Sandia National Laboratories

SAND2026-22421M

Code Release Highlights

Spring 2026

SIERRA 5.30
CUBIT 17.10
SPARC 26.3

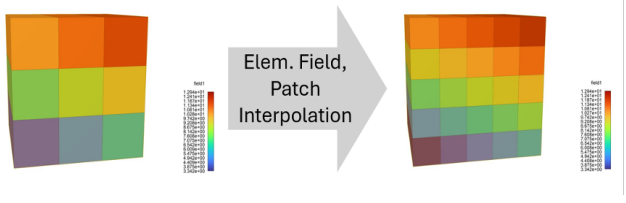
Researching, developing, and deploying state-of-the-art high performance computational engineering simulation codes.

Codes are actively being used for
B61, B83, W76, W78, W80, W87, W88, W93, ND Components & Transportation programs. A large fraction of the codes' internal compute cycles supports the Nuclear Weapons Complex: Captive-carry/free-flight aero/acoustic/structural coupled multi-physics for component design, normal/severe mechanical impact scenarios, abnormal thermal structural capabilities, normal/abnormal thermal simulations, aero/aero-structural spin-to-arm, and abnormal mechanical/accidents simulations.

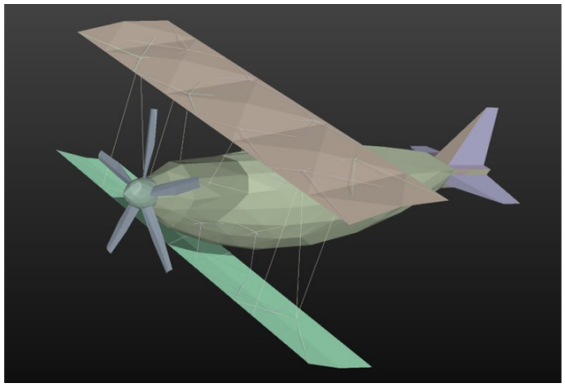
Standalone Transfer Capability

The STK team has developed a new user-facing executable to transfer solution fields between Exodus meshes without the need to run a physics application. The new stk_transfer executable is now available to transfer solution fields between Exodus mesh files. Users can transfer nodal fields using master-element interpolation. Also, nodal fields on a source mesh can be mapped to face fields on a surface or the destination mesh, or element-centered fields. Additionally, element fields on the source mesh can be mapped to the destination mesh using either copy-nearest or patch-recovery interpolation approaches.

Future work will expand capabilities to handle two-dimensional meshes, transfers between two and three dimensions, and allow for axisymmetric transformations.



Transfer an element-centered field from a 3x3 mesh to a 5x5 mesh using the patch-recovery interpolation feature.



Demonstration of element topologies supported in new stk_transfer capability. Elements supported are
HEXAHEDRON_8
WEDGE_6
TETRAHEDRON_4
TETRAHEDRON_10
PYRAMID_5
SHELL_QUADRILATERAL_4
SHELL_TRIANGLE_3
BEAM_2

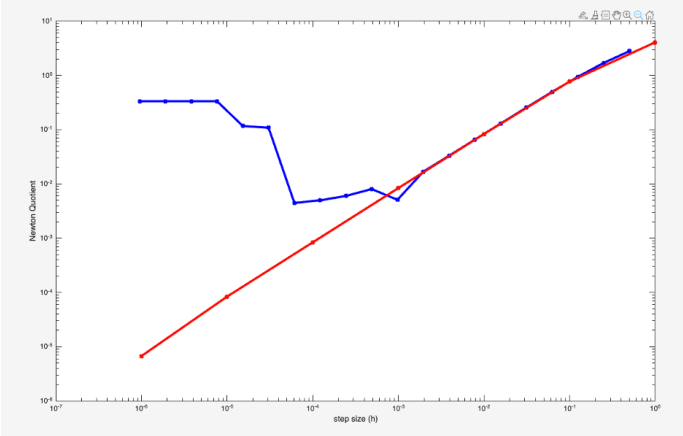
Code Team Office Hours:
- Cubit/Percept: Mondays 3:30-4:30 MT on MS Teams
- Sierra Thermal/Fluid: Tuesdays 10:00-11:00am MT on MS Teams
- Sierra Toolkit: By appointment at stk-ngpteam@sandia.gov
- Sierra DevOps: Tuesdays 10:00-11:00am MT on MS Teams
- Sierra Solid Mechanics: Thursdays 10:45-11:30 MT on MS Teams
- Sierra Structural Dynamics: By appointment to wg-sddev@sandia.gov
- SPARC: Mondays & Thursdays from 9:00 –11:00 MT on MS Teams
- SAW: By appointment at saw-help@sandia.gov
- Post questions or issues at any time on the CompSim Community Channels

