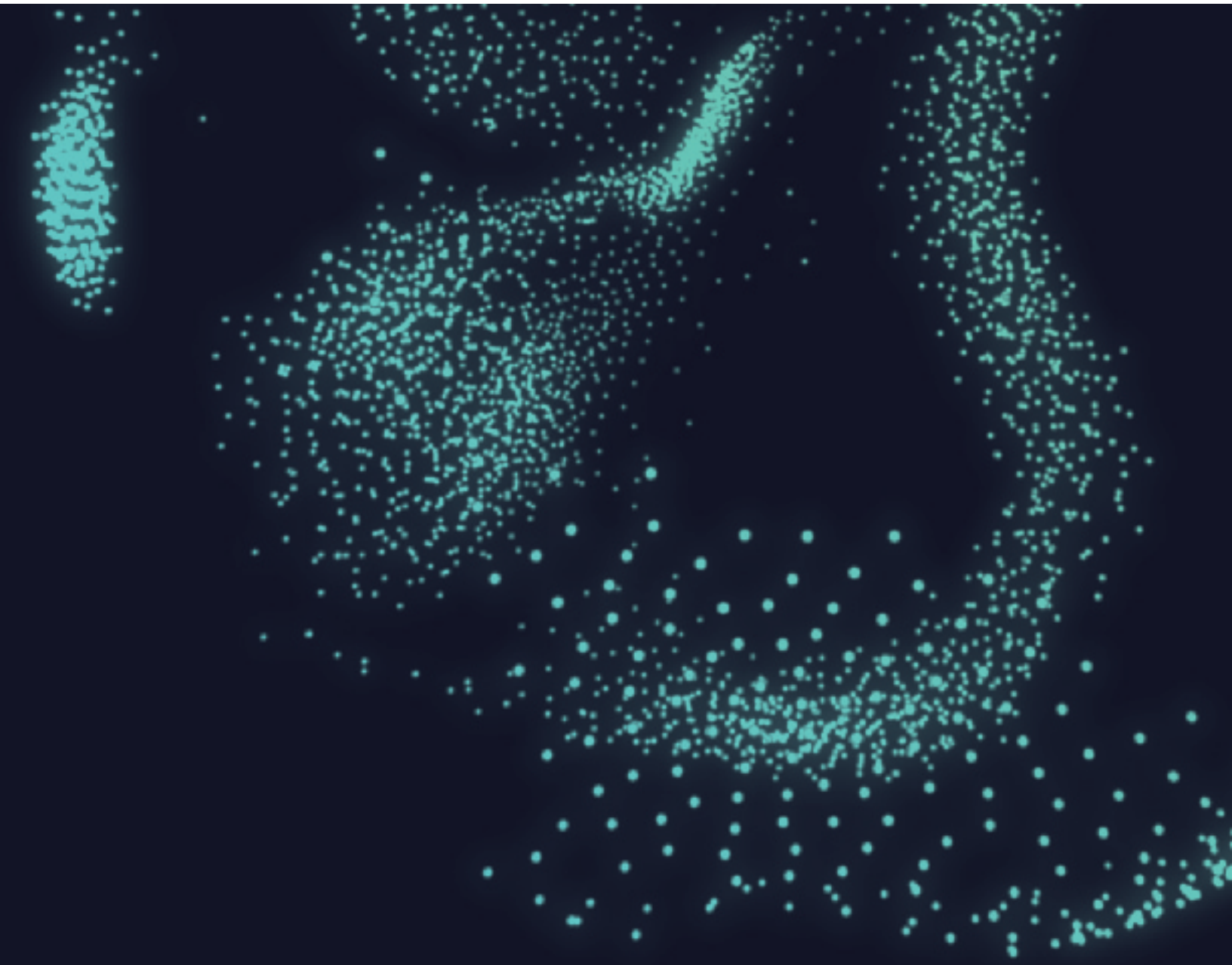


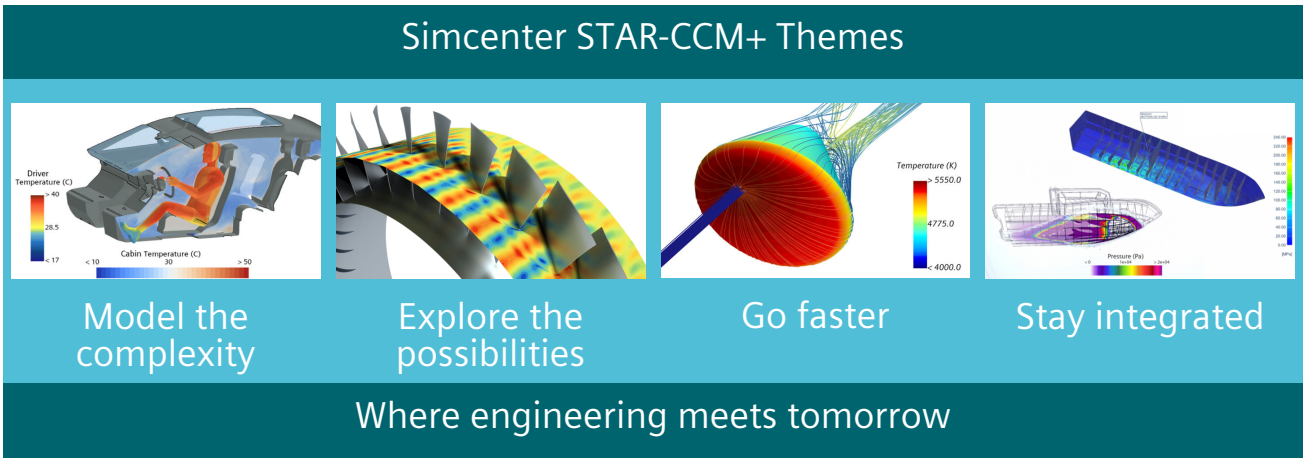
SIEMENS DIGITAL INDUSTRIES SOFTWARE

Simcenter STAR-CCM+ 2310

New Features and Enhancements

SIEMENS

New Features and Enhancements in Simcenter STAR-CCM+ 2310



Top new features and enhancements for this release are:

