NX Product Roadmap Thermal/Flow Solvers

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Premium Partners:

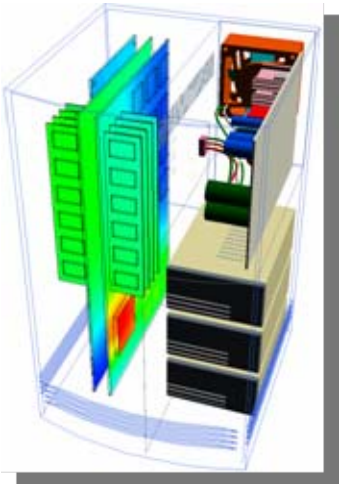
NX CAE Development Goals

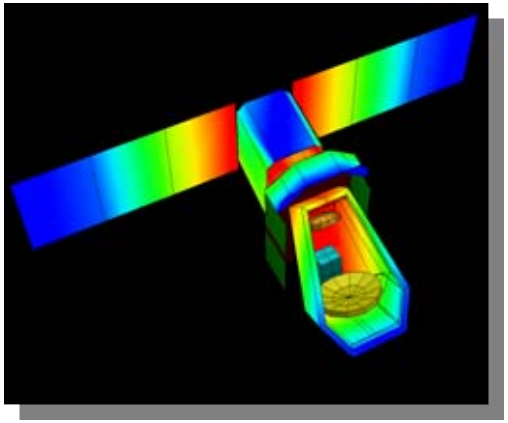
- Broaden the range of solutions available for both analysts and design engineers in the NX environment

- Deliver a comprehensive set of thermal and fluid flow (CFD) simulation capabilities in the NX suite of products
  - Migration path for I-DEAS TMG/ESC customers
  - Full integration
  - Highly functional
  - Advanced modeling & solver technology
  - Complementary to NX Nastran

Approach

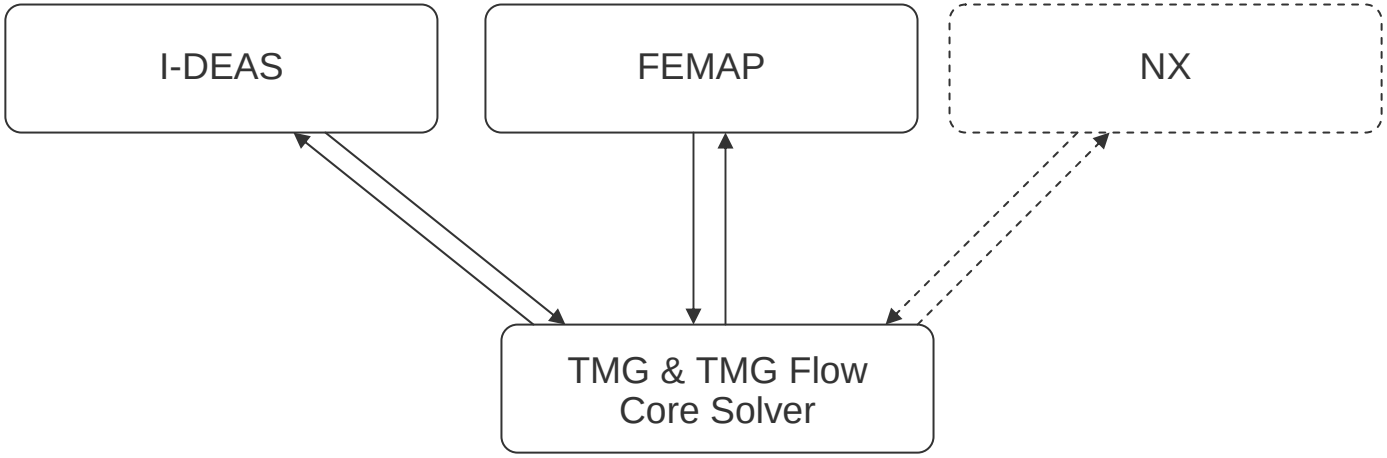
- Exploit the technology and heritage of the I-DEAS TMG/ESC products:
  - Comprehensive thermal and fluid simulation capabilities
  - Full integration into MasterFEM
  - Supports assemblies, contact at disjoint meshes
  - Extensive feature set
  - Robust CFD modeling tools
  - Advanced radiative heat transfer
  - Results transfer to NX Nastran
  - State-of-the-art solver technology
  - Seamless coupling of thermal/flow problems
  - Established, well-proven products





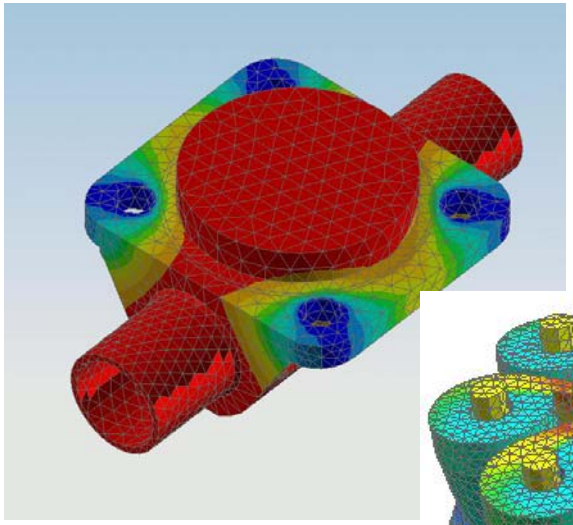
Approach

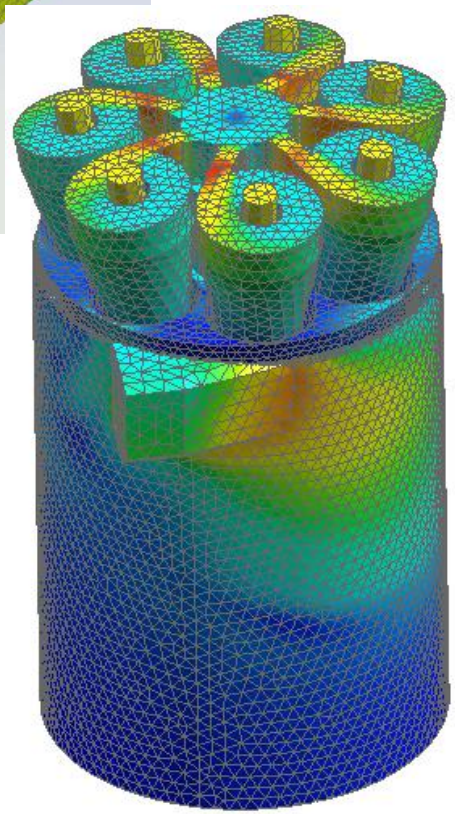
- Use the existing TMG and TMG Flow solver code as the basis for a new set of fluid flow and thermal analysis tools to be developed as modules of the NX CAE suite
- Full commonality at a solver level with I-DEAS TMG/ESC and FEMAP Thermal/Flow



NX Thermal/Flow Solver Products

- Thermal Stack:
  - NX Thermal
  - NX Thermal Advanced
- Flow Stack:
  - NX Flow
  - NX Flow Advanced
- Vertical Applications:
  - NX Electronic Systems Cooling
  - NX TMG Space Thermal