Deployment is across the DOE Nuclear Weapons Complex, DoD, and AWE:
Sierra is deployed on 10 different computing platforms (desktop & HPC), supports 400+ internal SNL users and 70+ distinct external licenses.
Cubit is deployed on 3 different architectures (Windows, Mac, Linux), regularly hosts 510 internal users and 1500+ external users.
SAW supports 300+ users and archives over 30 terabytes of analysis data

What's New in Sierra

Plato

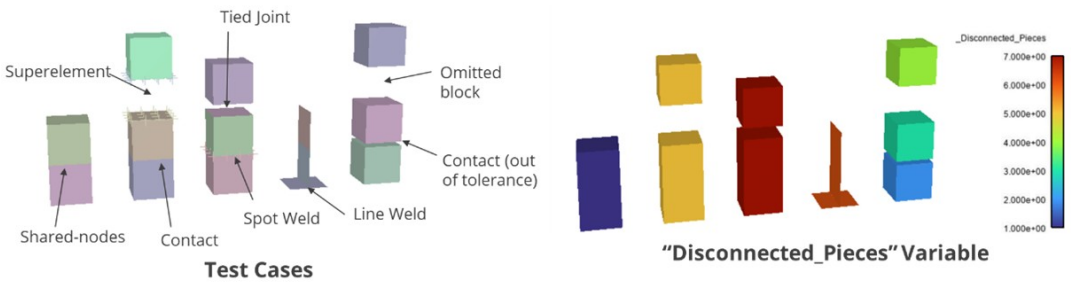
- Capability: Parallelization of constraints. Plato Engine is now able to evaluate constraints with multiple MPI ranks (previously, this was only possible with objectives). Even though constraints are usually less costly, their evaluation sometimes became a significant bottleneck.
- Bug Fix: Plato-Cubit precision issue. Our CAD-parameter geometry optimization module was sending Aprepro variables to Cubit with insufficient precision, leading to meshes being generated with imprecise parameter values, and corresponding gradient check issues. This has now been fixed.



Plato-Cubit gradient check with erroneous rounding (blue) vs correct using powers of 10 (red).

Structural Dynamics

- Capability: Two new fields have been added to the "constraint_info" diagnostic outputs. "Disconnected_Pieces" shows wholly disconnected sections of a model. This output can be used to debug missing constraints. "Num_Attached_Blocks" indicates how many blocks share each node and can be used to debug unmerged surfaces.
- Capability: An initial Sierra/SD supported installation of the Reentry Vibration Toolkit (RVTK) is available alongside Sierra 5.30 on some platforms by loading an RVTK module. Release of RVTK directly with Sierra is planned for 5.32. RVTK capabilities are also expanded. Paraview is now used for streamline generation (with TecPlot capabilities still available if needed), the pressure power spectral density (PSD) models are improved, and a new base pressure PSD model is available.
- Capability: The "viscofreq" keyword was added for the "receive_sierra_data" solution case, which sets the frequency at which the viscoelastic material properties are computed for subsequent QEVP solution cases
- Capability: The "material" output is now enabled for "isotropic_viscoelastic_complex" materials.
- Usability: A check was added to warn analysts when tet4 elements are being used without an explicit request to do so. Tet4 elements are usually inappropriate for SierraSD analyses (though with some useful cases) and can be introduced accidentally through workflows that include mesh generation tools.
- Usability: For analytic functions, sub-function expression variables now support user-defined arguments. The argument may be a constant value or any previous expression variables (including other functions).
- Usability: Analytic functions may now use the output of (1 or multi-dimensional) tables as expression variables. As with functions, the arguments to a table may be either constant value(s) or the output(s) of other expression variables.
- Bug Fix: Multi-dimensional tables with inputs below the origin would previously give incorrect results. This has been fixed.