- Batteries – 3D Cell Design solution
- Cabin Comfort
- Simcenter Cloud HPC available in Asia-Pacific (APAC) region
- Extended simulation automation through Stages
- GPU native coupled solid energy solver, Equilibrium Air equation of state, Radial Equilibrium boundary condition, soot models, and Gamma-ReTheta transition model
- Parallel Surface Wrapper
- Design Manager connection to Simcenter Reduced Order Modeling
- Lagrangian multiphase: Wall-bound droplets
- Faster EMP-LSI simulations through Implicit Multistep
- Faster workflow from Simcenter STAR-CCM+ to Simcenter 3D for vibro-acoustic applications through Conservative Maximum Distance Mapping

Enhancements to Simcenter STAR-CCM+ 2310 are presented by category:

Simcenter Cloud HPC

- **Availability and compatibility**
  - Simcenter Cloud HPC available in Asia-Pacific (APAC) region
    - Deployment in Tokyo, Japan, in October 2023
    - Supported versions: 2306
    - For more information on how to access Simcenter Cloud HPC, contact your Siemens sales representative or authorized reseller

Platform

High Performance Computing

- **GPU native coupled solid energy solver**
  - Faster Conjugated Heat Transfer (CHT) simulations with native GPU implementation of the coupled solid energy solver
    - Speed up CHT turbine blade cooling simulations leveraging coupled flow and solid energy solvers on GPU
    - CPU-equivalent flow solutions ensured by maintaining a unified code base
    - Performance comparison for a 8M cells turbine blade cooling model
- **GPU native Equilibrium Air equation of state**
  - Significantly faster supersonic and hypersonic aerospace aerodynamics with native GPU implementation of the Equilibrium Air equation of state
    - CPU-equivalent flow solutions ensured by maintaining a unified code base
    - Performance comparison for a 4.5M cells capsule re-entry model at Ma=20.5
- **GPU native Radial Equilibrium boundary condition**
  - More turbomachinery applications can now be run on GPU with a native GPU implementation of the Radial Equilibrium boundary condition
- **GPU native soot models**
  - Faster emissions modeling through GPU native soot models for flamelets

        - Includes Moss-Brookes-Hall two equation, Method of Moments, and Soot Sectional models
- **GPU native Gamma-ReTheta transition model**
    - Faster CFD simulation of laminar-turbulent transition flows with a native GPU implementation of the Gamma-ReTheta transition model
        - CPU-equivalent flow solutions ensured by maintaining a unified code base
        - Performance comparison for a 75M cells model for transitional flow over the Common Research Model at Natural Laminar Flow (CRM-NLF)

Deployment

- **Retired Operating System versions**
    - On Linux: AlmaLinux 8.4, Rocky Linux 8.4
    - On Windows: Windows 10 Enterprise 20H2
- **Added Operating System versions**
    - Certified on Linux: RHEL 9.0 and 9.2, Open SUSE Leap 15.4 and 15.5, AlmaLinux 9.0 and 9.2, Rocky Linux 9.0, 9.1 and 9.2
- **Scheduled Operating System support changes for Simcenter STAR-CCM+ 2402**
    - To be retired on Linux: Cent OS 7.9, Open SUSE Leap 15.3, Amazon Linux 2 and 2022
    - To be certified on Linux: SLES 15.5
- **Glibc upgrade notice**
    - Starting in 2402
        - Simcenter STAR-CCM+ glibc library minimum requirement will be upgraded to version 2.28
        - All operating systems not supporting glibc 2.28 will not be compatible with Simcenter STAR-CCM+ 2402 onwards, including
            - CentOS 7.9
            - RHEL 7.9
            - Scientific Linux 7
            - SLES 12 SP5
        - The operating systems listed above will then be retired

User Experience

- **Automation node**
    - Increased productivity with the new Automation section in the simulation tree
    - More streamlined workflows and less scrolling with automation enablers now grouped together
        - Better node organization
        - Increased discoverability
        - Fewer options now under Tools

- **Stages** Community Idea
    - Extended simulation automation intelligence with stages
        - Multiple physics setups in a single simulation
            - Stage different physics models, conditions, and other settings
            - Staged objects can have different settings for each stage
        - More end-to-end automated workflows unlocked
            - Reduced need for Java macros
        - Leverage the combined power of Stages and Simulation Operations

        - Example of cases enabled in single simulations: thermal soak for vehicle thermal management, 3D cell design
    - Automate sophisticated simulation steps quickly thanks to an easy workflow
        - Dedicated toolbar
        - Staged tree, where all staged objects are shown, opens automatically upon stage creation
        - Stage an object with one click
        - Quickly identify staged objects in the simulation tree with flag icon
- **Simulation guide enhancements**
    - Increased ease of use for the simulation guide with added capabilities
        - Improved adherence to your simulation templates by an automatic opening of the simulation guide for the simulation template users
        - Easier to find and identify when multiple simulations are open with the simulation name appended to the simulation guide tab name
        - Remain in your preferred working environment thanks to links opening in your default browser
- **Inline creation of user field functions and parameters**
    - Save time by creating user field functions and parameters where they are needed
        - Improved ease of use
        - Keep the focus on the field you are setting up
        - Reduced risk of user errors
        - Two enhancements:
            - Automatic inline parameter creation
            - Create user field functions and parameters from the expression editor
- **Simcenter Cloud HPC access from inside Simcenter STAR-CCM+**
    - Easier to send simulations to Simcenter Cloud HPC thanks to accessibility enhancements
        - Easier to find Simcenter Cloud HPC with the new Cloud menu
        - Launch simulation in Simcenter Cloud HPC from the Solution menu

CAD Integration

CAD-Clients

- **Supported CAD Packages**

CAD Clients	Supported CAD Versions
Client for NX (Linux and Windows)	NX 1872 to 2306, Simcenter 3D 1872 to 2306
Client for CATIA	CATIA V5-R2019 (R29) to V5-R2022 (R32)
Client for Creo	Creo Parametric 6.0 to Creo 9.0
Client for Inventor	Autodesk Inventor 2018 to 2023

- **Template sim files from CAD Clients**
    - Deploy your methodologies encapsulated in simulation templates without any CAD Client considerations
        - Available in NX, Catia, Creo, and Inventor CAD Clients

