NX Advanced Simulation

Summary
NX™ Advanced Simulation software combines the power of an integrated NX Nastran desktop solver with NX Advanced FEM, a comprehensive suite of multi-CAD FE model creation and results visualization tools. Extensive geometry creation, idealization and abstraction capabilities enable the rapid development of complex 3D mathematical models that enable design decisions to be based on insight into real product performance. NX Advanced Simulation enables a true multi-physics environment via tight integration with NX Nastran as well as other industry standard solvers such as Abaqus, Ansys and MSC.Nastran.

Benefits
- Embedded tools for 3D geometry creation and editing of both components and assemblies
- Association to the design geometry allows the analyst to work closely with the design engineer
  - Knowledge of design changes
  - "On-demand" FE model updates based on design geometry changes
- Supports NX Manager and Teamcenter® for all created FE data sets
- Solver environments customized for the nomenclature of the selected solver
- A full range of tools for FE model generation including predefined constraint conditions and automated mesh mating conditions
- Verify models before processing with a full set of graphical and mathematical tools that help check model suitability
- View analysis results quickly and easily with a dynamic visualization tool
- Extensive post-processing tools to continue the iterative phases of analysis or to export/import information
- Direct integration with Simulation Process Studio for CAE "best-practices" knowledge capture; including process wizard templates for vibration and stress analysis
- Integrated basic durability analysis

NX Advanced FEM includes the fundamental modeling functions of automatic and manual mesh generation, application of loads and boundary conditions and model development and checking. A robust set of visualization tools generates displays quickly, lets you view multiple results simultaneously and enables you to easily print the display. In addition, extensive post-processing functions enable review and export of analysis results to spreadsheets and provide extensive graphing tools for gaining an understanding of results. Post-processing also supports the export of JT data for collaboration across the enterprise with JT2Go and Teamcenter Visualization.

NX Advanced FEM provides seamless, transparent support for a number of industry-standard solvers, such as NX Nastran, MSC Nastran, Ansys and Abaqus. For example, when you create either a mesh or a solution in NX Advanced FEM, you specify the solver environment that you plan to use to solve your model and the type of analysis you want to perform. The software then presents all meshing, boundary conditions and solution options using the terminology or “language” of that solver and analysis type. Additionally, you can solve your model and view your results directly in Advanced FEM without having to first export a solver file or import your results.

- Advanced FEM features data structures, such as the separate Simulation (.sim) and FEM files (.fem) that help facilitate the development of FE models across a distributed work environment. These data structures also allow analysts to easily share FE data to perform multiple types of analyses
- Advanced FEM offers world-class meshing capabilities. The software is designed to produce a very high quality mesh while using an economic element count. Advanced FEM supports a complete complement of element types (0D, 1D, 2D and 3D). Additionally, Advanced FEM gives analysts control over specific meshing tolerances that control, for example, how the software meshes complex geometry, such as fillets
- Advanced FEM includes multiple geometry abstraction tools that give analysts the ability to tailor the CAD geometry to the needs of their analysis. For example, analysts can use these tools to improve the overall quality of their mesh by eliminating problematic geometry, such as tiny edges or slivers
Advanced FEM also supports the new NX Thermal and NX Flow solutions

- NX Thermal is a fully integrated finite difference solver. It allows thermal engineers to predict heat flow and temperatures in systems subjected to thermal loads.
- NX Flow is a computational fluid dynamics (CFD) solver. It allows analysts to perform steady-state, incompressible flow analysis and predict flow rates and pressure gradients for movement of fluid in a system.

When used in combination, NX Thermal and NX Flow provide fully coupled treatment of convective heat transfer, enabling robust simulation of conjugate heat transfer problems.

FE modeling tools

Getting and using geometry

Wireframe, surface and solid geometry from other CAD systems can be accessed through embedded standards-based interfaces (IGES, STEP AP203, STEP AP214, Parasolid and JT) or optional direct CAD interfaces for Catia and ProEngineer. A complete set of geometry creation and modification tools is provided to work directly with native and non-native geometry. Often design geometry must be modified to build an effective model. Details may need to be suppressed or eliminated, additional geometry may be required to control mesh density; or surfaces not present in the geometry may be needed for meshing. A complete set of idealization tools is provided that works directly on native or non-native geometry. History support or association is not required.

