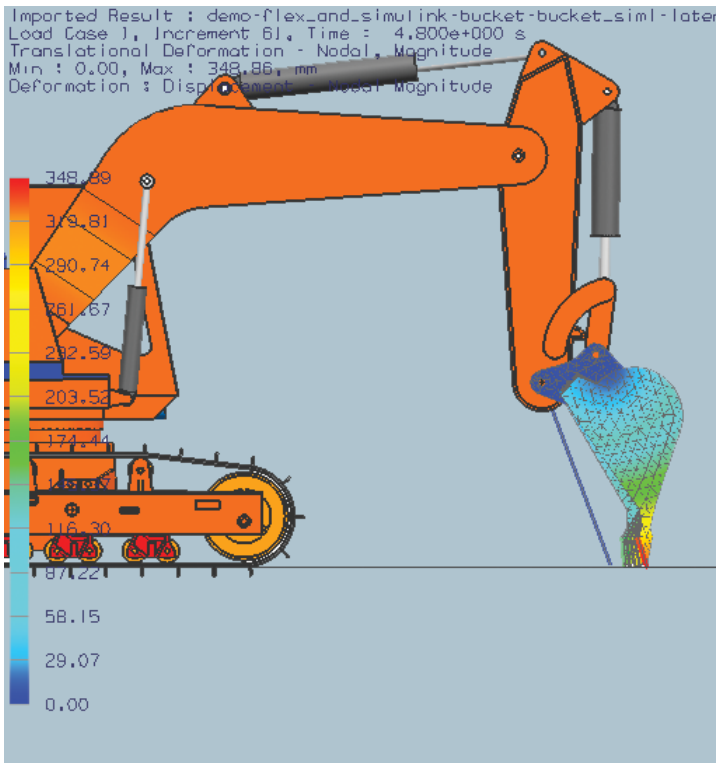
Direct matrix abstraction program (DMAP)

Direct matrix abstraction program (DMAP) is an add-on to NX Nastran that allows customers to expand NX Nastran capabilities by writing their own applications and installing custom modules. DMAP can be used to compute additional measures of structural response; to transfer intermediate data to and from NX Nastran (for example, externally generated system matrices); to incorporate the latest software enhancements without waiting for a major software release; or to access more than just the standard results output sets.

Solution partners

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

```
Imported Result : demo-flex_and_simulink-bucket-bucket_siml-later
Load Case 1, Increment 61, Time :  4.800e+000 s
Translational Deformation - Nodal, Magnitude
Min : 0.00, Max : 348.86, mm
Deformation : Displacement - Nodal Magnitude
```

348.89
319.81
290.74
261.67
232.59
203.52
174.44
145.37
116.30
87.22
58.15
29.07
0.00

Motion analysis combining flexible bodies and control systems

"Due to its open architecture via the Direct Matrix Abstraction Programming capability, NX NASTRAN has become an important software component of the multi-disciplinary product development at our division. This capability enabled the connection of the structural analysis with control system, multi-body and electromagnetic simulations."

Drs. Hans-Georg Köpken, Thomas Flöck and Christian Ballauf
*Siemens AG*
Industry – Drive Technologies, Motion Control

Coupling with third-party solver force results

Analysts can combine NX Nastran with third-party solvers for coupled analysis by taking externally generated force field results as a load to an NX 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 an NX Nastran solution. Responses of the structure to the combined structural and external electromagnetic field loads are then computed.

Scalable licensing and bundling
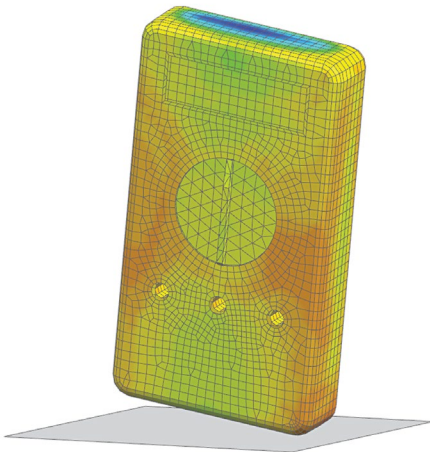
Small engineering firms to large, multi-national manufacturers use NX Nastran today for their simulation needs. This is made possible through NX Nastran's flexible and scalable licensing and bundling options.