- Locally or remotely

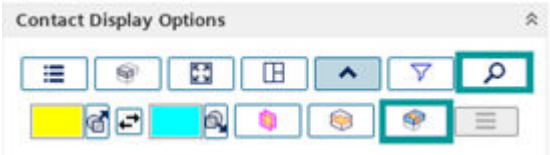
CAD-Exchange

Siemens CAD Readers	Supported Versions
ACIS	Up to 2021 1.0
Autodesk Inventor	Up to 2024
CATIA V4	Up to 4.2.5
CATIA V5	Up to V5-6R2023
CATIA V6/3DExperience	Up to R2022x
Creo- Pro/E	Up to Creo 9.0
IGES	5.1, 5.2, 5.3
JT	Up to 11.2.2.0
NX	Up to 2306
SolidWorks	Up to 2023
Solid Edge	Windows - Up to 2023
CGR	Up to V5-6R2022
STEP	AP 203, AP 214, AP 242
IFC	IFC2x3, IFC4
Parasolid	Up to 35.1

Geometry

3D-CAD

- **Contact Browser enhancements – diagnostic tool for body based imprints**
  - Easy identification of face pairs that are in close proximity to each other that have not been captured by an imprint operation
    - Search for face pairs within the CAD geometry that are within a defined proximity



    - Quick creation of Filters that capture the identified face pairs to perform an Imprint operation
- **Ability to create equation based curves**
  - Save time defining complex curvature in the geometry with the use of mathematical equations
    - Use defined parameters in the equation definition
      - Generic interval parameter (no units)
      - Length interval parameter
      - Angle interval parameter
  - Control the number of interpolation points used in defining the curve

    - Create natural splines by activating the Zero Curvature At End Points option
- **Improved performance of model tree**
    - Reduced time taken to expand and collapse the model tree nodes on large models by up to 43%
- **Improved primitive object manipulation**
    - Additional flexibility in the creation of primitives with support for independent modification of dimensions
        - Select the coordinate system to control the position of the selected primitives
            - Cylindrical
            - Spherical
- **Badge on Feature Group folder**
    - Quick identification of the status of features held within a Feature Group folder thanks to a visual badge on the Feature Group
- **Ability to import 3D Curves as Rigid Spline**
    - Up to 90% reduction in time taken for the import of 3D curves that contain a large number of internal points defining the curve
- **Ability to select the version of Parasolid during export of 3D-CAD models**
    - Higher flexibility on export of Parasolid files to support backward compatibility in the engineering supply chain
- **Partial success for Defeature Delete Interior Faces**
    - Improved success rate of the Defeature Delete Interior Faces operation by allowing for partial success when performed on multiple selections
- **Improved performance and synchronization between 3D-CAD and Parts**
    - Faster synchronization between 3D-CAD and Parts where only the bodies that have been modified are updated

Parts

- **Automatic copy of defined tags**
    - Save time in setting up models with shells via automatic copy of previously defined tags
        - Previously, newly created shell parts did not inherit tags that were associated with the source part surfaces
        - Now any previously defined tags in source part surfaces are copied upon shell parts creation

Mesh

Surface Repair

- **Restore previously displayed faces in surface repair scene**
    - Fast and easy recovery of previous scene display via Restore Previous tool
        - Dedicated icon in Display toolbar
        - Enabled when there are changes in the displayed faces, for instance the number of displayed faces or color mode
        - Disabled once a repair action changes the geometry or topology, for instance deletion of faces

Surface Mesh

- **Parallel Surface Wrapper** Community Idea
  - Reduced CAD-to-mesh time via distributed memory (MPI) parallelization of Surface Wrapper
    - Up to 2.4x speedup dependent on case complexity
    - Up to 43% reduction in wrapping time compared to legacy
    - Improved placement of gap closure faces
    - Legacy Surface Wrapper is still available as an expert property
    - Modified parallel gap closure algorithm may provide different results using previous settings
      - Requested gap closure size adheres better to user input
      - Can lead to a different number of gap closure faces and final surface triangles compared to legacy gap closure
    - Local and Partial Surface Wrapping are not supported and can be used when Legacy Surface Wrapper is enabled

Volume Mesh

- **Improved memory handling for meshing pipeline**
  - Improved memory handling by unloading upstream surface meshes on save action
    - Surface mesh unloading takes place automatically upon save of the sim file
    - Amount of freed memory strongly depends on the complexity, size, and conditions of each case
    - Unloaded memory not forced to be returned to the Operating System
      - Reported memory utilization can stay the same; however, freed memory will be re-used at the next server command, for example, solving
- **Automatic creation of volume mesh distribution in Directed Mesh**
  - Reduced number of mouse clicks via automatic creation of volume mesh distributions in Directed Mesh Operation
    - Default Distribution is populated automatically with the selected parts
    - User-defined volume distributions are still supported
- **Isolated Surface diagnostics for tetrahedral and polyhedral meshers**
  - Faster identification of potentially problematic areas that can cause bad mesh quality

CAE Integration

- **CGNS files – map on export**
  - Simplify integrated workflows with consistent import/export
    - Reduced exported file sizes when mapping surfaces from fine to coarse mesh
      - Faster CGNS file processing time in consuming application
    - Efficiently and accurately map at export
      - Map adjacent but non-aligned or intersected meshes
      - Map rotating or sliding interfaces
      - Consistent output mesh even when solution uses adaptive mesh
  - Limitation: Conservative mapper not supported in 2310
- **CGNS improvements**
  - Server memory usage improvements

        - 45% reduction in CGNS specific memory overhead compared to 2306
    - Updated CGNS to support version 4.3
        - Aligns with Simcenter Nastran adoption of CGNS v4.x
        - Improves robustness of reading CGNS files into other applications
    - CGNS single precision output option
        - Significant reduction in file size when downstream application usage does not need double precision data
    - New file overwrite options
        - Improved workflows for restarted or extended simulations