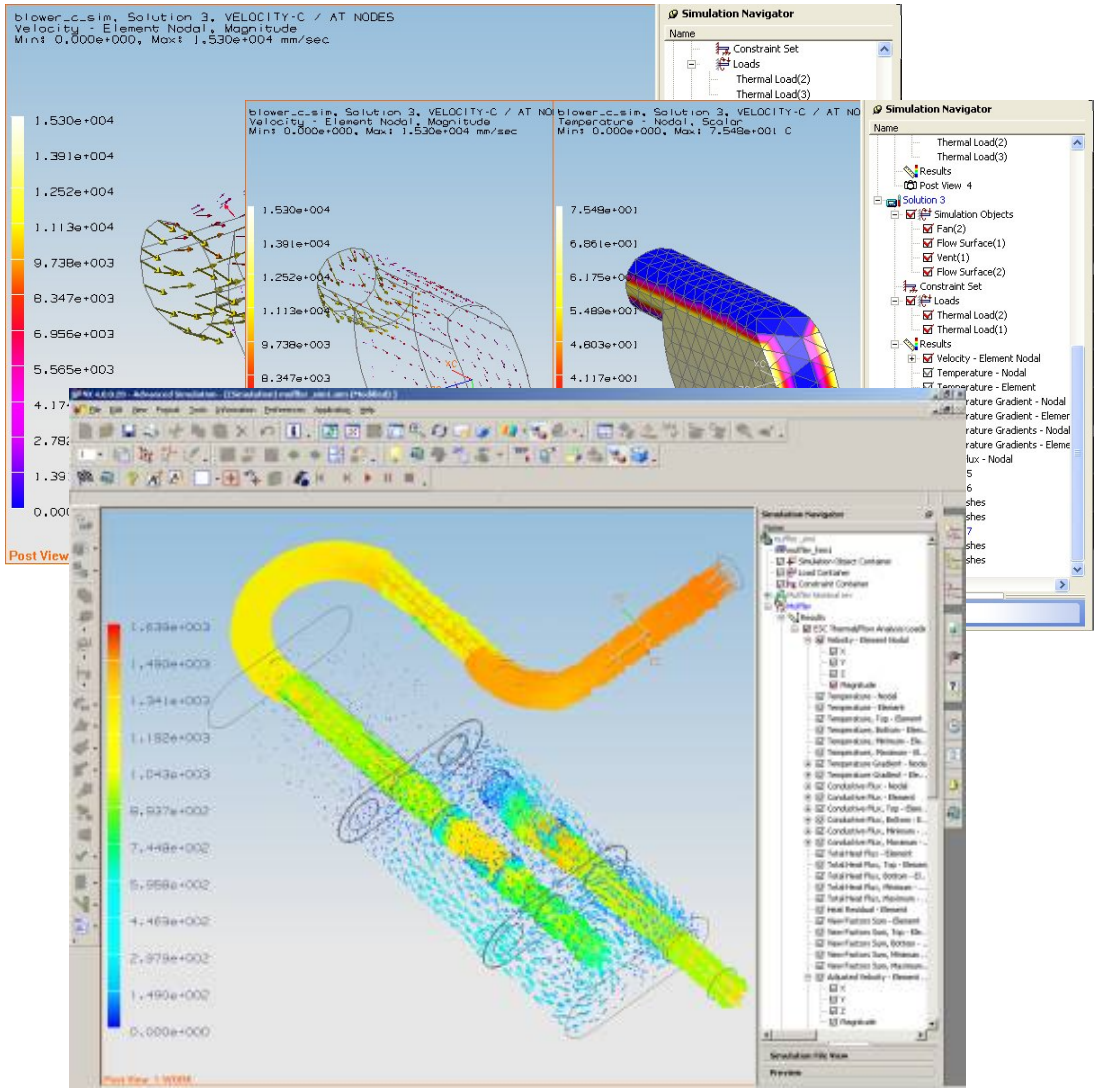


Release Plans

- NX Thermal & NX Flow are released with NX4
- NX Thermal Advanced & NX Flow Advanced will be available in NX5
- Vertical Applications (NX Electronic Systems Cooling and NX TMG Space Thermal) will also be released with NX5

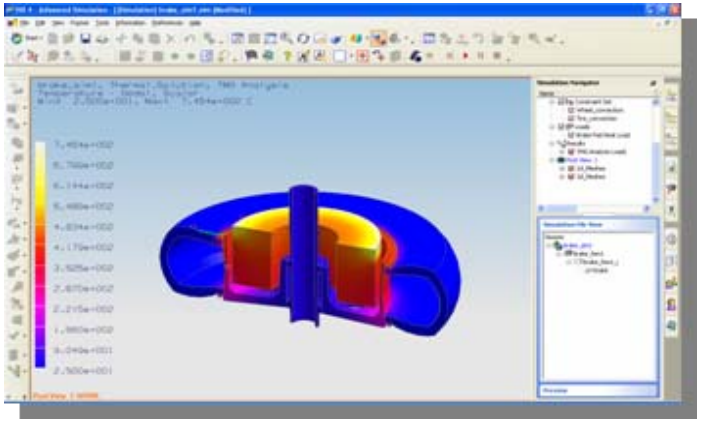
NX 4 – Native CFD & Thermal Simulations

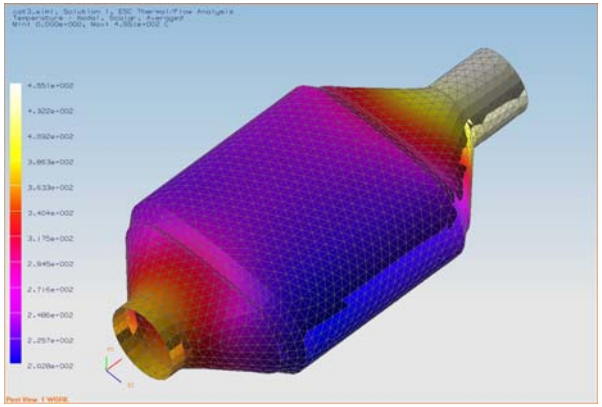
- **Integrated in NX, the combination of thermal and flow products to allow coupled thermal/flow analyses**
- **Prediction of fluid/heat interactions**
- **Applications**
  - Electronic enclosures
    - Computer equipment
    - Consumer electronics
  - Consumer goods
    - Appliances
  - Industrial Equipment
    - Drying equipment
  - Automotive
    - Air flow through exhaust system
    - Engine cooling



NX Thermal

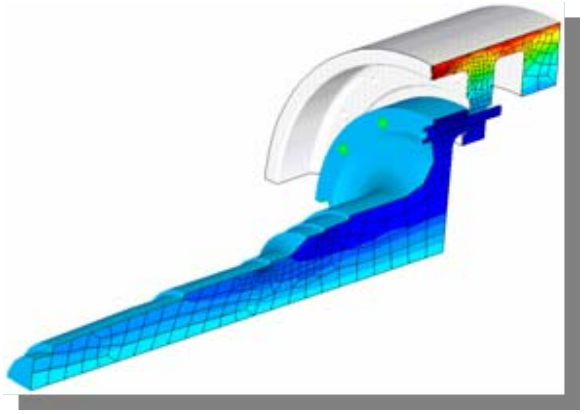
- Steady state and transient solutions
  - Conjugate Gradient solver
- Nonlinear material properties
  - Conductivity, specific heat, emissivity
- Boundary Conditions:
  - Heat loads, heat flux, heat generation
  - Applied temperatures, initial conditions
  - Radiation and convection to environment
  - Free and forced convection correlations
  - All BC’s can be time varying

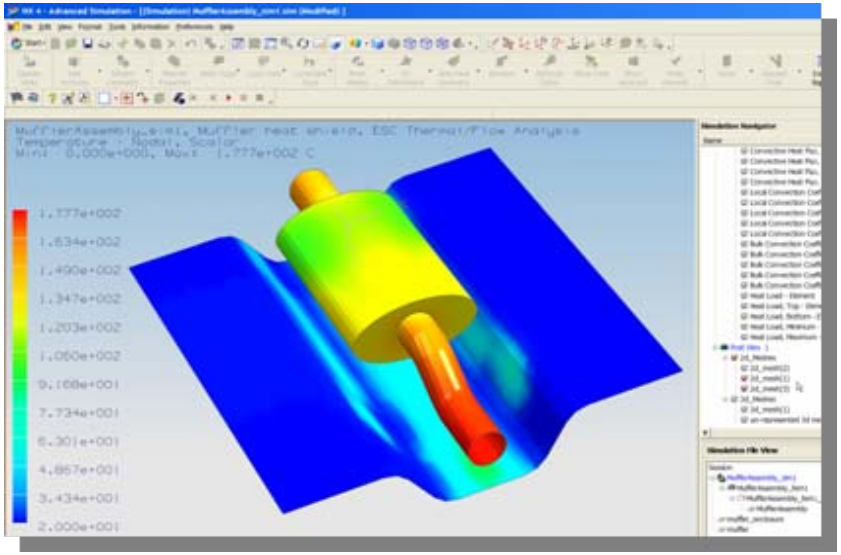




NX Thermal

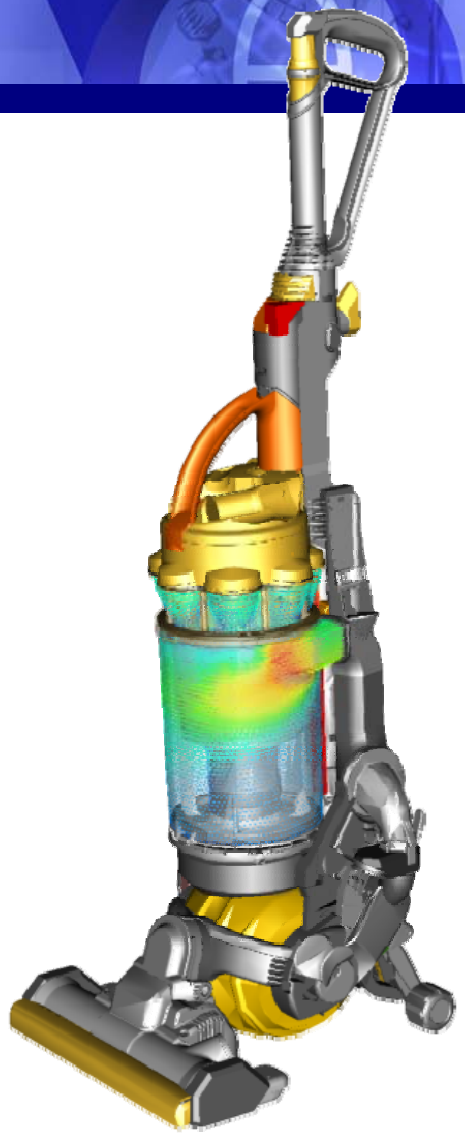
- Thermal couplings
  - Contact / radiative / interface
- Radiation
  - View factor calculation
  - Hemicube technology
  - Radiation patches
- Solution Restarts
- Axisymmetric modeling
- Temperature mapping
- Excel based results reporter





