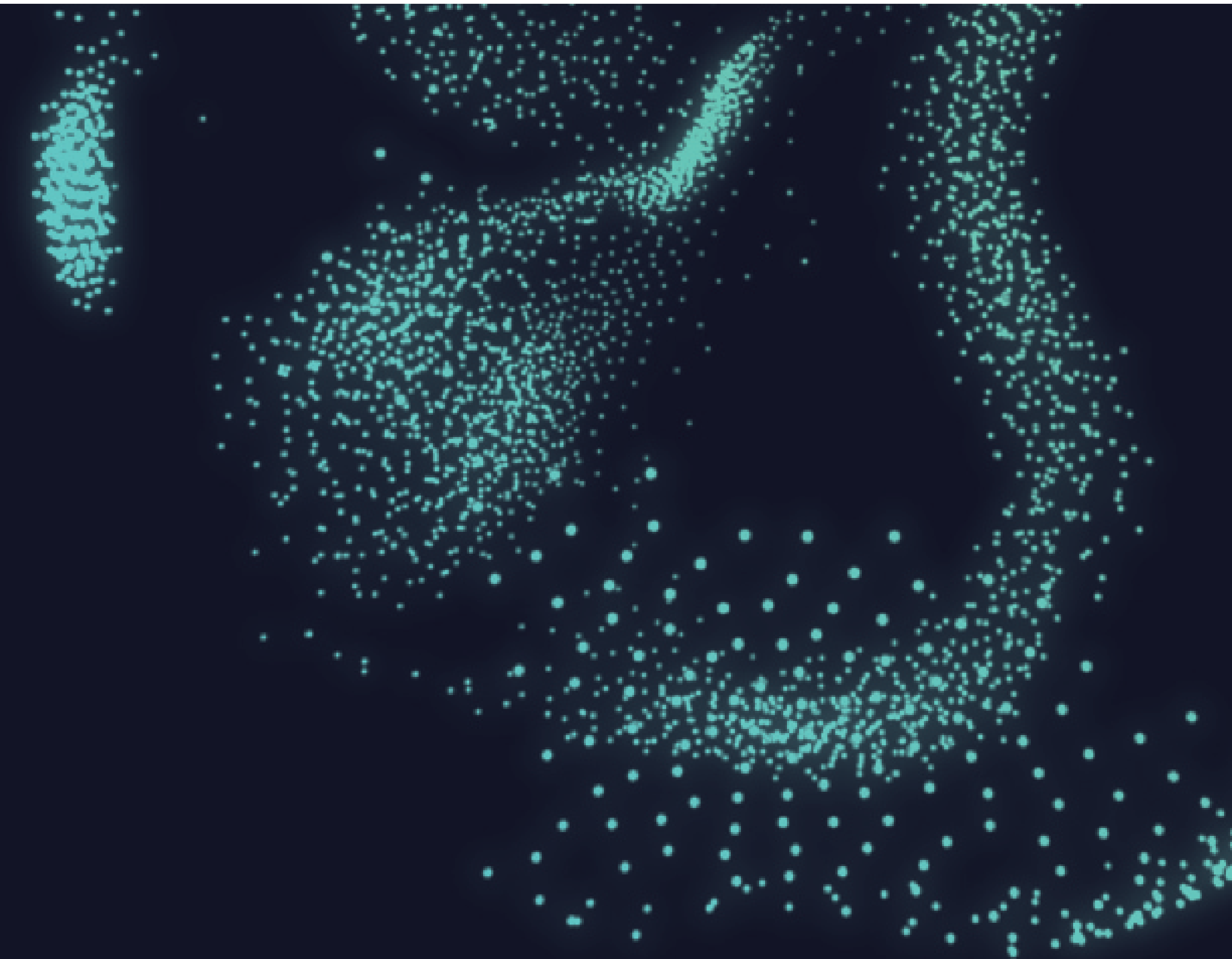

SIEMENS DIGITAL INDUSTRIES SOFTWARE

Simcenter STAR-CCM+ 2406

New Features and Enhancements

SIEMENS

About Siemens Digital Industries Software

Siemens Digital Industries Software is a global leader in the growing field of product lifecycle management (PLM), manufacturing operations management (MOM), and electronic design automation (EDA) software, hardware, and services. Siemens works with more than 100,000 customers, leading the digitalization of their planning and manufacturing processes. At Siemens Digital Industries Software, we blur the boundaries between industry domains by integrating the virtual and physical, hardware and software, design and manufacturing worlds. With the rapid pace of innovation, digitalization is no longer tomorrow’s idea. We take what the future promises tomorrow and make it real for our customers today. Where today meets tomorrow. Our culture encourages creativity, welcomes fresh thinking and focuses on growth, so our people, our business, and our customers can achieve their full potential.