Physics

CFD

Flow

- **Flow boundary diffusion option for the passive scalar solver**
    - Improve physical realism of the passive scalar solver for flows at high Knudsen number by allowing the user to disable diffusion at flow boundaries
        - Easily disable/enable diffusion of passive scalars at flow boundaries with the new expert property Flow Boundary Diffusion
        - Avoids need for field functions in order to drop diffusion of passive scalars close to flow boundaries
- **Fluid continua with no-flow solver support**
    - Improved flexibility and intuitiveness of the electrochemistry and electromagnetics workflows by making fluid flow in the region optional
        - The flow solver can be omitted for engineering problems where the fluid dynamics solution is of no interest
        - No need to rely on the Freeze Flow option or on defining fluids as Solid such as for airgaps in e-machines

Energy

- **New Cabin Comfort models**
    - Simulate HVAC (Heating Ventilation and Air Conditioning) systems, heating components, cabin design, and human comfort all in one tool with new cabin comfort models
    - Design cabins for optimal human comfort and efficient energy management
- **Cabin Comfort: FIALA Thermoregulation model**

    - Significant usability and fidelity improvement of cabin comfort and climate control simulations with the Fiala Thermoregulation model
        - Intuitive and automatable workflow with coherent interface
        - High fidelity bioheat models that can account for:
            - active systems such as: shivering, vasoconstriction, sweating, evaporation, vasodilatation
            - passive systems such as: respiration convection, radiation, conduction, metabolism, clothing
- **Cabin Comfort: Fiala Dynamic Thermal Sensation (DTS) and Percentage of People Dissatisfied (PPD) comfort index models**
    - Straightforward assessment of passengers' comfort with the Fiala DTS and PPD comfort index models
        - Dynamic Thermal Sensation (DTS) follows the 7 point scale proposed by the ASHRAE standards
        - Percentage of People Dissatisfied (PPD) is a statistical index
- **Cabin Comfort: Equivalent Homogeneous Temperature (EHT) comfort index model**
    - Enabling detailed assessment of comfort for each of the manikin's body segments via the Equivalent Homogeneous Temperature comfort index models
        - Implementation based on a novel formulation in line with the DIN EN ISO 14505 standard
- **Improved parts-based workflow compatibility with the Filtered Radiation Field Function** Community Idea
    - Faster automation and clearer visualization of radiation results via the Filtered Radiation Field Function
        - Added compatibility with more types of parts such as contacts

Reacting Flows

- **Acoustic Modal Solver: User defined heat release rate input**
    - Greater flexibility for thermoacoustic modeling with the option to specify user defined heat release rate input for flame shape
        - New option User Heat Release Rate added for the thermoacoustic n-tau model
        - Allows field functions and tables to be used to specify location of heat release
        - Example uses include:
            - Averaged heat release from a transient simulation
            - Simplified flame structure modeling e.g. approximation with a planar flame
- **Acoustic Modal Solver: Pressure phase field function**
    - More detailed understanding of thermoacoustic behaviour with Acoustic Pressure Phase field function
        - Phase of each acoustic mode now available
        - Understand if pressure peaks are nodes or antinodes
        - Can be used to visualize modes in time domain via User-Defined Field Functions
- **Acoustic Modal Solver: Improved first order accuracy**
    - Faster prediction of acoustic frequencies through improved diffusion treatment
        - Predicted frequencies using first order now more closely match second order predictions
        - Time to solution using first order can be up to an order of magnitude faster than second order
- **Complex Chemistry: performance improvement for large mechanisms**

- Reduced turnaround time when using Complex Chemistry model due to refactoring of kinetics calculations
  - Improvement most pronounced for larger reaction mechanisms or cases without chemistry acceleration (such as clustering)
  - Up to 15% reduction in runtime observed
- **Direct import of field functions for user coded reaction rates**
  - Easier implementation of bespoke chemistry with direct access to field functions in user code
    - Field functions required for user code can be selected under dedicated Field Functions node
    - Both User-Defined and standard field functions can be passed to user code
    - Field Functions can then be used in reaction rate functions:
      - Custom Reaction Source Terms
      - Modified Reaction Source Terms
      - Modified Internal Rates of Individual Reactions
- **Interphase Reactions for Mixture Multiphase (MMP)**
  - Extended range of multiphase reaction functionalities with MMP - interphase reaction compatibility
    - Example use cases include any interphase reactions where phases are miscible such as battery cell level reactions prior to a thermal runaway event
    - Previously, interphase reactions were only available for Eulerian Multiphase (EMP) or Volume of Fluid (VOF) multiphase models
- **Boundary Mixing State specification for ECFM-CLEH**
  - Physically realistic boundary conditions for simulation of hydrogen combustion with Fuel/Oxidizer Mixing State Specification
    - Mixing state can be defined as Premixed or Unmixed
    - Previously, mixing state was always assumed to be premixed, however this is not valid for gaseous injection of hydrogen as a fuel

Multiphase Flow

Eulerian Multiphase (EMP)

- **Implicit Multi-Step for Eulerian Multiphase - Large Scale Interface (LSI)**
  - More efficient EMP-LSI simulations with Implicit Multi-Step
    - Mirrors existing implementation for VOF and MMP-LSI
    - Reduce run time for a given accuracy
      - Increase flow time-step size whilst carrying out more sub-steps for the volume fraction
    - Increase accuracy for a given runtime
      - Carry out additional volume fraction sub-steps for the same flow time-step size
- **Interface Turbulence Damping (ITD) for Large Scale Interfaces (LSI)**
  - Accuracy and robustness have been improved for the Wall Type treatment by an updated algorithm for determining interface cells and associated 'wall' distance
    - Grid independence in the vicinity of the free surface is more easily achieved as a result

Volume of Fluid (VOF)

- **Conservative mapping for VOF for arbitrary remeshing events**

- Ensures conservation of volume fraction in VOF simulations involving periodic remeshing events by performing a volume preserving correction step after mapping onto a new mesh
  - Useful in Fluid Structure Interaction (FSI) simulations
  - Ensures conservation of mass in case of constant density and convergence to machine precision
- Mapping of the flowfield onto the new mesh after each remesh could previously introduce small errors leading to mass imbalance in VOF cases, this is now rectified

- **Face flux discretization for free surfaces in VOF simulations**
  - Better convergence and reduced spurious noise when using small timesteps due to a revised scheme

Lagrangian Multiphase (LMP)