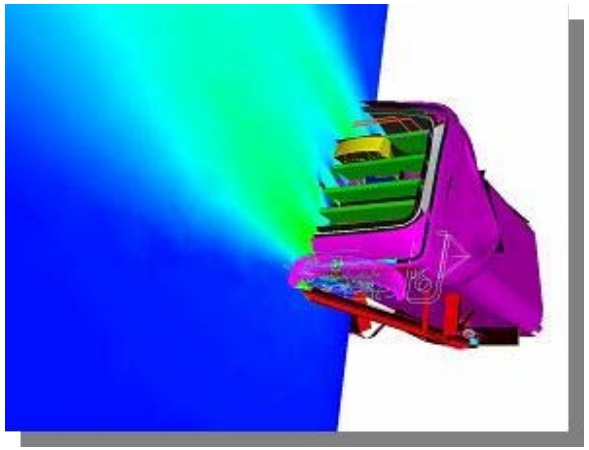
NX Flow

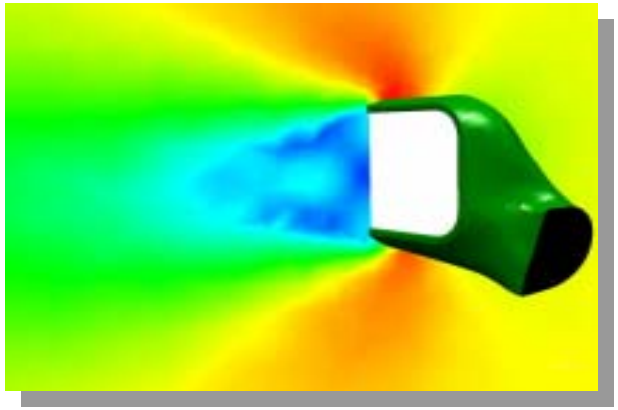
- Steady state and transient solves
  - Adaptive correction multigrid solver
- Unstructured fluid meshes
  - Supports tets, bricks, wedges
- Multiple fluids in separate fluid domains
- Laminar and turbulent flow
  - k-ε, mixing length turbulence models
- Heat loads and temperature restraints on the fluid
- Automatic generation of fluid mesh
  - Boundary layer meshing



NX Flow

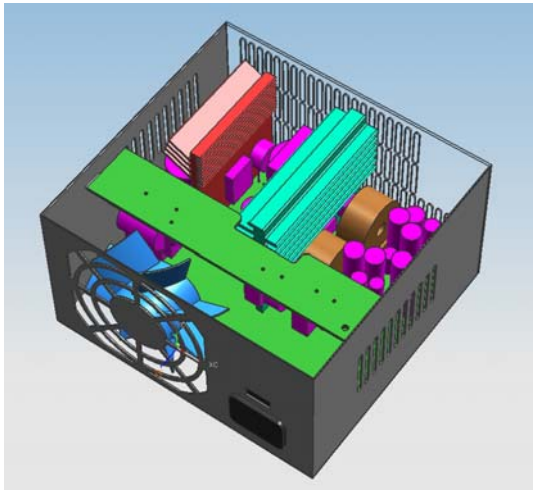
- Flow BC's
  - Fans/pumps, inlets/outlets
  - All BC's can be time varying
- Solid blockages, screens, baffles
  - Isotropic, orthotropic porous blockage
  - Automatic fluid mesh splitting at embedded flow surfaces
- Handles disjoint fluid meshes (fluid couplings)
- Restarts

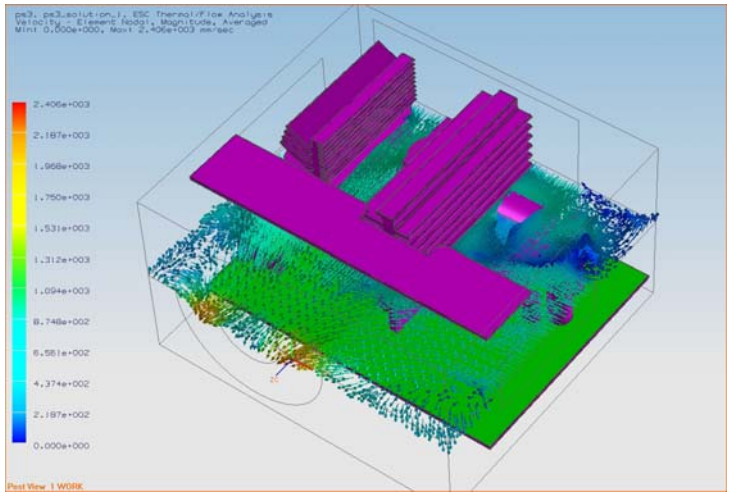




Coupled Thermal & Flow

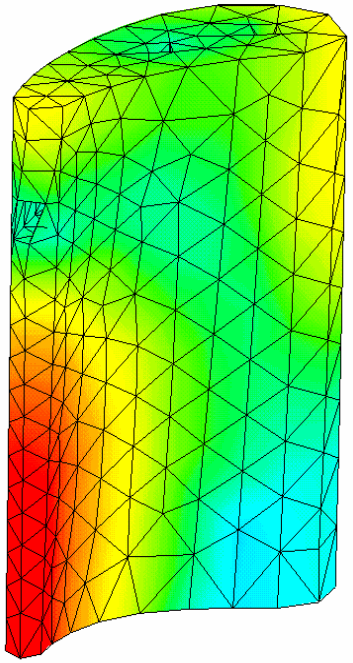
- NX Thermal and NX Flow models can be fully coupled
  - Concurrent coupled solver
  - Automatic calculations for forced, natural and mixed convection
  - Handles all types of conjugate heat transfer problems
  - Meshes can be fully disjoint at fluid/solid interface

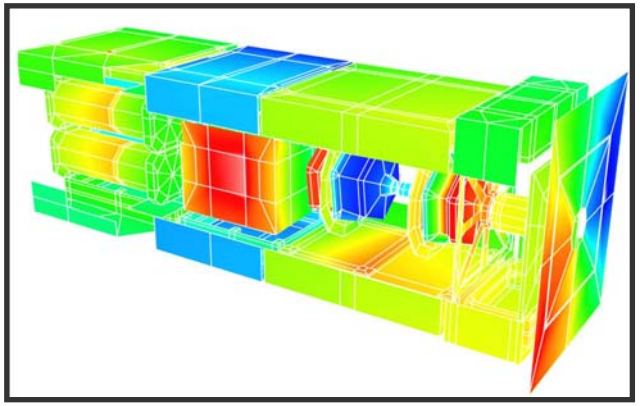




NX Thermal Advanced [NX5]

- Add-on to NX Thermal
- Will deliver additional capabilities:
  - Advanced radiative heat transfer
    - Complex thermo-optical property models (full BRDF)
    - Radiation with participating media
    - Monte-Carlo ray-tracing
  - Radiative heating by diffuse or collimated sources
  - Articulating, spinning assemblies
  - Diurnal (terrestrial) solar heating
  - Duct and hydraulic flow
  - Joule heating
  - Solver Open Architecture (User subroutines)