NX Nastran Desktop

NX Nastran Desktop licensing is ideal for smaller customers without centralized computing servers. Desktop licensing means the NX Nastran solution initializes from within the CAE preprocessing environment (NX CAE or Femap software), and solver execution occurs on the same CPU as the FE preprocessing solution.

The same NX Nastran Desktop solver is used across NX Advanced Simulation, NX Design Simulation and Femap/NX Nastran bundles. This means the same NX Nastran technology can scale from high-end, expert analysts to design-integrated solutions for consistent and accurate analyses.

NX Nastran products and capabilities

NX Nastran Basic bundle*
Linear static analysis

Normal modes analysis

Buckling analysis

Heat transfer analysis (steady-state and transient)

Basic implicit nonlinear analysis

Spot weld analysis

Accelerated acoustic coupling

NX Nastran Advanced bundle – Add-on
Dynamic response analysis module

Aeroelasticity analysis module

Superelements analysis module

Direct matrix abstraction programming (DMAP)

Distributed memory parallel processing (DMP)

NX Nastran Optimization – Add-on
Design optimization module

NX Nastran Advanced Nonlinear – Add-on
Implicit solver

Explicit solver

### NX Nastran Rotor Dynamics – Add-on
Rotor dynamics

*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 info

NX Nastran Enterprise
NX Nastran Enterprise licensing gives customers the
most flexibility to deploy the solver so it best suits their
simulation needs. Enterprise licensing enables NX Nastran
to solve any valid Nastran input file from any preprocessor
(NX CAE, Femap, MSC Patran, Altair HyperMesh and others).
Additionally, the NX Nastran solver can be located on a
different CPU from the preprocessing system, such as
on a separate server or cluster.

"NX Nastran is widely implemented across industries either as a stand-alone enterprise solver or as an embedded technology within product development environments. As a result, we are seeing a significant increase in the effective use of simulation technology by engineers and designers at all levels."

Jim Rusk
Vice President
Product Engineering Software
Siemens PLM Software
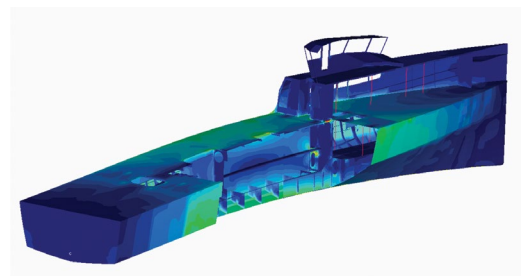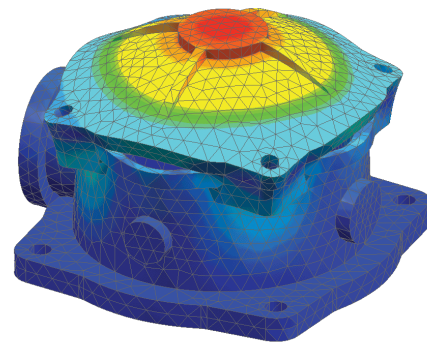
World-class support and documentation

Siemens believes that access to a live support engineer or specialist is important and therefore measures all aspects of support to ensure world-class quality and responsiveness. The bottom line is that it's not about the software...it's about realizing your business goals.

GTAC
Siemens is well recognized for the dedication, professionalism and efficiency of our worldwide support team. The Global Technical Access Center (GTAC) is the focal point for software support. GTAC provides both application and operating systems software support through telephone and electronic access. GTAC is organized into specialized teams which support specific product disciplines.

NX Nastran specialists are located in each world region and are tightly integrated with product development groups so they can quickly identify the path that will lead you to improved productivity. Electronic forums for products are also available enabling users to ask questions and get responses from other users, GTAC support staff, developers, technical sales support and marketing.