NX Advanced FEM provides extensive model editing capabilities, including:

- Interactively suppress features defined within the NX part
- Perform sensitivity analysis using design parameters as defined in the CAD model
- Remove fillets and holes automatically using the idealize command set on both native and non-native geometry
- Add, modify or delete entities (sheet body, solid body)
- Extract the mid-surface representation directly from the solid body for modeling thin walled components. Surface thickness is mapped to from the solid to the 2D representation
- Relationships between the component CAD model and the FE model are automatically supported within NX Manager and Teamcenter

Abstracting CAD for FE meshing

Often CAD topology contains details that are of no use to the analyst. Sliver surfaces, detailed embosses (e.g., “Made in U.S.A.”), small fillet radii and small holes are examples of details the analyst may not wish to mesh. There are multiple tool sets to abstract and idealize the geometry for model preparation.

Idealize commands are provided to allow the user to remove and suppress design features like holes and fillets. This can be done on NX native or non-native 3D CAD geometry. This set of powerful tools allows the user to change the design geometry without the need to own the original geometry.

Abstraction commands are provided in the FEM for removal of design artifacts such as sliver faces, small edges and isthmus conditions. It does not remove the actual design features but rather allows for...
the removal of geometry artifacts that affect the overall quality of the mesh. This set of commands allows the analyst to mesh the geometry at a level of detail that sufficiently captures the design intent relevant to a particular FE analysis.

A key concept is that the CAE-driven modifications, either idealized or abstraction, do not change the original design geometry and are completely associated, allowing the user to accept modification to the design geometry without the need to rebuild the FE modeling intent.

**Meshing**

Powerful abstraction and meshing technology allows a user to free mesh any 2D or 3D solid or sheet body or 1D type elements, curves or edges.

Free meshing capabilities include:

- Automatic meshing of surfaces and of volumes, with no topology restrictions
  - 3D tetrahedral
  - 3D swept mesh
  - 2D mesh
    - 2D mapped meshing available with 2D free meshing
    - Sweep meshing “paver”
    - 2D meshing boundary
    - 2D dependent boundary
  - 1D mesh
    - Beam
    - Rigid
    - Spring
    - Gap
    - Damper
  - Transition meshing from fine to coarse for 2D and 3D free meshing
  - User controlled automatic abstraction during meshing
  - Surface meshing with linear or parabolic quadrilaterals, triangles or quadrilateral dominant meshes that insert triangles in a quadrilateral mesh to automatically reduce element distortions
  - Solid meshing with linear, parabolic tetrahedral elements
  - Lets you define allowable distortion for tetrahedral elements before meshing
  - Local element control for precise mesh generations
    - Number of elements on edge
    - Chordal tolerance
    - Geometric progression
  - Enables geometry-based definition and generation of lumped masses, rigid bars, spring, gap and damper elements
  - Associates mesh generation settings with geometric features (updates occur with design geometry changes)

**Element library**

A complete library of finite elements lets you perform many types of analysis and modeling quickly and efficiently. More than 125 standard element types are provided, including linear and parabolic forms of shells and solids, axisymmetric shells and solids, beams, rods, springs, dampers, masses, rigid links and gaps. Scalars and other special elements have unique graphic symbols. P-elements (solid tetrahedra) are supported for linear structural analysis.
**Beam section properties**

Beam section properties may be defined from a standard set of sections or directly from CAD geometry simplifying the task of generating the appropriate data for the beam definition.

**Loads and boundary conditions**

NX Advanced FEM provides extensive capabilities to define loading and boundary conditions to correctly simulate operating environments:

- Loads can be defined on and associated with geometry. The creation of the load will ensure a node is placed at the location during automatic meshing
  - Mesh point
  - Face
  - Edge
  - Curve
- Restraints defined on and associated with geometry
  - Mesh point
  - Face
  - Edge
  - Curve
- Support for surface-to-surface contact definitions
  - Surface-surface glue contact
  - Automatic face pairing
  - Coupling
  - Automatic coupled DOF
  - Manual coupled DOF
- Constraints and restraints, including nodal displacement
- Structural loads
  - Nodal forces and temperatures
  - Element face and edge pressures
  - Acceleration (gravity, translation, rotation)
  - Ambient and reference temperatures
- Heat transfer loads
  - Nodal and distributed heat sources
  - Face and edge fluxes, convection and radiation
- All loads and restraints displayed with unique graphical symbols
- Associativity of geometry-based loads and restraints is maintained through design geometry changes
- Define time-varying loading and boundary conditions to correctly simulate nonlinear loading conditions
**Complete model checking tools**