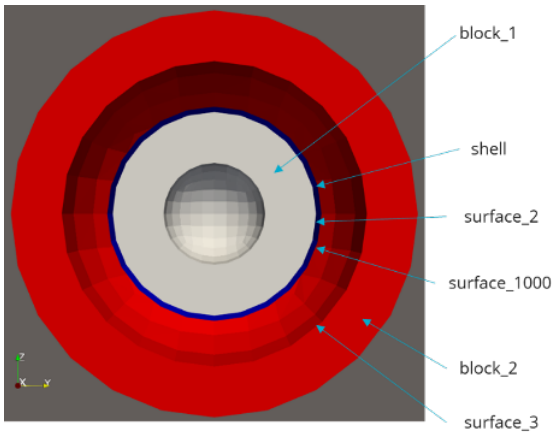


SD connectivity test cases (left) and resulting "Disconnected_Pieces" diagnostic output (right).

- Bug Fix: Sub-functions of analytic functions called with element data would previously hit a fatal error. This is no longer the case.
- Bug Fix: Several bugs related to the communication and conversion of frequencies were found and fixed. Conversion bugs (rad/s vs. hz) were fixed that affected the stress output of “isotropic_viscoelastic_complex” materials, which may be noticed in user results. Other fixed issues related to passing a default/0.0 frequency to frequency-enabled routines but are unlikely to affect user results.

Thermal Fluids

- Capability: Enabled non-synchronized output when running a coupled MPMD SPARC/Aria problem with SPARC leading and Aria stepping at a smaller time step.
- Capability: Added the ability to solve enclosure radiation using a shell-lined enclosure. The shell can either be provided in the mesh or generated automatically by Aria. The shell is automatically tied to the attached volume using contact. This enables using runtime mesh adaptivity on problems with enclosure radiation without expensive viewfactor recalculation. It also allows separate refinement rules and frequency for the enclosure shells and volumes if desired.
- Capability: The space charge equation set (voltage and charge density) was extended to allow generic flux models, tested, and the beta flag for it has been removed.
- Capability: The tied pressure contact enforcement model has been augmented so it is now compatible with decomposing ablator materials, allowing gas flow between ablators tied together in contact.
- Usability: All Aria flux boundary conditions now support toggling, an expansion from the prior set that was largely limited to energy/enthalpy flux terms.
- Usability: Transfers can now support mixed dimensional meshes, for example sending data from a 3D mesh to a 2D mesh.
- Usability: A significant refactor of the ablation model setup in Arpeggitar has allowed consolidation of several similar boundary conditions, allowing users to simplify their input files and providing more options for customizing models. Deprecation warnings in the upcoming releases will indicate which commands can be removed or need to be updated.
- Bug Fix: Mesh adaptivity driven by surface criteria like contact was fixed to properly un-refine when contact interfaces move, and to properly combine with volume-based refinement indicators attached to the refined surface.
- Bug Fix: The equation command included a parsing option for a level set phase, but did not actually use it, forcing users to mix “string-decorated” syntax with newer named phase syntax. This has been fixed to correctly allow both syntax forms.
- Bug Fix: A bug affecting data probes with mixed coordinates, node IDs, and block restrictions could cause probes to warn but pull the wrong values and has been fixed in this release.
- Bug Fix: A bug causing a significant increase in runtime memory use in Aria when using universal expressions with many string functions has been fixed, significantly reducing peak memory use for problems with many blocks/surfaces.



Example shell-lined enclosure, allowing adaptivity on volume blocks without an expensive viewfactor recalculation.

Solid Mechanics

- Capability: Zapotec updates improve force-application performance through three selectable algorithm options, provide more efficient dynamic memory handling for surface facets via automatic container sizing, and update the CTH coupling to version 13.1.2.
- Usability: Improved cylindrical and radial boundary condition handling for implicit quasi-statics removes input-deck order dependence and enforces zero radial/cylindrical velocity constraints on axis nodes, fixing incorrect and unintuitive axis motion.
- Usability: Solver robustness for inertia-relief and other free-floating body analyses has been im-

proved by more consistent rigid body mode filtering, automatic tangent scaling, and expanded serial and parallel test coverage for tied contact and MPCs.