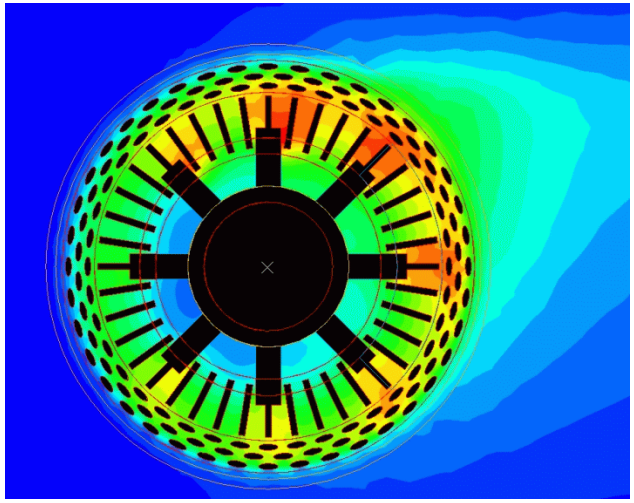


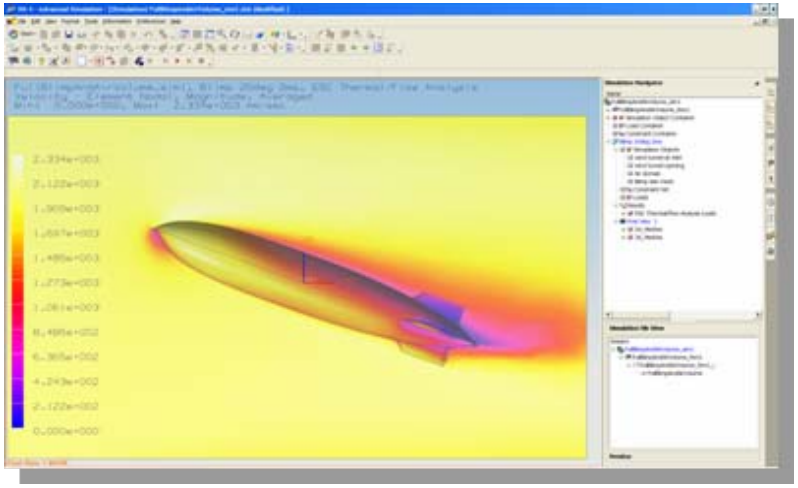


NX Flow Advanced [NX5]

- Add-on to NX Flow

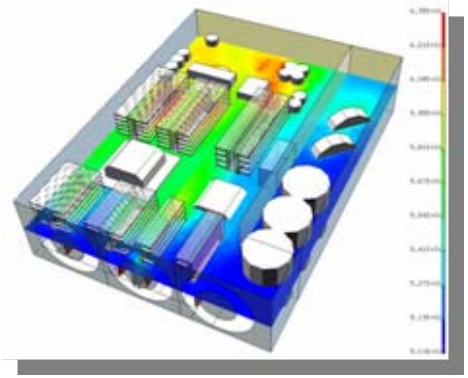
- Provides additional capabilities:
  - Compressible flow
  - Additional turbulence models
  - Rotating frames of reference
  - Nonlinear fluid properties
  - Transport of species
    - Humidity, condensation

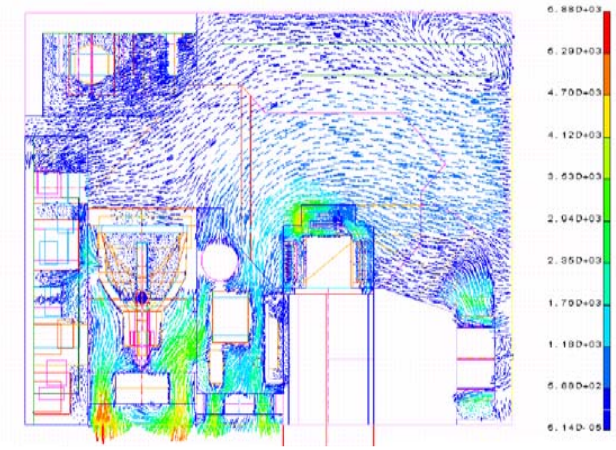




NX Vertical Applications [NX5]

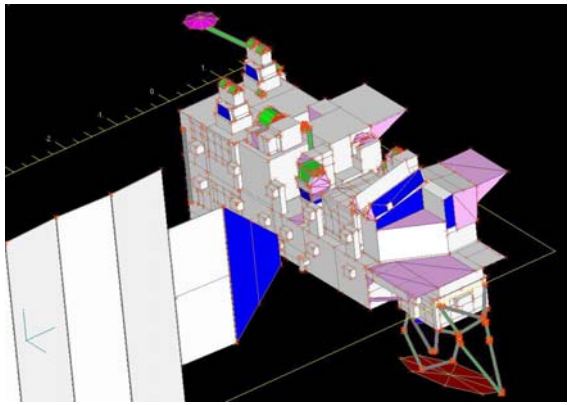
- ***<u>NX Electronic Systems Cooling</u>***
  - Comprehensive application for simulation of heat transfer and fluid flow in electronic systems and components
  - Includes all capabilities of NX Thermal and NX Flow
  - Adds specialized tools:
    - Fan Catalogs
    - Heat Sink Modeler
    - PCB data exchange (ECAD/MCAD)

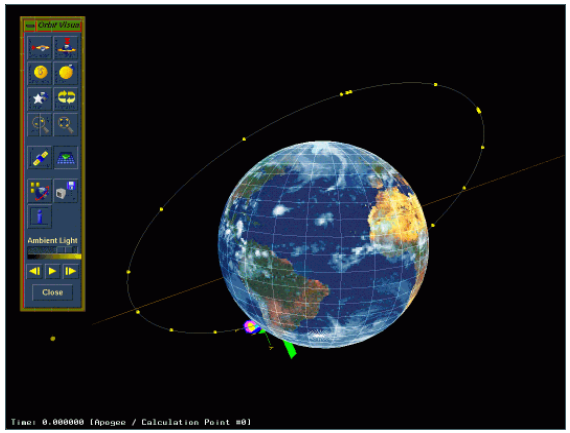




NX Vertical Applications [NX5]

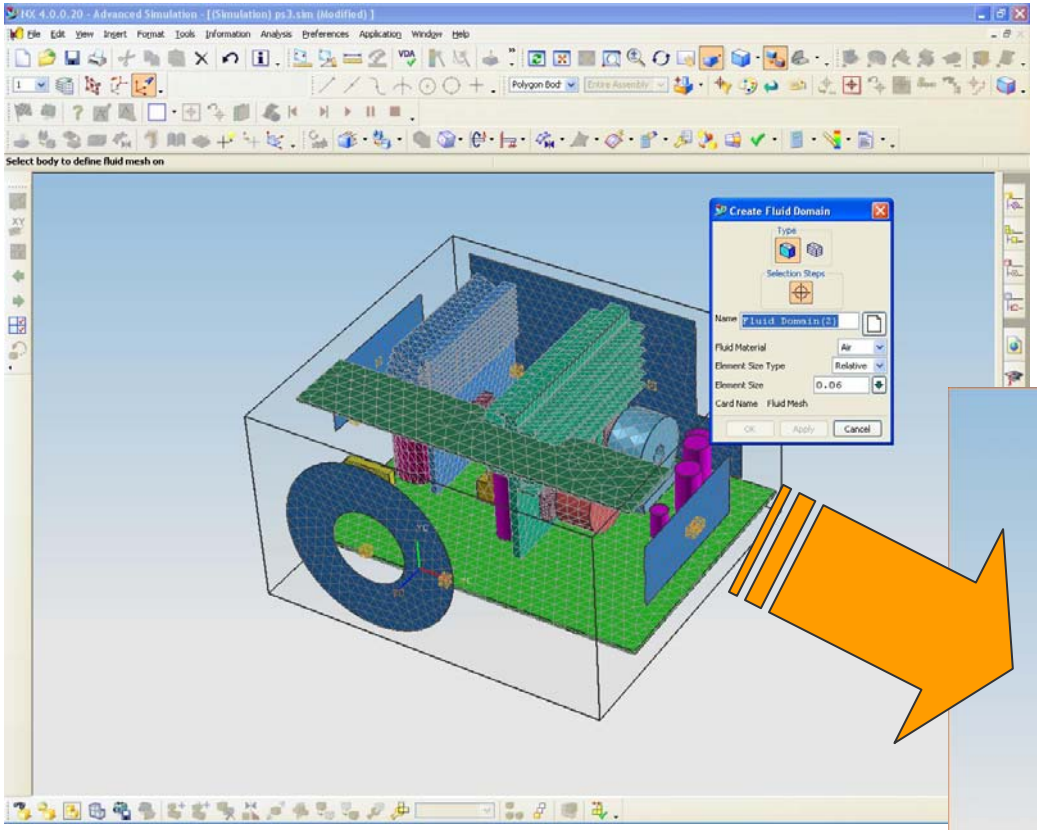
- ***<u>NX TMG Space Thermal</u>***
  - Thermal analysis of space systems
  - Includes all capabilities of NX Thermal and NX Thermal Advanced
  - Adds specific capabilities for modeling space systems
    - Orbital environment modeling
    - Radiation primitives
    - Interfaces to SINDA, ESATAN, TSS, STEP-TAS