Analyzing a model with errors can be time-consuming and expensive, and errors are often not detected even after analysis. NX Advanced FEM provides a full set of graphical and mathematical tools to help verify that a model is complete and correct before you submit it for solution:

- Coincident node and element checks eliminate duplications
- Free-edge and face checks avoid unwanted cracks in a model
- Shrink element display verifies that elements are located properly
- Element shape checks (distortion, warping, etc.) verify that elements do not violate limits and can produce accurate results

**Getting the best results from analysis**

For the mixed science and art of analysis to impact design decisions, results must be presented in an understandable form. NX Advanced FEM provides extensive graphics and manipulation capabilities that focus on critical data and present it for review and action. A comprehensive and flexible methodology has been adopted to enable the user to act before, during and after FEM solutions are sought.

Using NX Advanced FEM, you can:

*Create:*
- Animated, stepped or smooth-shaded displays
- Cutting plane, contour, element and arrow displays
- Templates of display options for repeated use

*Control:*
- How data is displayed (for example, data components and coordinate system to use averaged and unaveraged data)
- Text, headers and colors

*View:*
- Multiple results simultaneously
- Results in multiple viewports
- Deformed geometry

*Insert:*
- 3D probe results annotations
- 3D and 2D text annotations

*Export:*
- Displays for report-ready printing/plotting
  - VRML
  - PNG
  - JPEG
  - JT
  - GIF
  - TIFF
  - BMP
  - Animated GIF
- Single or multiple result sets to spreadsheets or directly to Excel (Windows only) for further manipulation

*Report generation*
- HTML customized report generation for model data and results inspection

*Import:*
- Modified result sets back from Excel (Windows only) or a spreadsheet text file
Optional solver environments
The NX Advanced FEM user layout is driven by the solution environment or language chosen by the user. This environment is customized to immerse the user in the language of the selected solver. From element and loading terminology to the appropriate loads and contestants available for the solver are all controlled by the solver language.

All environments are available to the user but import and export of FEA data is controlled by an optional solution environment add-on module for solvers such as Abaqus, Ansys, MSC.Nastran, etc.

The solution environments currently supported by the NX 4 Advanced FEM product includes:

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<th>Analysis type</th>
<th>Solution type</th>
</tr>
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<td>Structural</td>
<td>Linear statics (SOL 101) with surface-to-surface contact</td>
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<td>Thermal</td>
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<td>Linear statics (SOL 101)</td>
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<td>Nonlinear statics (SOL 106)</td>
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<td></td>
<td>Axisymmetric thermal</td>
<td>Heat transfer (SOL 153)</td>
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Abaqus          | Structural            | General analysis                                                              |
|               | Thermal               | Heat transfer                                                                 |
|               | Axisymmetric structural | General analysis                                                              |
|               | Axisymmetric thermal  | Heat transfer                                                                 |
Features

Powerful analysis capabilities
Complete element library including spot welds
Full range of material models
Easy combination and addition of load cases
Comprehensive array of Eigensolvers
Design sensitivity analysis for assessing design changes
Efficient solvers
Comprehensive thermal analysis capabilities
Basic nonlinear capability for large displacement and material nonlinearities
Surface-to-surface contact for linear static solutions
Glue connections for joining dissimilar meshes

Solver | Analysis type | Solution type
--- | --- | ---
Ansys | Structural | Linear statics
 |  | Modal
 |  | Buckling
 |  | Nonlinear statics
 | Thermal | Thermal
 |  | **
 | Axisymmetric structural | Linear statics
 |  | Nonlinear statics
 | Axisymmetric thermal | Thermal

NX Thermal and NX Advanced Thermal

Thermal | Finite difference thermal (based on TMG)

NX Flow

Fluid flow | Incompressible computational fluid dynamics (CFD)

Coupled thermal/flow | Coupled

NX Advanced Flow

Fluid flow | Compressible computational fluid dynamics (CFD)

NX Nastran – Desktop

The Advanced Simulation bundle includes a license of the NX Nastran – Basic desktop solver integrated with a desktop license of the NX Nastran Environment translator. The NX Nastran – Desktop Advanced bundle and/or individual modules for NX Nastran listed below can be added on to a seat of NX Advanced Simulation.

