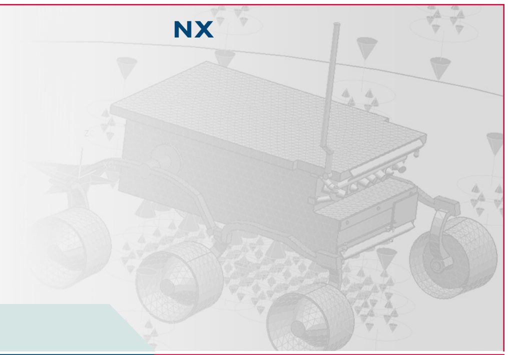


NX

NX Space Systems Thermal

fact sheet

Siemens PLM Software www.siemens.com/plm

Summary

NX® Space Systems Thermal software is the space industry vertical application that leverages the entire numerical capabilities found within the NX Thermal solver to provide a comprehensive set of tools to simulate orbital heating within the NX Advanced Simulation environment. NX Space Systems Thermal helps resolve thermal engineering challenges early in the design process and is a valuable aid in understanding the physics of orbital heat transfer for all space-bound as well as interplanetary-bound vehicles.

Benefits

Perform accurate on-orbit heat transfer analysis quickly and efficiently

Perform thermal analysis as part of a collaborative engineering process

Minimize learning time and enhance productivity by leveraging the power of all NX-embedded simulation applications

Use a highly automated solution process that requires no additional input files and carries out analysis in a single pass

Features

Use advanced numerical techniques to model nonlinear and transient heat transfer processes

Use NX 3D part modeling as the foundation for thermal analysis, creating and associating FE models with abstracted geometry

Use sophisticated technologies for the efficient solution of element-based thermal models

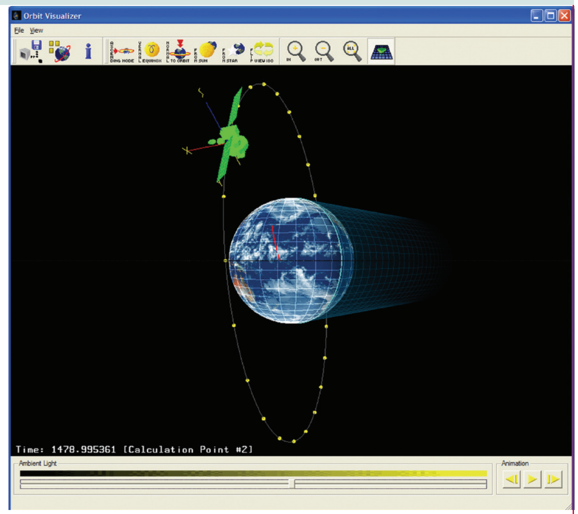
Simulate complex transient motion influencing the radiation view factors and other heat transfer mechanisms efficiently

Perform analysis of assemblies with tools that connect disjointed meshes automatically at runtime

Employ thermal results mapping from/to different and dissimilar meshes for loading structural finite element models for thermo-elastic analyses within the NX Advanced Simulation framework

Product description

NX Space Systems Thermal is ideal for modeling orbital vehicle applications with complex 3D design geometry. Users can easily employ NX Space Systems Thermal to build the 10 thermal nodes model while using MS Excel hand calculations to perform conceptual studies all the way to the million faces model when detailed analysis is required.



An integral part of the NX Digital Product Development simulation suite, the NX Space Systems Thermal module enables you to effectively use simulation to provide design guidance early in the design cycle instead of just during design verification. Modeling of complex and/or large 3D CAD assemblies is made easy with the NX Advanced FEM capabilities (a pre-requisite). No additional input files or geometry conversions are needed to build your thermo-fluid models. Moreover the CAD-neutral NX openness philosophy and smart geometry translators are available if or when needed to deal with geometry from a supplier or contractor that originated from another CAD system.

NX Space Systems Thermal also has embedded interfaces with other legacy and commercial software tools used for radiation and thermal analysis in the space systems industry.

Main NX Space Systems Thermal features

Specific thermal analysis capabilities for the space industry include:

- Orbital models for all planets of our solar system at any specific point in time and attitude
- Powerful and fast view factor calculations (including parallel computing for large Space Systems Thermal models)
- Powerful and smart view factor transient re-calculations for the case of articulation simulations such as for solar panel joints rotation allowing constant pointing at the sun or antenna pointing to specific location

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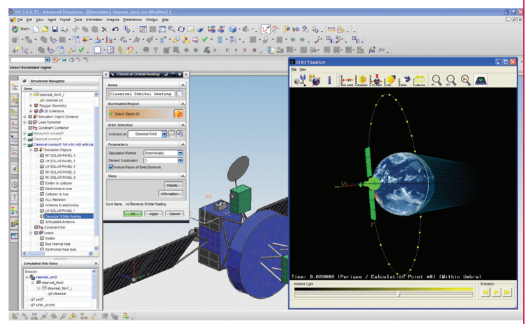
- Efficient transient solution for thermal shock transient analyses during eclipse
- Multi-layer shells specific formulation for MLI and TPS applications
- Direct interfaces to other thermal analysis tools:
  - SINDA
  - TSS
  - TRASYS
  - ESTAN
  - ESARAD
  - Thermica