- Other Enhancements
  - Implicit Solver: Improved tangent diagonal scaling consistency and documentation
  - Implicit Solver: Fixed a GDSW MPI communicator growth issue
  - Documentation: Manual changes now automatically trigger the documentation build pipeline
  - Documentation: Example problem files are now available online
  - Mesh Assemblies: Corrected element death block removal issue
  - Prescribed Rotations: Improved documentation and test coverage
  - Friction Models: Model name is now required for improved robustness
  - Total Lagrange Elements: Improved consistency of volume handling for material models
  - Total Lagrange Elements: The 10-noded composite tetrahedral formulation is now the consistent default
  - Preload: Now provides parallel-consistent global strain output
  - Error Reporting: Unsupported contact topologies now provide better error reporting
  - Usability: Shape metrics performance has been improved
  - Deprecation: The region-level global energy reporting command has been removed in the 5.30 release

SPARC

- Usability: SPARC 26.3 is production ready on El Capitan. See Figure below for scaling results.
- Capability: Rigorous verification via method of manufactured solutions (MMS) has been added to the SPARC credibility test suite for 3D MEIT (Momentum Energy Integral Technique) solutions.
- Capability: An embedded error model has been implemented that enables the calculation of discretization error and truncation error. This represents a substantial step towards delivering an error-based mesh adaptivity capability.
- Usability: Developed a set of best practices to enable robust and fast axisymmetric coupled aero/ablation simulations.

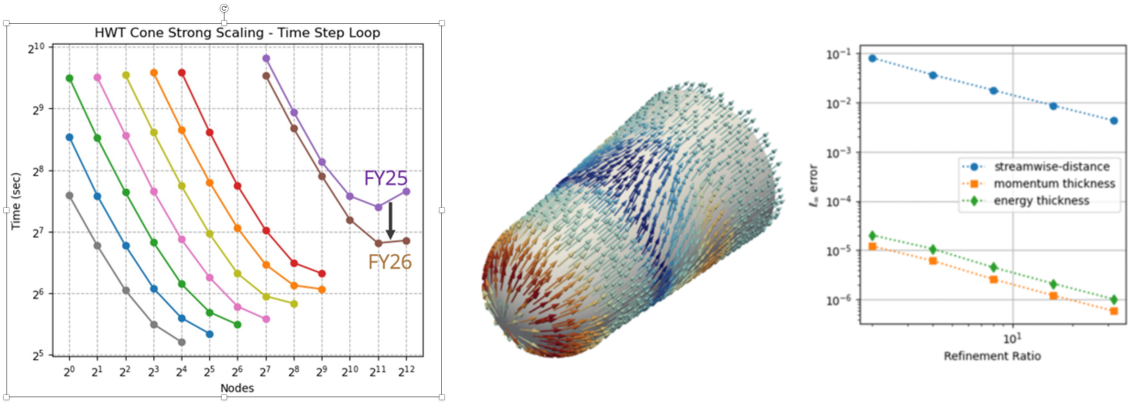
FuSED

- Capability InverseAria
  - Multi-equation support for heat flux inversion.
- Bug Fixes: InverseSD
  - Corrected multi-processor design variable output to text files.
- Usability: OED
  - Mixed tri-ax uniaxial sensor types
  - Tri-ax sensor support for both greedy and gradient-based methods

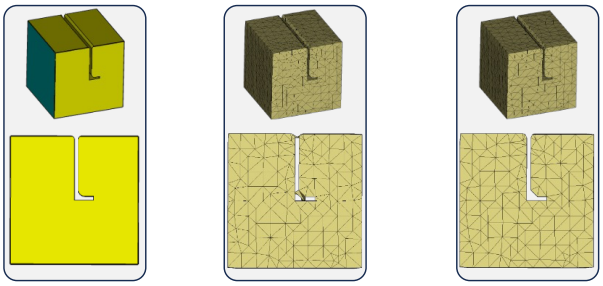
FAST

Meshing

- Capability: The “surface collection volume” capability in the Morph tet mesher was significantly improved for robustness in geometrically thin channels for EM/Gemma mesh generation. Morph’s “surface collec-



Strong scaling analysis on 4096 nodes (37%) of El Capitan (Left). Custom analytical flows enable precise representation of slip flows at angle of attack and provide the basis for rigorous 3D MMS verification of MEIT.