NX Nastran – Basic provides access to a broad library of finite element types and material models, robust manipulation of load cases, along with several efficient solution sequences for linear statics, buckling and normal modes analyses on models of unlimited size. A heat transfer capability provides solutions to steady-state and transient thermal analysis and design problems. A basic nonlinear capability enables including large deformation and material nonlinear effects in the solution.

NX Nastran analysis feature and capabilities | Basic bundle | Advanced bundle* | Available separately
--- | --- | --- | ---
Basic analysis capabilities
Linear static analysis | •
Normal modes analysis | •
Buckling analysis | •
Heat transfer analysis (steady-state and transient) | •
Basic implicit nonlinear analysis | •
Spot weld analysis | •
### NX Nastran analysis feature and capabilities

<table>
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<tr>
<th>Advanced analysis capabilities</th>
<th>Basic bundle</th>
<th>Advanced bundle*</th>
<th>Available separately</th>
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<td>Dynamic response analysis module</td>
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<td>Advanced nonlinear analysis module</td>
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<td>Superelements analysis module</td>
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<td>Direct matrix abstraction programming (DMAP)</td>
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<td>Design optimization module</td>
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<td>Aeroelasticity analysis module</td>
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<tr>
<td>Rotor dynamics</td>
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* Basic bundle is a prerequisite for all add-on modules and the Advanced bundle. The Advanced bundle is not available with Femap. Distributed memory parallel processing (DMP) is available only in the Enterprise version of NX Nastran – not available with the NX Nastran desktop versions.

### Solution processes

NX Advanced FEM also supports the definition of solution processes, which represent a multi-step solution and work with any of the supported structural solvers. The following processes are supported in Advanced FEM: adaptive, durability and optimization.

#### Adaptive solution

Adaptive analysis is a linear statics solution option, available for all supported solvers, that uses a solver-independent h-adaptive analysis method to perform automatic mesh refinement during solve iterations. The main objective of adaptive analysis is to automate the lengthy and repetitive process of running multiple finite element analyses with different mesh densities. The mesh refinement is determined by error estimates associated with element stress discontinuity. Based on these error estimates, critical regions are identified on the model, which then become the target for further refinement of the mesh.

Once the critical regions are identified, the local refinement is implemented internally. An element sizing scheme is used to estimate the new size. Furthermore, element quality is checked along transition areas to eliminate false hot spots that may later influence the refinement process.

Adaptive analysis is supported for all 2D and 3D triangular elements. Hex, wedge and pyramid elements are not supported. During the adaptive solve, the refinement of existing mesh elements involves replacement by matching template patterns. Element nodes needing refinement are identified by the software and modified accordingly.

#### Durability

Structural fatigue analysis is a tool for evaluating a design's structural worthiness, or its durability, under various simple or complex loading conditions, also known as fatigue duty cycles. NX Advanced FEM supports the creation of a durability process solution. Results of a fatigue analysis are displayed as contour plots that show the duration of cyclic loading (number of fatigue duty cycles) the structure can undergo before crack initiation occurs.
Fatigue analysis uses the cumulative damage approach to estimate fatigue life from stress or strain time histories. Estimation is accomplished by reducing data to a peak/valley sequence, counting the cycles and calculating fatigue life. A library containing standard fatigue material properties is provided.

**Optimization**

Optimization is a process that helps the analyst arrive at the best solution for a given design goal. NX Advanced FEM allows the user to create an optimization solution process. The user can define a goal such as the mass of a part or component, a constraint such as maximum allowable Von Mises stress and the design parameter(s) to vary on the component. The optimization solution process will run based on the design criteria while varying the design parameters to enable the design engineer to determine if there is a better structural design alternative vs. the original baseline design.

**Product availability**

NX Advanced Simulation is the core CAE package in the integrated suite of NX digital product development applications. It is a prerequisite for all other add-on NX CAE applications in the NX Advanced Simulation suite such as NX Nastran Desktop advanced modules, NX Response Simulation, NX Flow, NX Advanced Flow, NX Thermal, NX Advanced Thermal, NX Electronic Systems Cooling, NX Space Systems Thermal Simulation and NX Laminate Composites as well as the customized solver interfaces for Nastran, Ansys and Abaqus.

NX Advanced Simulation is available on most major hardware platforms and operating systems (Windows, Linux, UNIX) including selected 64-bit systems.