Documentation
Clear, concise documentation that is informative, easy to use and has a logical place for critical information is key to usability. The NX Nastran documentation is effective in helping new users get up to speed quickly. Documentation is a core factor in establishing NX Nastran as the standard for all other solvers to be measured against.

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

Quick reference guide
The NX Nastran quick reference guide is available as a printed, two-volume guide that provides comprehensive information on using Nastran executive control, case control and bulk data entries. It is also searchable in an electronic format on the NX Nastran online help library CD-ROM or GTAC website.

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

Siemens simulation solutions leveraging NX Nastran

Siemens PLM Software's strategy is to continue to develop NX Nastran as a premier FEA solver and also leverage NX Nastran technology to drive superior solutions in a range of CAE applications. These include:

NX Advanced Simulation – an open, multi-CAD and CAE solver-neutral environment that enables rapid simulation as an integral part of the design process. Powered by an integrated NX Nastran desktop solver, users have direct access to comprehensive model review, structural optimization and results visualization capabilities to enable design decisions to be based on insight into real-world product performance. Extensive geometry idealization and abstraction capabilities support rapid simulation of complex geometries operating in a multi-physics environment.

NX Response Simulation – an interactive, visual environment for evaluating NX Nastran dynamic results. Conduct linear evaluation of the structural dynamic response of a system when subjected to complex loading conditions such as random vibration, transient, harmonic and shock spectra.

NX Flow and NX Advanced Flow Simulation – a complete suite of CFD simulation capabilities available as add-ons in the NX Advanced Simulation environment. Map pressure results as loads to an NX Nastran structural model, such as when evaluating tank integrity with sloshing fluid inside. Users can seamlessly conduct multi-physics simulations by combining NX Flow with NX Thermal or NX Advanced Thermal.

NX Thermal and NX Advanced Thermal Simulation – a complete suite of thermal simulation capabilities available as add-ons within the NX Advanced Simulation environment. NX Thermal can be combined with NX Flow, NX Advanced Flow or NX Nastran to conduct multi-physics simulations.

NX Laminate Composites – an extension to the NX Advanced FEM or NX Advanced Simulation packages, this integrated capability is uniquely tailored to the productive design and evaluation of laminate composite structures which can then be solved using NX Nastran.

NX Topology Optimization – an extension to NX Advanced Simulation that leverages NX Nastran. Topology optimization is used at the earliest stages of design to derive new design concepts which can then be easily provided to designers for refinement.

NX Advanced Durability and NX Durability Wizard – advanced simulation products for calculating the fatigue life of mechanical components subjected to cycles of loading. Both products are extensions to the NX Advanced FEM or NX Advanced Simulation packages and can take NX Nastran results as input.
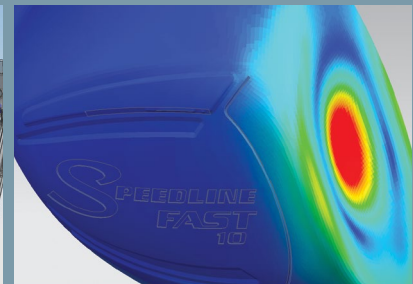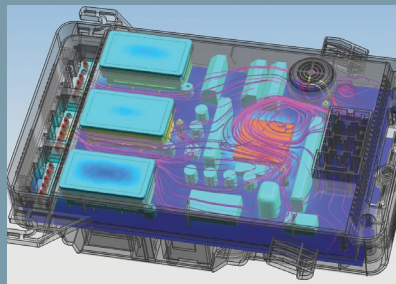
NX FE Model Correlation and NX FE Model Updating – add-on products to NX Advanced FEM or NX Advanced Simulation. FE Model Correlation quantitatively and qualitatively compares modal simulation results from NX Nastran or other solvers and physical modal test results, as well as compares two different simulations. FE Model Updating enables automatic adjustment and optimization of the analysis model to improve its correlation with physical modal test results.
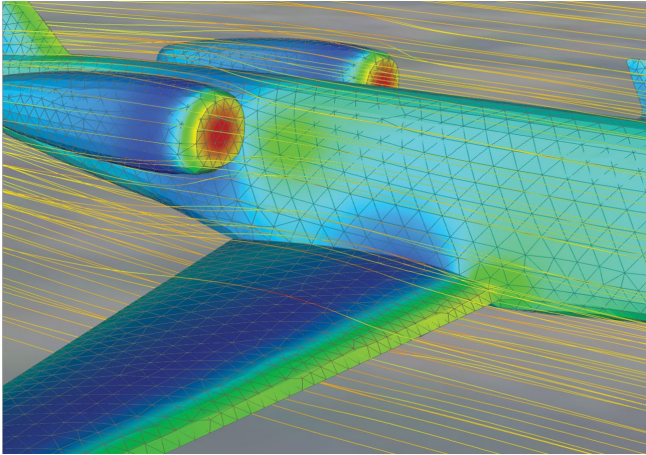
NX Motion Simulation, NX Motion Flexible Body and NX Motion Control – a design-integrated environment for evaluating the kinematic and dynamic performance of new product designs. Mechanisms can include flexible bodies for coupled motion-structural analysis with NX Nastran as well as for performing co-simulation with control systems developed in Matlab/Simulink.