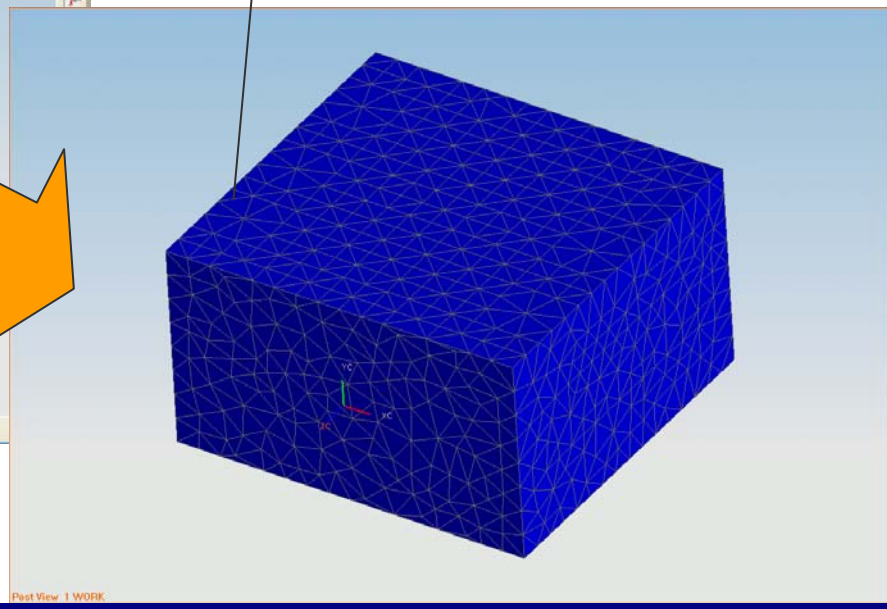




Modeling & Meshing

- Powerful fluid domain mesher for fast and efficient meshing of complex enclosures



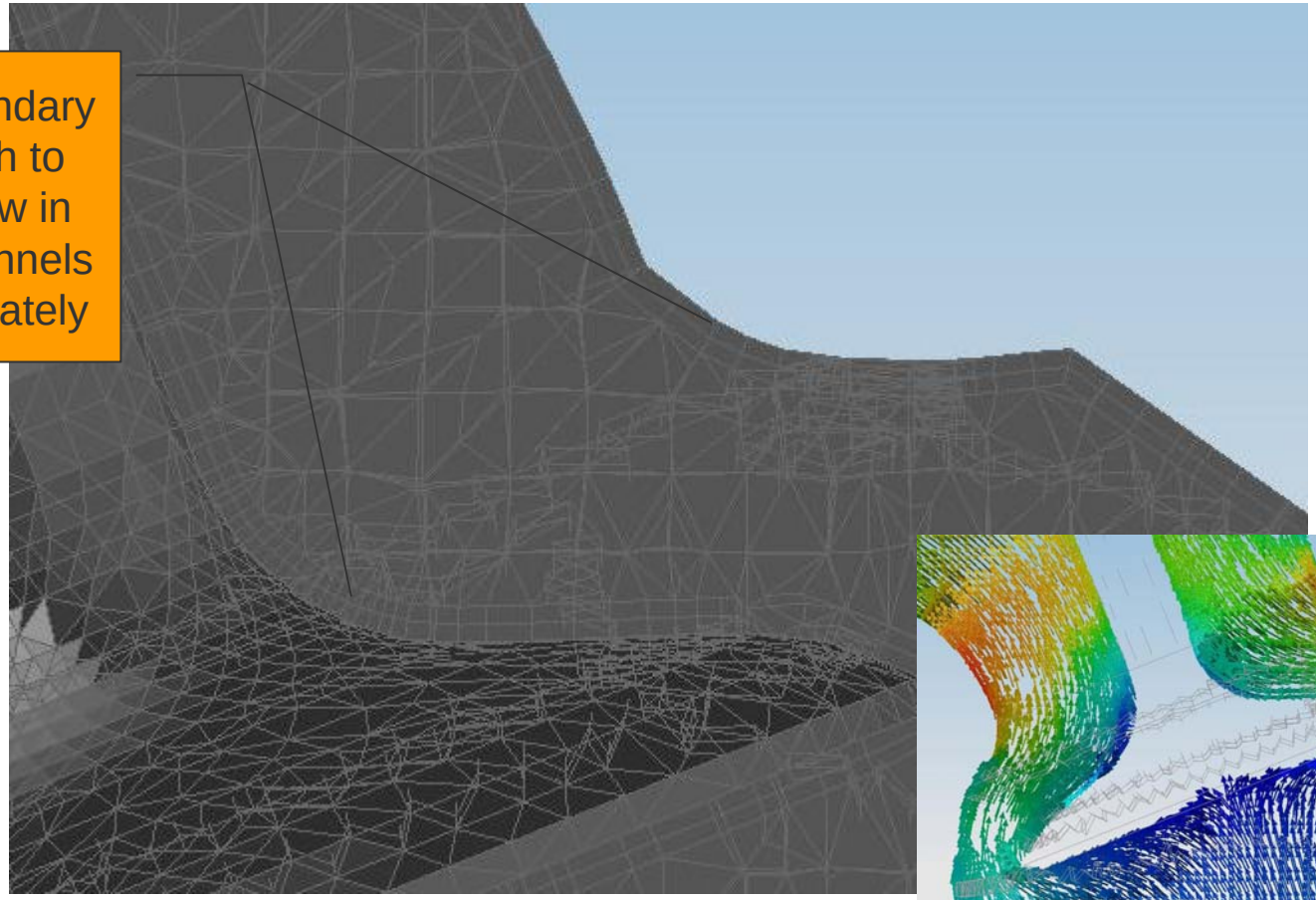


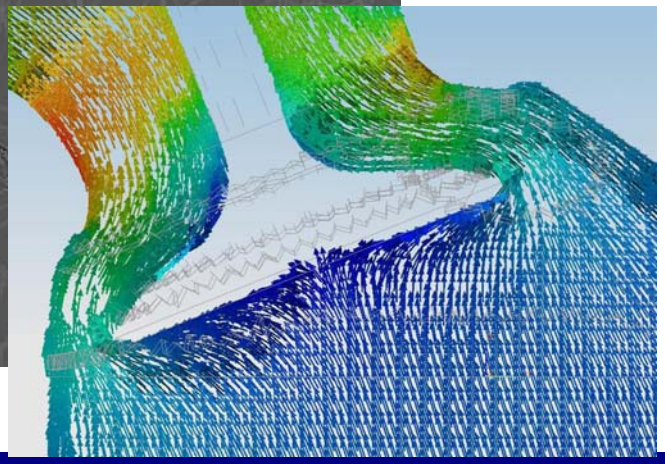
Creates fluid domain mesh during solution