- **Wall-bound droplets** Community Idea
  - Improved accuracy and speed of water management simulations with a new type of Lagrangian phase that lives in shell regions
    - A new particle shape model is provided, Spherical Cap Particles
      - Improves the accuracy of drag and heat transfer calculations
      - User input: Contact Angle value for the boundary
    - 2-way coupling with shell region is added in addition to 2-way coupling with volume region
      - Wall-bound droplets can be absorbed into the fluid film, passing the mass, momentum, and energy to the fluid film
    - A new model to account for the frictional effect of surface tension is provided, Adhesion Force
      - Uses the Contact Angle Hysteresis concept
      - User input: Advancing Contact Angle and Receding Contact Angle
    - Use cases include rain droplets sliding on the surfaces of moving vehicles, including windshields, mirrors, and car sensor surfaces

- **Composite collision modeling for droplets** Community Idea
  - Improved accuracy in modeling the collisions between droplets by providing an option to define the adaptive collision map
    - The new Composite Method option allows four types of possible collision outcomes in the same simulation: Bounce, Coalescence, Grazing (Stretching) Separation, Reflexive Separation
    - Three boundary lines of the collision map are configurable by the user, they can be disabled to eliminate specific collision outcome type
      - Bounce line follows Sommerfeld correlation
      - Stretching Separation line follows Suo-Jia correlation
      - Reflexive Separation line follows Ashgriz correlation
    - Typical applications include spray drying in chemical and food industries
- **Liquid-Solid-Gas particles compatible with Passive Scalar**
  - Improved accuracy and powerful postprocessing in wet solids simulations
    - Applies for both LMP and DEM particles

Discrete Element Method (DEM)

- **Cohesion model for non-spherical particles**
  - Improve accuracy of simulations in agriculture, mining, construction, chemical processing, and food industries by enabling compatibility with non-spherical particles

        - Typical applications include various equipment interacting with wet granular materials like rocks, sand, grass, etc
- **Impact Cutting model**
    - Increased speed and reduced set-up time in crop cutting simulations with a new built-in Impact Cutting model
        - A single bond between segments of flexible fibers or spheres of particles clumps is broken when cutting tool impact velocity exceeds the threshold value

General Multiphase

- **Post-Processing and Filtering for Adaptive Timestep Providers**
    - Gain insight into the source of proposed timestep sizes through the addition of field functions and filtering options for each timestep provider
        - Field functions available for each provider timestep proposal and for the accumulated timestep proposal across all active providers
            - Useful in determining source of smallest timescales and whether these are coming from features of interest and need to be resolved
        - Addition of Filtering Profiles
            - Filtering profiles can be used to remove certain cells from consideration by a timestep provider
            - Cells are eliminated based on a chosen field function having non-zero values
        - Percentile based cut-off filtering has also been added for all providers that it was not already available for

Computational Rheology

- **Free Surface Model: Transient Extrusion**
    - Extrusion can now be modeled as a transient process when using Arbitrary Lagrangian Eulerian (ALE) approach with the Free Surface model
        - Mesh can now extend in the direction of extrusion using morphing and layering to accommodate growth of extrudate
        - Previously morphing only permitted in direction normal to extrusion which allowed for steady simulation only

Solid Mechanics

- **Optimal (Chung-Hulbert) and HHT (Hilber-Hughes-Taylor) methods**
    - Adds flexibility of choice for second order time integration with the addition of two complementary methods to the WBZ (Wood-Bossak-Zienkiewicz) method
        - Available for the determination of the integration coefficients of the Generalized Alpha scheme
- **Additional Young's modulus and Poisson's ratio Neo-Hook hyperelastic material specification**
    - Improves ease of use by making it possible to enter a parameter set of Young's modulus and Poisson's ratio
        - Previously, the only option for the material coefficients was Bulk modulus and c10 coefficient
        - Conversion was necessary if the known parameter set was Young's modulus and Poisson's ratio

- **Inertial loads due to rigid body motions based on the deformed configuration**
  - Improves accuracy, mainly for long, flexible, and fast rotating structures by taking deformation into account
    - Previously the inertial loads due to rigid body motion were based on the undeformed configuration, which is a limiting assumption
    - Beneficial for cases such as wind turbine blades, propeller blades, or rotor blades of air crafts
- **Lumped Heat Capacity Matrix for Finite Element Solid Energy**
  - Adhere with industry best practices of Finite Element thermal analyses by lumping the heat capacity matrix
    - Improve robustness in problems involving thin thermal boundary layers
    - The lumping strategy for a region can be defined through the Physics Conditions > Lumped Heat Capacity Matrix Option
    - Available options are: No lumping, Lump 1st-order elements
- **HYBRID MUMPS new default direct solver**
  - Faster and more memory efficient Finite Element simulation runs with new default direct solver option
    - Performance difference on a number of sample cases was mostly noticeable on higher process counts (24 processes):
      - Memory reduction ranges from 4% to 41% with an average of 19%
      - Speedup ranges from 0.95x to 1.41x with an average of 1.15x
- **Fluid Structure Interaction (FSI) Coupling solver stabilization method choices limited to applicable methods**
  - Improves the ease of use for FSI simulations by making the stabilization methods Constant Displacement Under-relaxation and Boundary Interface Added Mass only displayed if applicable
    - For those methods to be applicable the setup must be two way coupled
      - Motion of solid region must be Solid Displacement
      - FSI Coupling Specification of interface boundary in solid region must be set to any method other than Uncoupled
- **Run FSI simulations with no fluid present from the onset**
  - Enables new applications and simulation sequences by supporting FSI simulations for which the fluid mesh is not present from the onset of the simulation
    - For example, the following simulation sequence is now possible
      - Computation of the installed configuration of a solid component as a solid only simulation step (without yet having fluid mesh, fluid region, or FSI interface)
      - Extraction of the fluid domain based on the deformed shape of the solid
      - Creation of the fluid region, fluid mesh, and FSI interface
    - The sequence of simulation steps above is very common for FSI applications such as seals or sleeves of check valves

Electromagnetics and Electrochemistry

Electromagnetics

- **New formulation of the uniform potential boundary condition in the EDP model**

- Improved convergence and accuracy of electromagnetics simulations using the electrodynamic potential (EDP) model with uniform electric potential boundary condition via a newly developed algorithm.