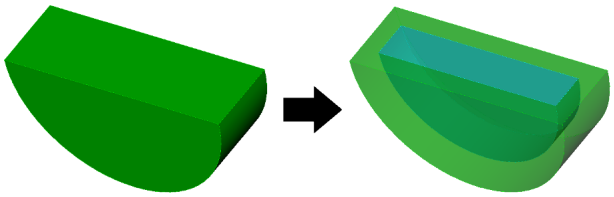
Left: CAD geometry. Middle: Mesh generated by Morph in Sierra 5.28. Right: Clean mesh generated by Morph in Sierra 5.30.

tion volumes" are non-watertight volume definitions that eliminate the difficult task of imprint/merge on dirty production geometry. Thin channels present significant challenges that are now handled in Morph.

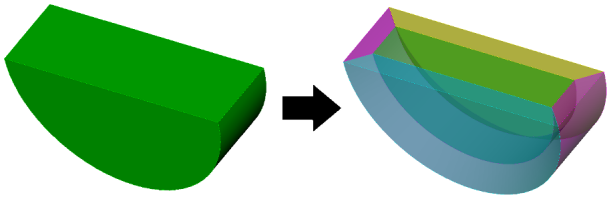
- Usability: New options are now available for anisotropic sizing on conical type geometries.
- Bug Fix: Triangle meshing robustness, especially with composite surfaces, has been improved with an updated version of MeshGems.
- Bug Fix: Several bugs were fixed in tri and tet collapses to increase element quality and to better handle higher order nodes.

Geometry

- Usability: Performance of geometry evaluations on facet-based geometry and composite geometry has increased with more efficient calculations.
- Usability: Users can better control Cubit's sliver removal by excluding specified curves and surfaces from removal.



Webcut offset



Webcut offset with 'loft' option

- Usability: Boolean operations (subtract, unite, intersect) now have a 'keep_tool' option, preventing the tool volume/body from getting consumed.
- Capability: Webcut by offsetting a set of surfaces. This decomposition can be useful for creating boundary layers. In the images below, the half cylinder is webcut by offsetting three of its surfaces inward. The 'loft' option creates individual volumes for each offset surface.

Graphical User Interface

Usability: The journal editor now uses a consistent font for all documents in the journal editor.

Input/Output

Capability: Ability to import MCNP files as CAD geometry.
Usability: The Cubit `save` or `save as` commands now store data in a modern HDF5 format.
Capability: Abaqus users can specify an Abaqus specific element type that will replace default element types on element sets during export.

Miscellaneous

Usability: Python scripts are now allowed to use message handlers to capture and process output, even while running under the GUI.

On the Horizon

(Plato) New and improved stress-constrained mass minimization capability.
(Plato) Overhang constraints to improve printability of topology-optimized designs.
(Sierra/SD) Expand support for thermal effects across element types.
(Sierra/TF) New penalized Dirichlet mesh displacement boundary conditions are in development that may offer stability and solvability improvements over the current rotated boundary conditions used in ablation problems and other fluid flow problems.
(Sierra/SM) GPU migration work continues, with the default Uniform Gradient Hexahedron finite element internal force calculation now approximately 90% ported to GPU hardware; user functions have been extended to support multivariate functions; nightly testing data collection and monitoring have been improved to strengthen regression tracking and code health assessment.
(Sierra/SM) In-core remeshing has undergone extensive verification testing and is showing improved agreement relative to known solutions.
(Sierra/SM–Sierra/SD) Workflows are being advanced through improved hooks to SD capabilities.
(SPARC) Error-based unstructured mesh adaptivity.
(SPARC) Automated credibility documentation.
(FuSED/InverseSD) productionizaton, improved interface identification
(FuSED/OED) multi-objective sensor placement optimization
InverseAria: support for enclosure radiation
(FuSED/Trace) transfer learning
(FAST) Morph integration as a meshing scheme in Cubit
(FAST) Propagation of Granta material properties

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