Modeling & Meshing

- Fluid domain mesher can automatically create boundary layer mesh

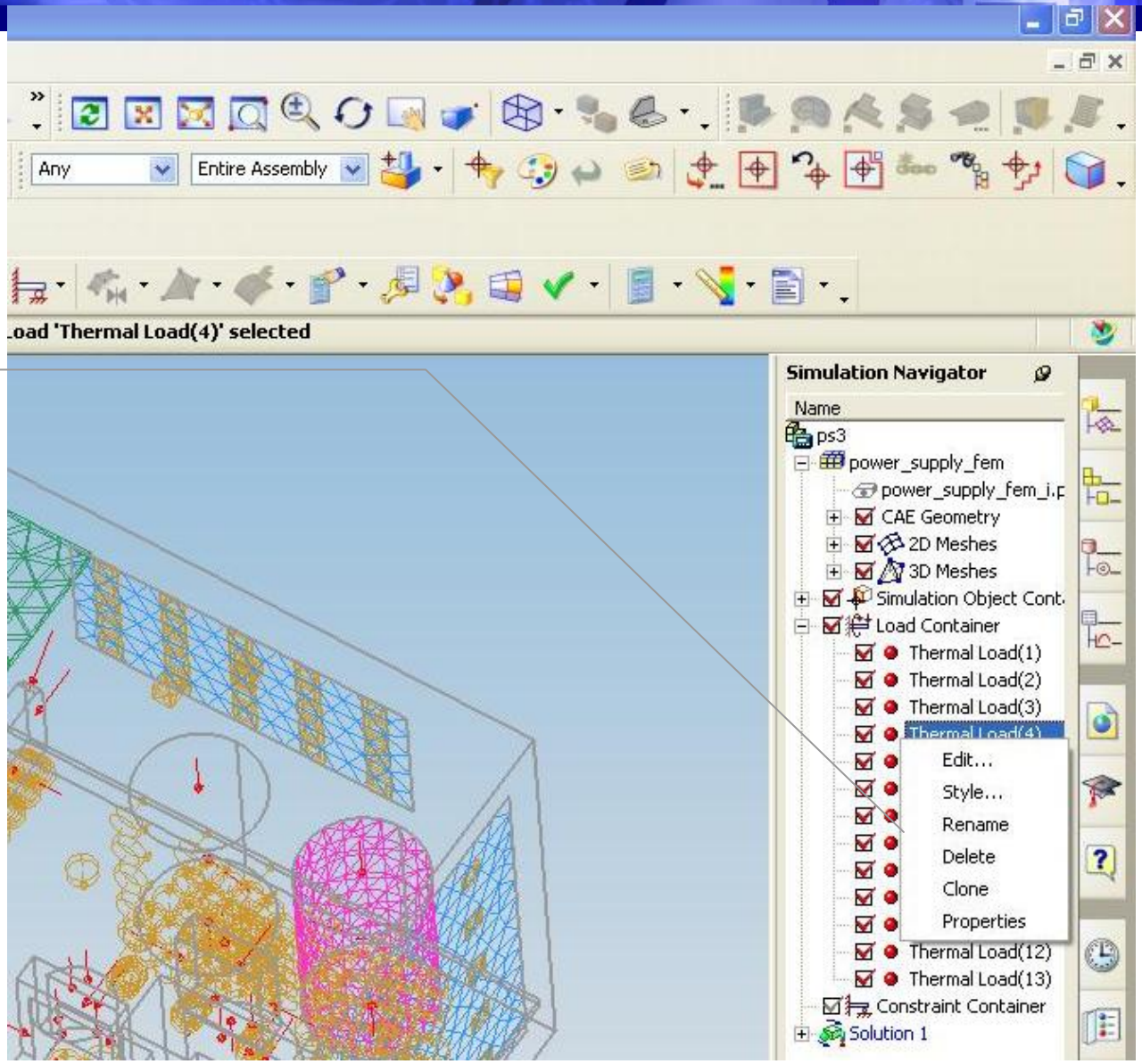
Create boundary layer mesh to resolve flow in narrow channels more accurately