- **Specify conductivity via the resistivity**
  - Improved user experience and troubleshooting of electromagnetics problems where electrical conductivity depends on temperature via a new property specification method using the resistivity
    - Users can choose to specify either electrical conductivity or resistivity when using the Table(T) and Polynomial in T methods in the given Physics continuum
    - This functionality is also mirrored also in the Material Databases under *Tools*

Electrochemistry

- **Electrochemistry models for battery Cell Design Solution**
  - Capture detailed physical phenomena during battery cell design with Sub-grid Particle Intercalation and Concentrated Electrolyte models
    - Sub-grid Particle Intercalation: Capture the transport of ions as they intercalate into an active electrode
    - Concentrated Electrolyte: Capture Lithium cation migration with an additional transport term
    - Further details on Cell Design Solution under Application Specific Tools > Batteries
- **Direct use of Hypre for Electric Potential linear solver**
  - Simplified user set up with automatic use of Hypre for Electric Potential
    - The option to choose between Hypre Linear solver and AMG Linear solver for Electric Potential has been removed
    - Use of Hypre typically results in faster convergence of Electric Potential
    - Default values aligned with recommended best practices (V-Cycle and Bi-Conjugate Gradient Stabilized acceleration)

Aeroacoustics

- **Conservative Maximum Distance Mapping**
  - Faster workflow from Simcenter STAR-CCM+ to Simcenter 3D with with new mapping option for vibro-acoustic applications
    - Map a fine CFD mesh to a coarser acoustic mesh directly in Simcenter STAR-CCM+
    - Drastically reduced CGNS file size
    - No added time to the overall simulation workflow
    - Equivalent results to prior mapping method
    - Same mapping algorithm as in Simcenter 3D
      - Only two parameters to set: Number of influencing nodes, Maximum distance
    - Additional mapping option not requiring user input also available: Conservative Enclosed Face Mapping
- **Post FW-H compatibility with .simh**
  - Increased productivity in data analysis thanks to the compatibility of Post FW-H with .simh
    - Use .simh instead of .trn as input for Post FW-H analysis
    - Smaller file size compared to .trn
    - Marginally faster performance
    - Same capabilities as the .trn format

        - Ensures consistency of results
- **Acoustically transparent Porous Baffle Interfaces**
    - Improved physical realism of porous baffle behavior thanks to acoustically transparent interfaces
        - Acoustic hybrid solvers no longer treat Porous Baffles Interfaces as rigid walls
        - The acoustic field can now propagate through unaffected
        - For applications where porous media have negligible damping effects but which induce a pressure drop in the flow such as textiles, thin porous material
- **FFT In-core calculation**
    - Speed up the FFT turnaround time thanks to FFT In-core calculation method
        - From ~4 hours down to 20 minutes for a 10 000 states simulation, input .simh file of 82GB, 1.6s signal with 1Hz frequency resolution
        - Select In-core surface FFTs option under Data Set Functions to activate this calculation method
        - FFT results unsaved in .simh file in this release
    - Reduction of memory consumption
        - 6x reduction for the case above
- **3rd subdivision octave bands**
    - Expanded acoustic data analysis capabilities thanks to the visualization of more standard octave bands for FFTs
        - The octave bands added are 6^{th}, 12^{th} and 24^{th} along with the already existing octave and 3^{rd}
- **Acoustic Modal Solver enhancements** (see Reacting Flows section)
    - **User defined heat release rate input**
    - **Pressure phase field function**
    - **Improved first order accuracy**

Motion, Mesh Adaption, and Mapping

- **Region Reposition Solver** Community Idea
    - Easily transform overset Region via Region Reposition solver
        - Region, Managed Coordinate System, and solution are all transformed
        - Eliminates the need to use a Java macro
        - Facilitates easy Design Exploration
- **Distance driver constraint for DFBI**
    - Easily simulate cases in which the distance between points or bodies must be controlled
        - New Distance Driver constraint available under DFBI Body Constraints
        - New field function named “InitialVelocityOfDfbiConstraint” available for easy constraint setup
- **Support for VOF-Lagrangian interaction in Overset**
    - Accuracy improvements in overset cases with VOF Lagrangian transition
        - Better mass conservation for specific cases
- **Parts based support for boundary axis specification**
    - More flexible and templatable approach to define an axis
        - Axis can be defined either on a per-boundary or per-part surface fashion

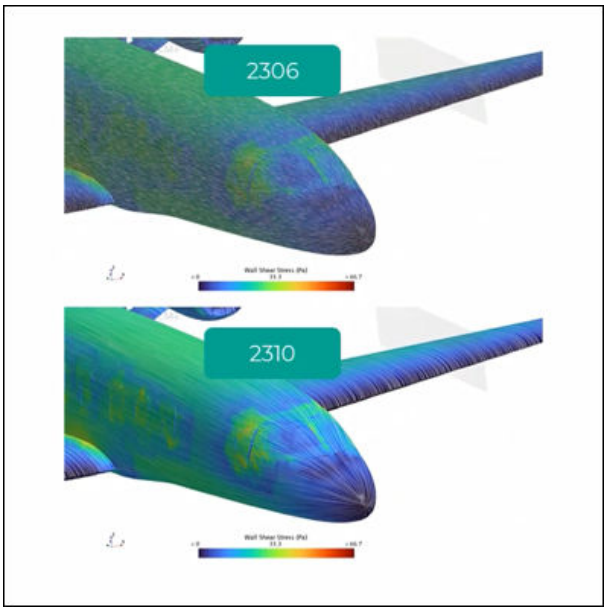
Design Exploration

Design Manager

- **Design Manager connection to Simcenter Reduced Order Modeling**
  - Instantaneous and validated responses to parameter changes with reduced order modeling
    - Automated process in Design Manager offering predictions within seconds
    - Control on the accuracy level using fidelity index
    - Field data using Proper Orthogonal Decomposition based on images
  - Improved collaboration between analysts and designers thanks to immediate scenario variant views
    - Suitable for any application
  - Works for limited geometry change on any type of parameters
- **Sort N Designs Set for advanced save options**
  - Preserve disk space by saving only the best designs with Sort N Designs Set
    - By creating a design set sorted "Largest to Smallest" on the performance function and choosing the number of designs
      - Applying this design set to the "Save Simulation Files" field
  - Understand your design space better by creating subsets of designs
    - Allows you to sort ascending or descending by any parameter, response, performance, or design number
- **Group by Studies**
  - Easily find a plot with respect to the study it belongs to
- **Aspect Ratio uniformity** Community Idea
  - Have a consistent view point by keeping aspect ratio value from the simulation