Core solver capabilities

- Steady-state (linear and nonlinear)
- Transient (linear and nonlinear)
- Material nonlinear thermal properties
- Multi-layer shells for MLI and TPS applications
- Axi-symmetric modeling
- Cyclic thermal problems
- Iterative conjugate gradient solver technology
- Fully coupled conduction, radiation and convection heat transfer simulation
- 1-D duct and hydraulic network elements
- Articulation and motion modeling (translational motion and rotational joints)

Thermal couplings technology for modeling thermal contacts within NX assemblies

- Thermally connect disjoint and dissimilar mesh faces and edges
- Surface-to-surface, edge-to-edge or edge-to-surface contact modeling between parts: constant, time or temperature-dependent coefficient of heat transfer, resistance or conductance
- Radiative exchange between disjoint part faces and faces within a single part
- Interface modeling between connected parts: constant, time or temperature-dependent coefficient of heat transfer, resistance or conductance
- Convective exchange correlations between faces: parallel plates, concentric spheres or cylinders
- Join
- One Way heat transfer
- User defined
- Connection break or Series or T-junction

Optical and other advanced material properties

- Electrical resistivity
- Phase change and ablation properties
- Extinction coefficient
- Refraction
- Bi-variate tables
- Transmissivity/specularity
- Angle dependent optical properties

Applied heat loads

- Constant and time-dependent:
  - Heat loads
  - Heat flux
  - Heat generation
- All applied loads controlled with temperature-controlled thermostat conditions or PID controllers
- Radiative heating
- Peltier coolers modeling
- Electrical joule heating

Temperature boundary conditions

- Constant temperature for steady-state or transient
- Time varying for transient and for nonlinear steady-state
- Thermostat temperature controls or PID controllers

Conduction heat transfer

- Ability to handle large conduction models (memory efficient data scheme)
- Temperature-dependent conductivity, specific heat
- Orthotropic conductivity
- Heat of formation at phase change temperature

Convection heat transfer

- Constant, time and temperature-dependent heat transfer coefficients
- Parameter and nonlinear temperature gradient functions

Free convection

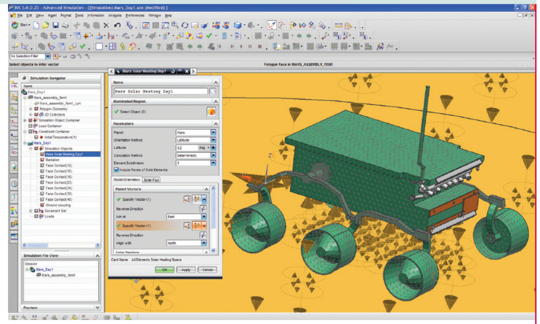
- Correlation-based free convection to ambient for inclined plates, cylinders and spheres

Forced convection

- Correlation-based convection for plates, spheres and cylinders in forced fluid flow

Radiation heat transfer

- Constant and temperature-dependent emissivity
- Multiple radiation enclosures
- Diffuse view (form) factor calculations with shadowing
- Net view (form) factor calculations
- Adaptive scheme for view (form) factor sum optimization
- Hemicube-based view (form) factors calculation using graphics card hardware
- Radiation patch generation to condense large element-based radiation models
- Radiation matrix controls and parameters
- Additional radiation request types
  - Among group
  - Group to group
  - Monte Carlo calculation method
  - Enhanced radiation with Ray Tracing



Initial conditions

- Starting temperatures for both steady-state and transient
- Starting temperatures from previous solution results, from file

Solver solution attributes

- Restart conditions
- Cyclic convergence criteria
- Direct access to solver parameters
- Solver convergence criteria and relaxation factors
- Solver monitor with solution convergence and attributes
- Intermediate results display and recovery directly from solver progress monitor
- Open architecture (user subroutines)
- Support to include external files

Other features

- Results Reporter
- Summary of results to MS® Excel worksheets
- Heat flow calculation between groups
- Heat maps
- Complete or partial deactivation of selected elements (for radiation form factors calculations)
- Temperature mapping for Nastran FE models

Results post-processing

- Temperatures
- Temperature gradients
- Total loads and fluxes
- Conductive fluxes
- Convective fluxes
- Convection coefficients
- Residuals
- Heat maps
- View factors sums

Industry applications

Typical space systems thermal analysis applications include:

- Transient and steady-state orbital heating simulation
- MLI and TPS design, modeling and performance analysis
- Laser pointing and other ray tracing optical applications
- Re-entry vehicle aero-heating and thermal ablation modeling
- Thermal sub-systems optimization
- Interplanetary spacecraft thermal design and analysis
- Material coating selection (checkered board or other strategies)
- Loop heat pipes analysis
- Thermal shock transient simulations
- Orbital maneuvering transient thermal simulations
- Mars orbiter thermal management systems analysis
- Fluid pulse-driven cryo-coolers
- Space test-bed experimental apparatus thermo-fluid analysis
- Space station and future space modules HVAC

Supported hardware/OS

NX Space Systems Thermal is an add-on product to NX Advanced FEM in the NX Advanced Simulation suite of applications. It requires a license of NX Advanced FEM as a prerequisite. All standard NX hardware/OS platforms are supported (including Windows, Linux, Unix and selected 64-bit platforms). Contact Siemens PLM Software for any other specific hardware/OS support requests.

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