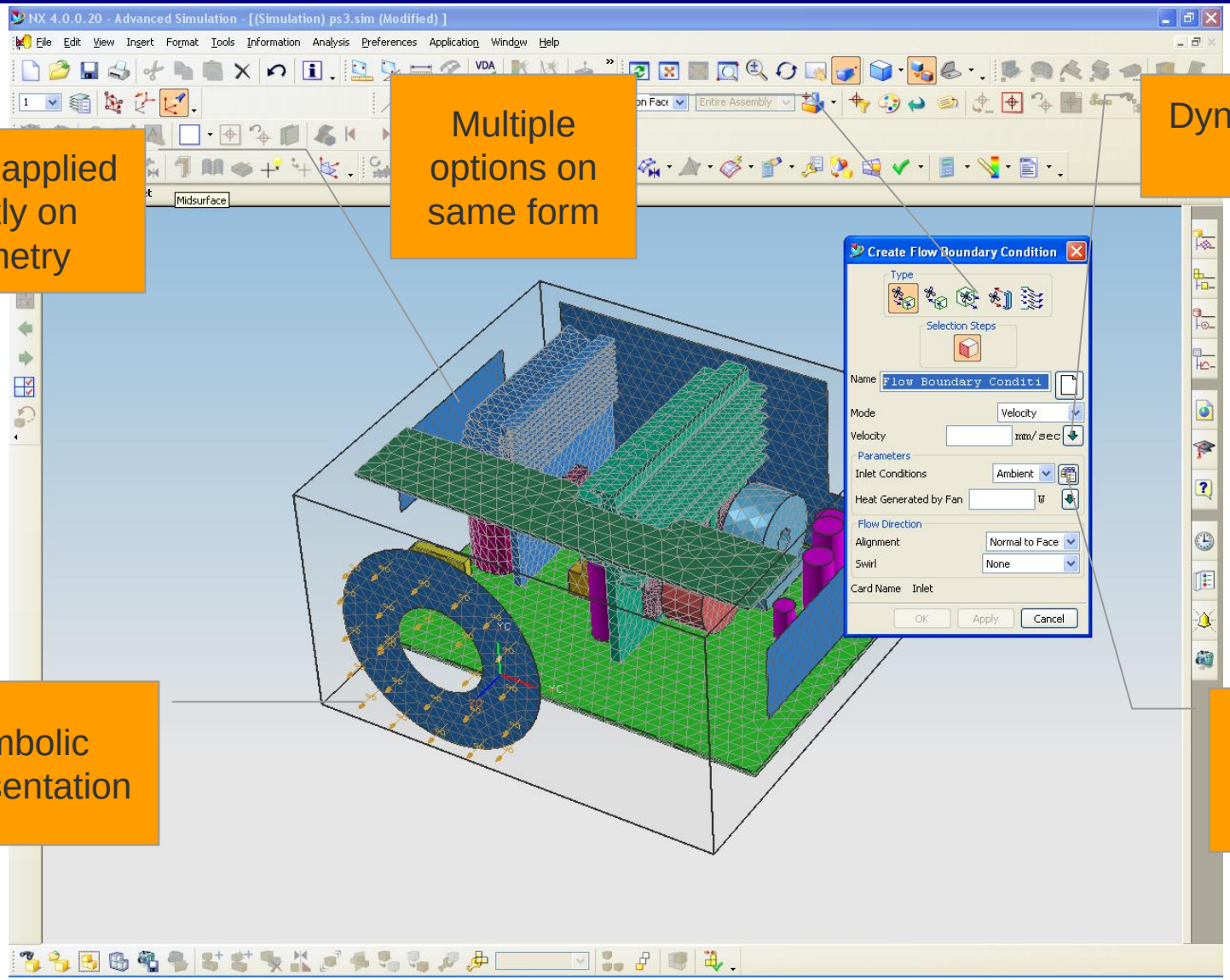


User Interface – Simulation Navigator

Simulation Model data management



User Interface – Boundary Conditions



All BCs applied directly on geometry

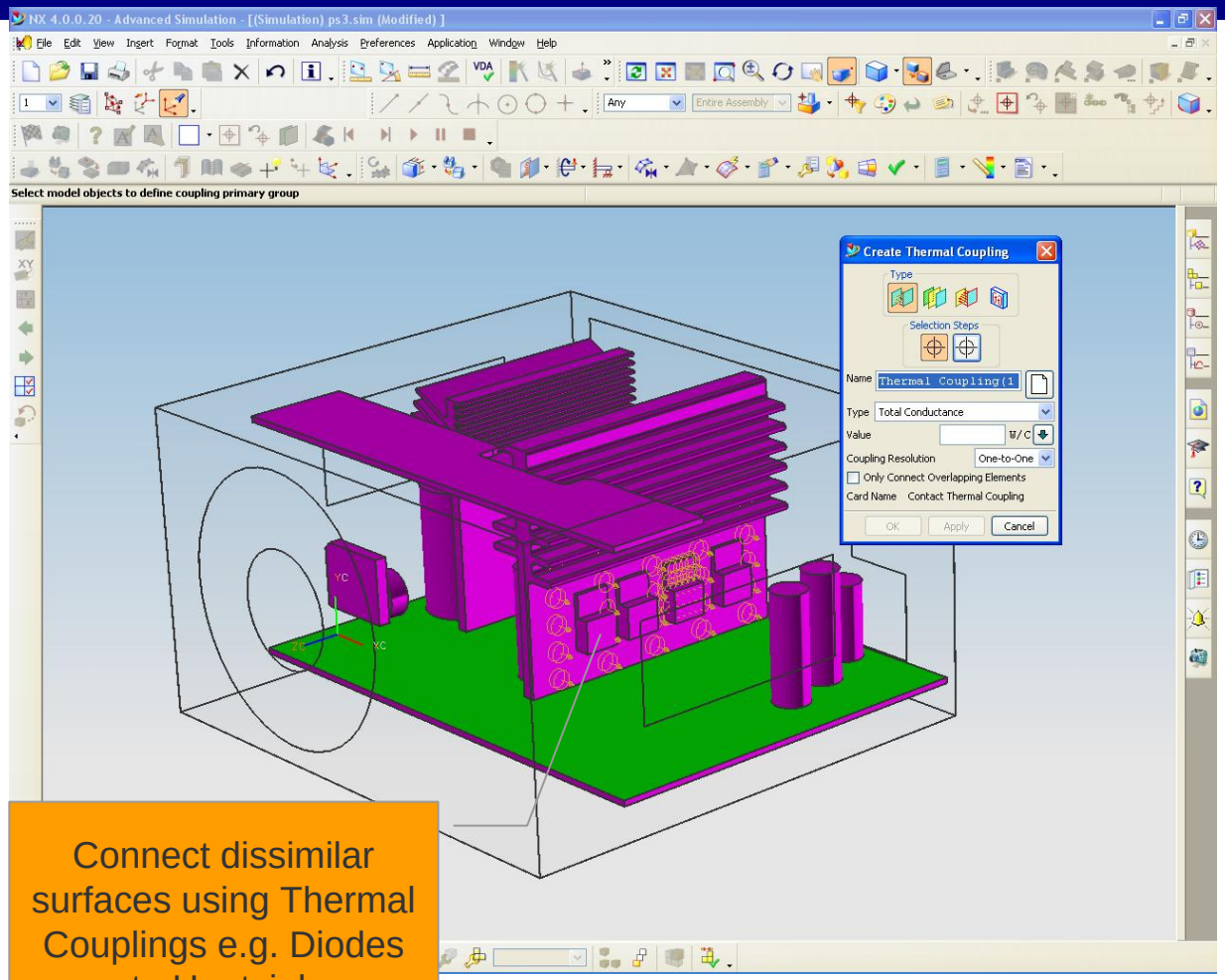
Multiple options on same form

Dynamic Units

Symbolic representation

Modeling Objects

DxMesh for Thermal Assemblies



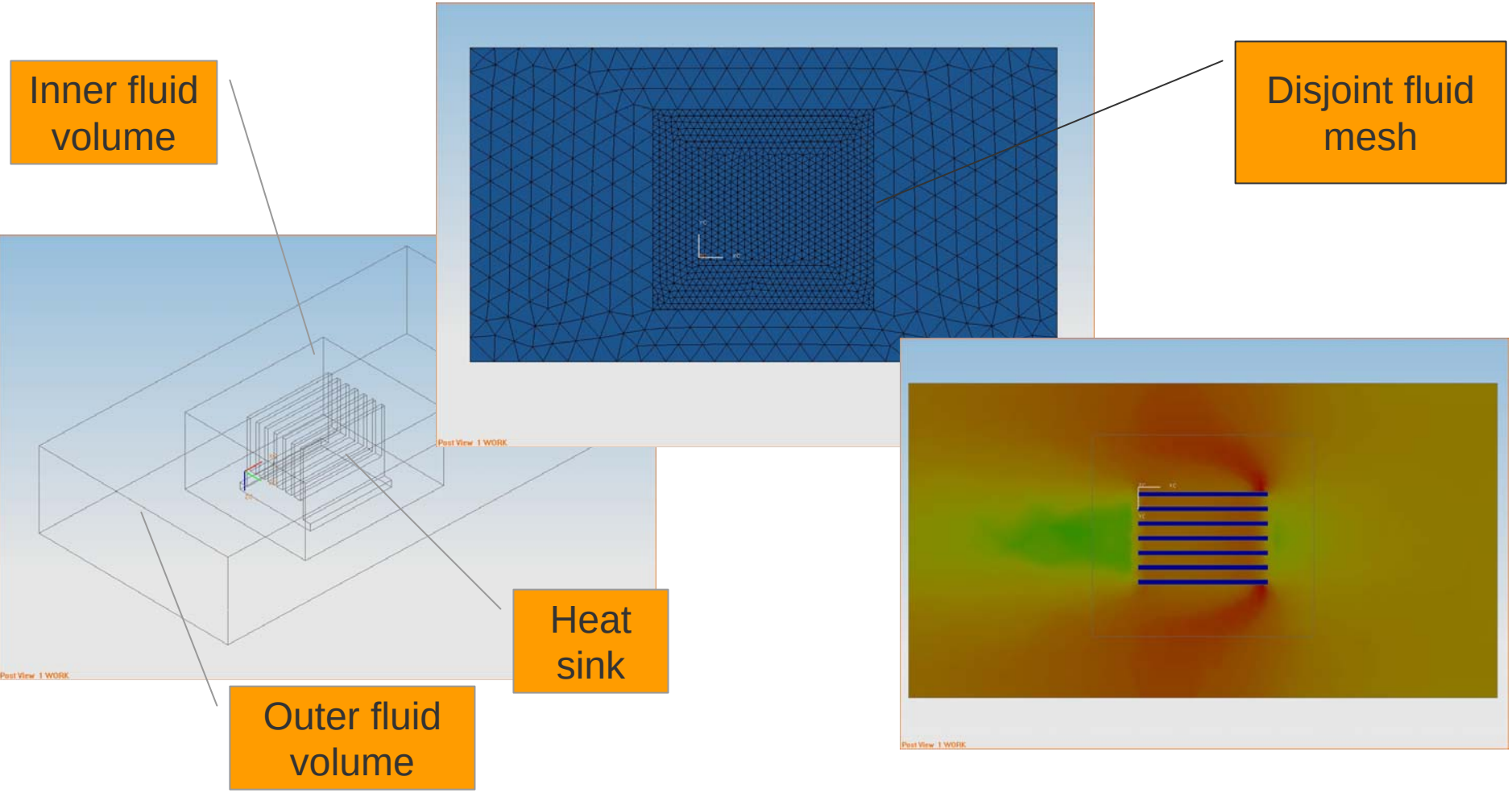
Connect dissimilar surfaces using Thermal Couplings e.g. Diodes to Heatsink

Thermal Couplings create a heat path between independent parts, they can be used to simulate

- Bolted, Welded joints
- Components on PCB
- Interface materials

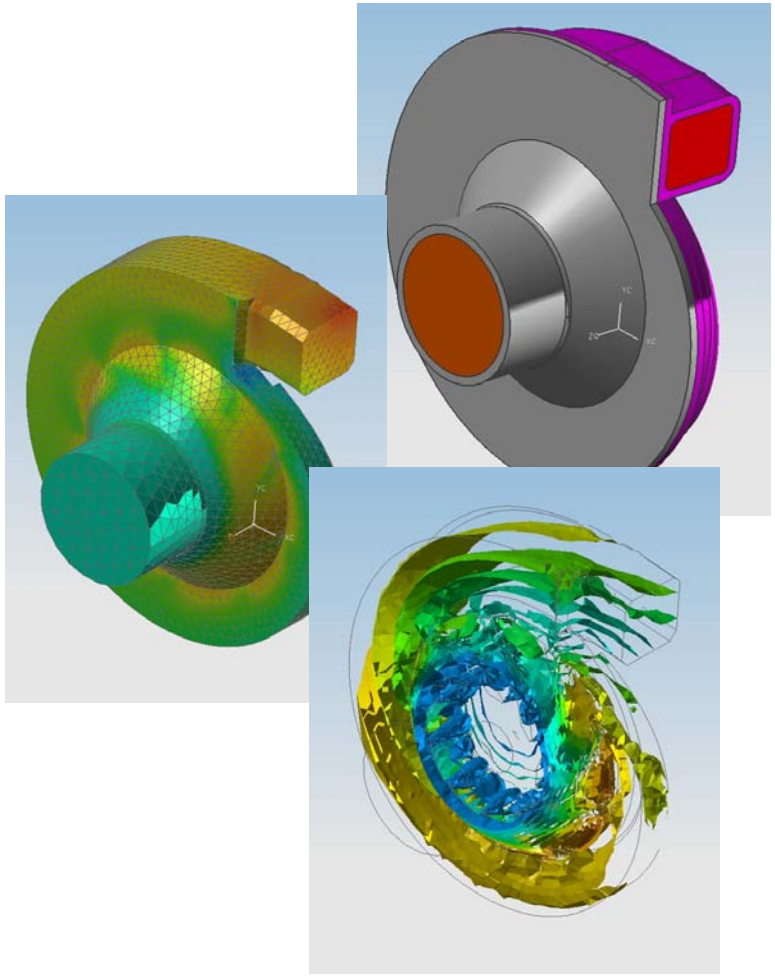
DxMesh for Fluid Assemblies

- DxMesh for Fluid Assemblies, automatically models fluid flow across disconnected fluid meshes