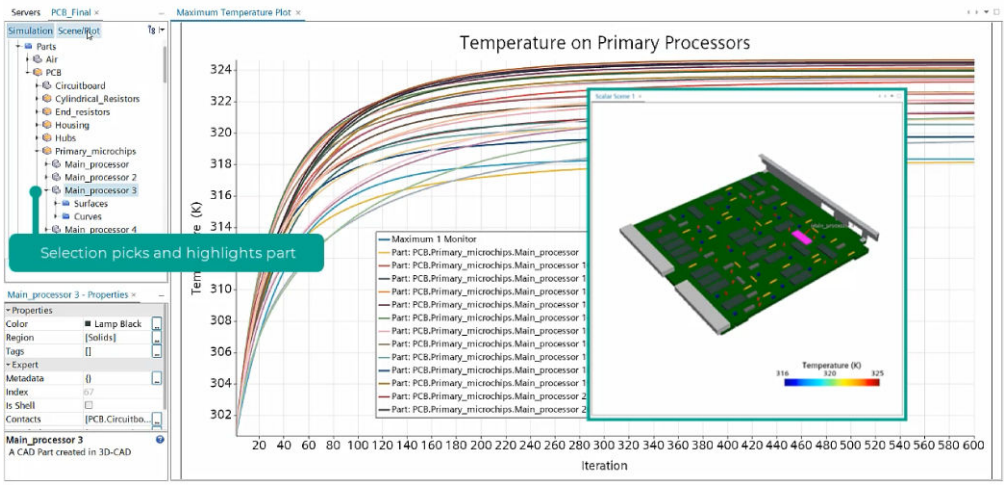
Data Analysis

- **Enhanced visualization and user interaction for Line Integral Convolution (LIC)**

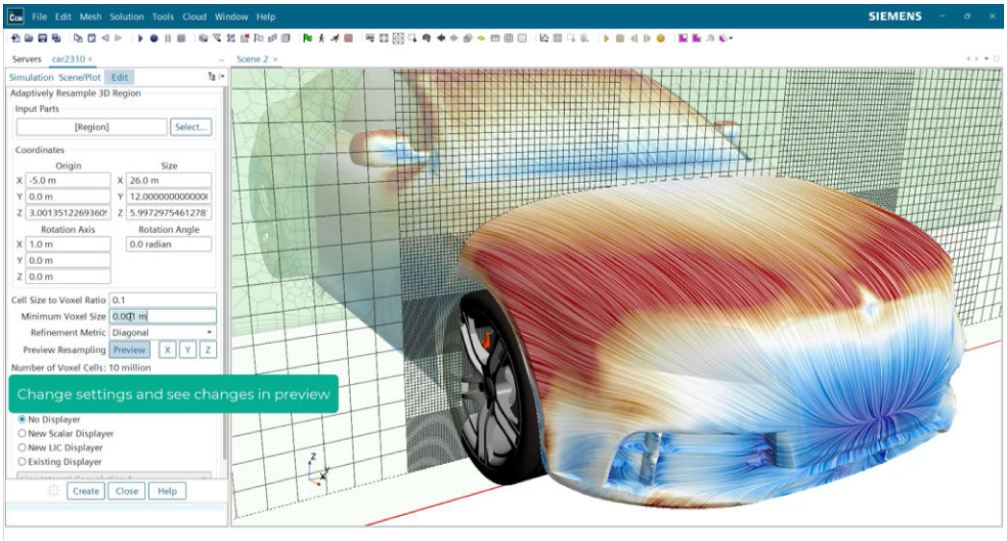


  - Instantaneous visualization of detailed vector fields with enhanced Line Integral Convolution (LIC)

        - Large quality and performance increase during view change through modernization of existing LIC algorithm
    - Easier setup thanks to fewer and more intuitive settings
        - New pre-configured Displayer
        - Only 3 intuitive parameters to configure appearance
- **Usability improvements for plots**



    - Accelerated plotting workflow through usability improvements
        - Efficiently identify input data by picking and highlighting input parts directly from the plot
        - Quickly adjust axis bounds through convenient user interaction
    - Easily manage styling of plots using a multivalued monitor
        - Efficiently hide individual lines per part
        - Customization of lines and symbols
- **Show mesh lines of resampled volume during creation and slicing**



    - Comprehensive resampling through visualization of mesh lines
        - Easily verify resampling settings by investigating mesh lines during preview
        - Conveniently check discretization of Resample Volume by viewing mesh lines in a slice

- Gain insight by comparing finite volume and Resampled Volume discretization

- **Idealization support in displayers for symmetries and extrusions**
  - Effortless extraction of full visual results from a partial model through idealization
    - Minimal user interaction required for setup
    - Instantaneous visual feedback
  - Understand quickly the full results of partially simulated cases:
    - Handles cases with (Axi-)Symmetries, Extrusions, Periodicities, Compositions (concurrent multiple idealizations)
- **Display Summaries in Simcenter STAR-CCM+**
  - Improved workflow by viewing and updating Summaries directly in Simcenter STAR-CCM+
    - Remain in simulation environment to view and check content of Summary
    - Ability to update to current simulation status with one click
- **Simcenter STAR-CCM+ Web Viewer Simulation Structure**
  - Deep-dive into simulation results by using Simulation Structure
    - Manage view by hiding and showing content
    - Use multiple visualization layers
    - Intuitive usability
  - Present, explore, and communicate more information in a single Scene
    - "Look under the hood" of Scene content
    - Take snapshots on-the-fly of currently visible objects
- **Representation-sensitive filtering**
  - Easier selection in Color Bar dialog through representation relevant filtering
    - Color bar dialog will only show field functions that exists for selected representation, very useful when working with Solution Histories
- **Removed 2D fixed view heuristic**
  - Harmonized viewing experience for 2D and 3D simulations