NX Design Simulation – a design-integrated and easy-to-use NX application that enables design engineers to quickly evaluate the structural performance characteristics of 3D product design concepts earlier in the development process. Powered by the same underlying NX Nastran solver used by analysts to ensure solution consistency.

Femap – a multi-CAD, Windows-native FEA modeling environment that enables engineers and analysts to handle complex analysis tasks easily, accurately and affordably. Femap with NX Nastran Desktop is available as a bundle for a complete desktop simulation suite. Femap is based on the industry-standard Parasolid® software modeling kernel.

Teamcenter simulation process management – a CAE-specific Teamcenter® software module that enables the capture, re-use and sharing of simulation data, CAE product structure and simulation processes across the enterprise. This Teamcenter module manages NX Nastran bulk data, results files as well as third-party CAE applications and data.

NX Advanced FEM – powerful FEA pre and postprocessor that includes all the modeling capabilities offered in NX Advanced Simulation. NX Advanced FEM can be used in conjunction with several standard FEA solvers (see next item).

Solver environments for Ansys, Abaqus, LS-Dyna and Nastran – add-ons to NX Advanced FEM that tailor the FE modeling user interface and analysis process in language specific to the FE solver.

NX Electronic Systems Cooling Simulation – an integrated solution that enables evaluation of the cooling effects of airflow around enclosed, densely packed heat-generating electronics systems used in many industries.

NX Space Systems Thermal Simulation – an integrated solution that enables evaluation of complex heat transfer characteristics of space systems during both orbital and interplanetary missions.
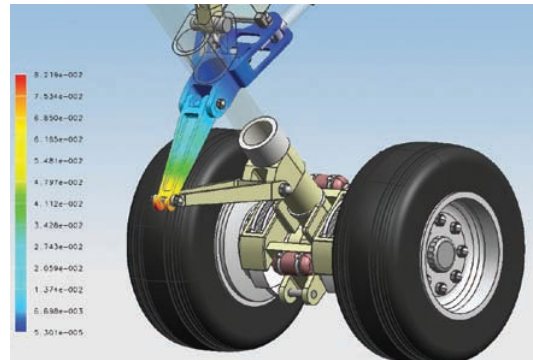
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Siemens PLM Software, a business unit of the Siemens Digital Factory Division, is a world-leading provider of product lifecycle management (PLM) software, systems and services with nine million licensed seats and 77,000 customers worldwide. Headquartered in Plano, Texas, Siemens PLM Software helps thousands of companies make great products by optimizing their lifecycle processes, from planning and development through manufacturing and support. Our HD-PLM vision is to give everyone involved in making a product the information they need, when they need it, to make the smartest decisions. For more information on Siemens PLM Software products and services, visit www.siemens.com/plm.

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