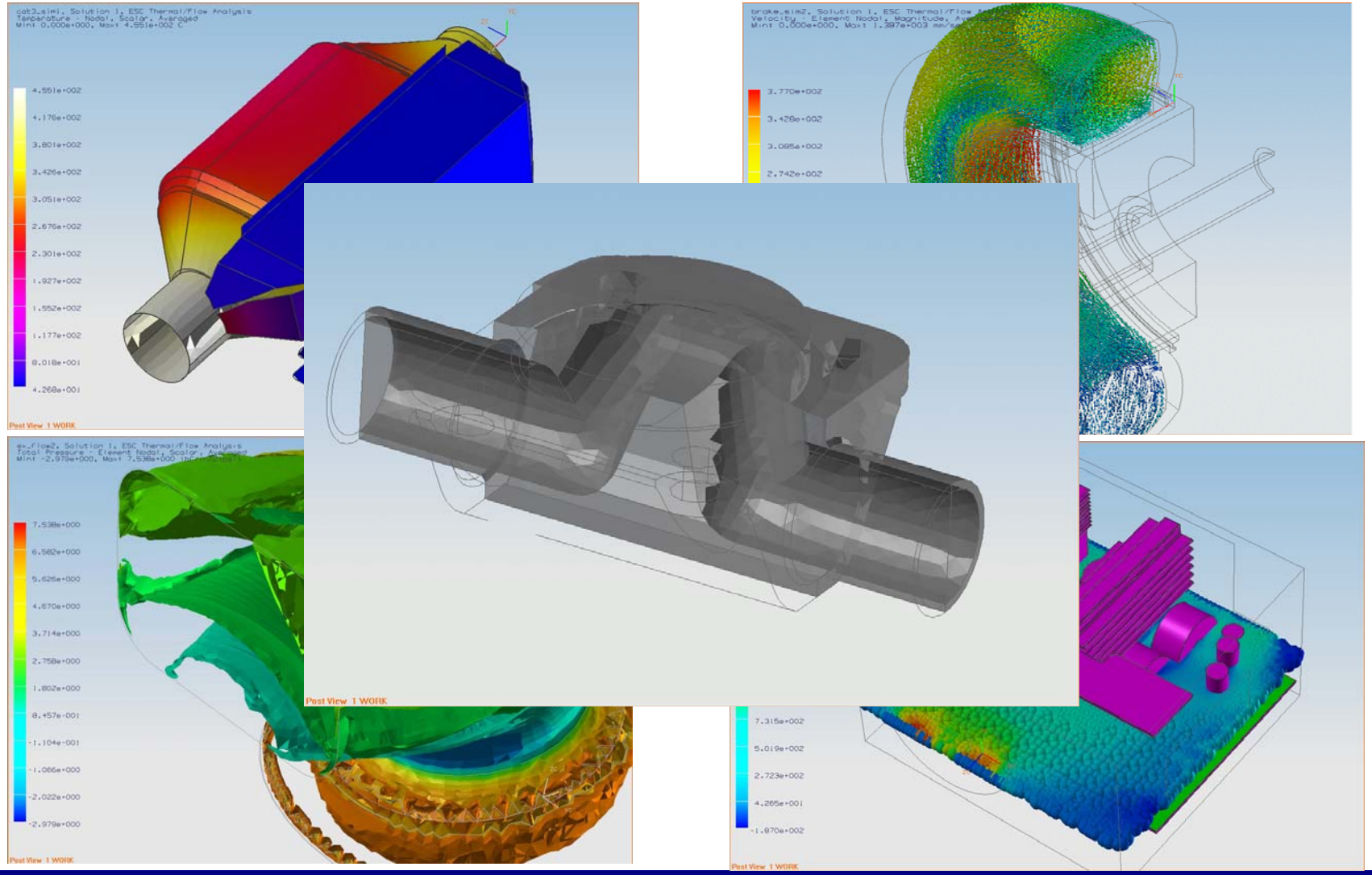
Post Processing

- Comprehensive set of thermal and flow results, provide complete physical insight into simulation model
  - Thermal results
    - Temperatures
    - Heat Fluxes, Heat Loads
    - Temperature Gradients
    - View Factor Sums
  - Flow Results
    - Velocities
    - Pressures, Static and Total
    - Heat Transfer Coefficients
    - Mass Fluxes
    - Turbulence Dissipation



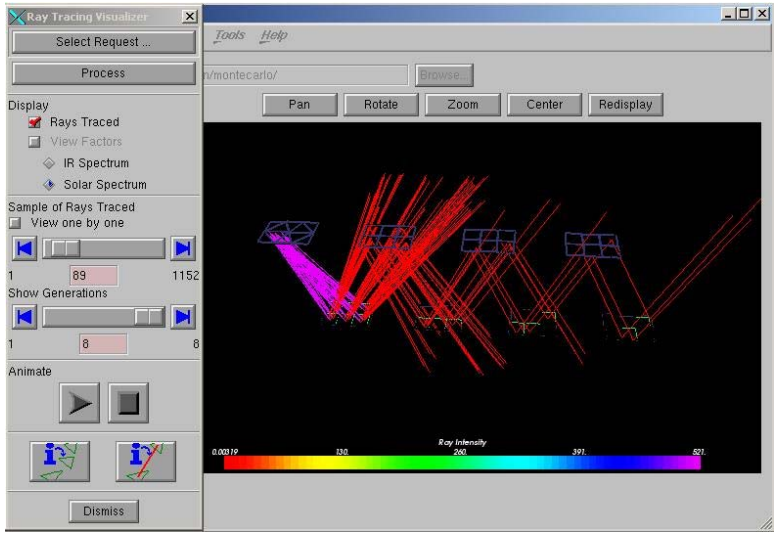
Post Processing

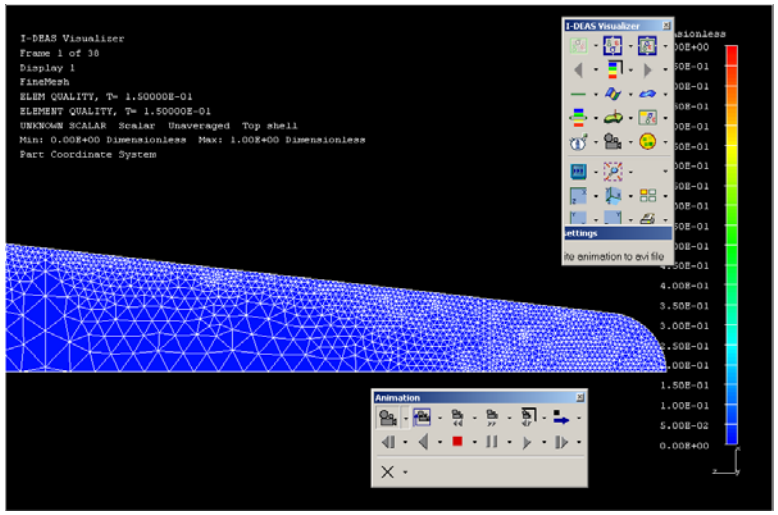
- Multiple options for viewing results



Recent Solver Developments

- 64 bit port, Linux
- Non-Newtonian fluids
- High speed flow enhancements
- Radiation in participating media
- Ablation modeling
- Monte Carlo methods





Monte Carlo Technology

- Alternate method to compute view factors, radiative conductances, and environmental heat loads
- Provides capability to compute environmental and radiative heat loads directly, bypassing Oppenheim's (radiosity) and Gebhardt's methods
- Allows for the simulation of interaction of radiation with participating media, i.e., absorption and scattering of light through a semi-transparent solid
- Permits simulation of advanced optical properties
  - Direction-dependent emissivity
  - Bidirectional reflectance distribution functions (BRDF)
- Fully compatible with other TMG radiation analysis methods

General Enhancements

- TMG solver now uses double-precision for temperatures
  - Enables extremely precise computation of heat flows
- Improved handling of ablative models
  - Phase change supported with multilayer shells, solid and axisymmetric elements
  - Increased solution robustness
  - Accommodates char material
- Improved accuracy for treatment of specular reflections and transmission

General Enhancements

- Proportional, PID Heater Control
  - Thermostat entities can be defined to model proportional or PID controller
- New Results Data
  - Minimum/Maximum temperatures for each element over a transient solve
  - Element phase change quality
- Steady-state solve to initialize a transient

Non-newtonian Fluids

- Three physical models supported
  - Power law (molten polystyrene, polymers)
  - Herschel-Bulkley and Bigham for viscoplastic fluids:
    - Blood, drilling mud, nuclear fuel slurry, mayonnaise and toothpaste.

Supersonic Flow

- Viscous heating effects now taken into account in the energy equations.
- Thermal wall functions modified to account for viscous heating using recovery / adiabatic wall temperatures.
- Transient pressure terms added to energy equations: improves accuracy and robustness of high speed flow solutions.
- Additional terms accounted for in energy equation for rotating flows (RFR) at high speed.
- Flow solutions up to Mach 4 now supported
- New Supersonic Inlet entity: specify Mach number, flow direction, and other inlet conditions

Thank You