Application Specific Tools

In-cylinder solution

- **RNG K-Epsilon with Two-Layer All y+ Wall Treatment**
  - Enhanced robustness of simulations with RNG K-Epsilon compatibility with Two-Layer All y+ Wall Treatment
    - Addresses the limitation of the previously used High-y+ Wall Treatment in domain areas characterized by low y+ values
    - Significant impact on the vicinity of the engine valve throat around valve opening & closing events, where the previous treatment could impede solver convergence
    - Minimizes differences in the numerical result between the old and the new treatment

- **CAD validity check**
  - Reduced opportunity for errors in meshing pipeline thanks to a new input validity check
    - Ensures that the imported CAD geometry is fully valid
    - Validity check in the panels and active by default
    - Warning issued in case of invalid parts
  - Avoid errors in creation of the In-Cylinder domain parts with an additional check
    - Shows an error message during the Create Cylinder and Valves operation
- **Consistent usage of crank angle degree unit**
  - Less prone to setup errors by consistently enforcing in-cylinder specific units
    - Clarifies the time unit including “degCA” in numerous panels and objects, replacing the previously misleading "deg"
    - Harmonizes usage across reports, plots, scenes, parameters, and many more
    - Makes use of auxiliary objects which may not be displayed in add-on panels
- **Speedup of mesh morphing within in-cylinder simulations**
  - Better handling of cases in which the mesh is deformed around a comparably smaller body
- **Injector nozzle sorting based on index**
  - More intuitive sorting of injector objects in the user interface

Batteries

- **3D Cell Design solution**
  - Design Lithium-ion cells with the highest fidelity on the market with Simcenter STAR-CCM+ cell design template solution
    - Parametric 3D CAD design with geometrically resolved electrode layers and tabs
    - Full 3D physics-based electrochemical model enhanced from Newman-Doyle-Fuller initial formulation
    - Supporting 3 cell shapes in 3 different simulation templates
  - Streamlined workflow tailored for cell designers
    - Set up the mesh in a few clicks
    - Dedicated industry-standard post-processing
  - Full capability requires the Batteries add-on license
- **Thermal runaway simulation configurator: gas venting**
  - Faster pre-processing of thermal runaway simulations thanks to a simulation configurator
    - Easy selection of the venting surfaces
    - Dedicated field function to manage energy balance
    - Fewer inputs for the trigger and release conditions
    - One set of input parameters for all cells in the pack
  - Simplified workflow with automation
    - Automatic gas venting release with boundary condition modification upon trigger condition
    - Dedicated quantities for gas venting are applied to reports and plots which are automatically generated in “Battery Module Reports”
- **Power load type boundary condition for batteries simulations**
  - Simplified boundary condition inputs with Power load type now supported for simulations within Batteries add-on

        - Supports Power vs Time profile tables as boundary conditions
        - Removes constraints to convert profile into Current vs Time
        - Ease battery performance comparison between Batteries add-on and System level simulations

E-Machines

- **Power load type boundary condition for e-machines simulations**
    - Supports Power vs Time profile tables as boundary conditions

Turbomachinery

- **Expanded coverage of Harmonic Balance field functions**
    - Increased productivity for Harmonic Balance data analysis through additional coverage of standard field functions
        - Consistency between steady and Harmonic Balance field functions
        - 16 additional Harmonic Balance field functions (such as absolute pressure, CFL number, entropy, mass flux, relative Mach number)
        - Benefit from the export of the standard field functions capabilities
    - Concise simulation tree with Fourier modes field functions within Harmonic Balance Solution View
- **Fourier mode solution periodicity with Harmonic Balance Solution View**
    - Enhanced understanding of the flow unsteadiness through the solution periodicity in the Harmonic Balance Solution View
        - Periodicity is now respected without discontinuity for all Fourier modes: Real, Imaginary, and Phase
        - Create compelling visuals from the simulation solution with more than one blade passage
- **Improved Turbo slicer to extend inlet and outlet surfaces**
    - Achieve successful creation of periodic regions with the use of Auto Extend Inlet/Outlet option
        - Extend surfaces beyond the hub and shroud when multiple inlets or outlets are present

User Guide

- **User Guide**
    - Initial release of the Field Function Library
- **New Tutorials**
    - Discrete Element Method
        - Flexible Fiber Model: Lawnmower
    - Design Exploration
        - Export of 2D Field Data for ROM: Airfoil Analysis
- **Retired Tutorials**
    - Proton Exchange Membrane Fuel Cell
    - Thermal Comfort Wizard: Single Occupant in a Cabin
- **Modified Tutorials**
    - DES and FW-H On-The-Fly: Noise from a Cylinder (Unsteady Analysis) – updated to use `.simh` file instead of `.trn`

- Ffowcs Williams-Hawkings: Sound Propagation – updated to use `.simh` file instead of `.trn`
- Signal Post-Processing: FFT and Wavenumber – updated to use `.simh` file instead of `.trn`
- Multi-Part Solid: Graphics Card Cooling – updated for contact browser changes
- Steady Flow: Backward Facing Step – revised to use a parabolic velocity profile that scales with the step height
- General Remesh: Gerotor Pump with Small Gap – now uses the morphing method, `BSpline`
- Acoustic Modal Analysis: Thermo-Acoustic Stability of a Cylindrical Burner – reference point location modified to point inside a cell
- Directed Meshing: Electrical Machine – updated with new default volume distribution
- Linear Stress Analysis: Cantilever I Beam – updated with new default volume distribution
- Gap Closure in Surface Wrapper: Drone Main Body – updated due to new surface wrapper
- Surface Wrapper: Intake Manifold – updated due to new surface wrapper
- Local Wrapper: European Truck – updated to retain the legacy surface wrapper
- Diesel Engine: Closed-Cycle Sector Model – revised to use fuel material properties from the NIST database
- Thermal Runaway: Battery Pack Heat Release and Venting – added venting calculation
- Several tutorials were updated due to the introduction of the **Automation** node

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