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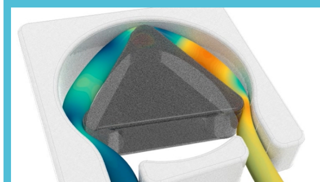
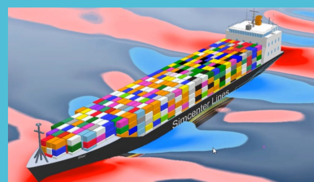
New Features and Enhancements in Simcenter STAR-CCM+ 2406

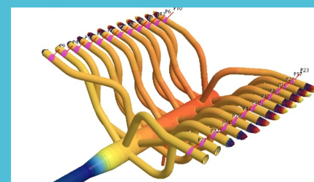
Simcenter STAR-CCM+ Themes



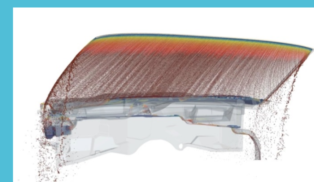
Model the complexity



Explore the possibilities



Go faster



Stay integrated

Where engineering meets tomorrow

Top new features and enhancements for this release are:

- SPH - Inlet boundary conditions
- Batteries - 3D Cell Design – Physics-based aging models
- Higher Order Finite Element Electromagnetic solver
- Multiphase - LMP to MMP sub-grid phase interaction
- Virtual Reality support for Simcenter STAR-CCM+ Web Viewer
- GPU-native S2S radiation model
- Solid Mechanics - Advanced contact enforcement
- Faster sliding mesh interfaces
- Design Manager - Reuse previous Designs
- Surface radiation property input revision and Surface properties database

Enhancements to Simcenter STAR-CCM+ 2406 are presented by category:

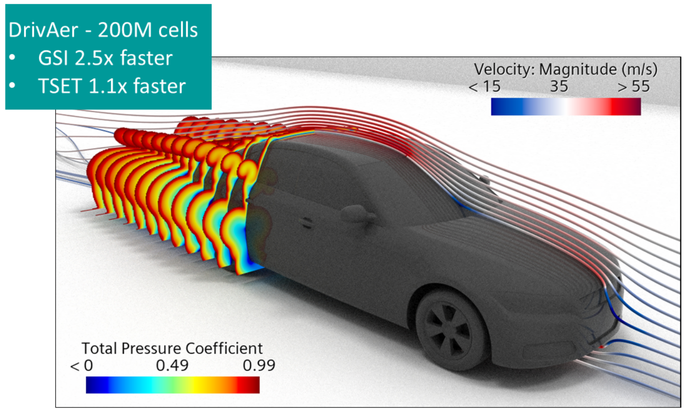
Simcenter Cloud HPC

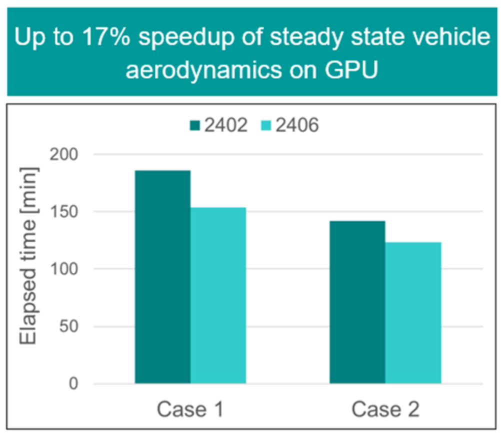
- **Get an overview of the new Simcenter Cloud HPC features and enhancements in the Simcenter Cloud HPC What's New Fact Sheet fact sheet**

Platform

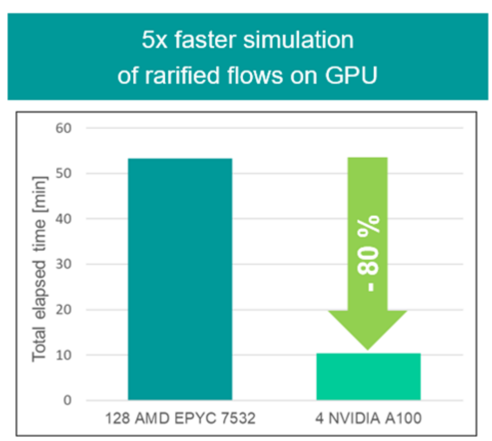
High Performance Computing

- **Extended AMD GPU support**
  - Benefit from more hardware options to leverage GPU-accelerated computation
    - AMD Instinct MI300 series is now supported
    - Includes MI300X
  - Additionally Radeon Pro W7x00 GPUs now supported
    - W7800 and W7900 are recommended
- **GPU-native Grid Sequencing Initialization**
  - Up to 17% faster steady state simulations of vehicle external aerodynamics on GPUs with a GPU-native implementation of the Grid Sequencing Initialization (GSI) method for the Coupled Flow Solver
  - Note: when running on GPU, the number of Maximum Grid Levels is internally set to 6

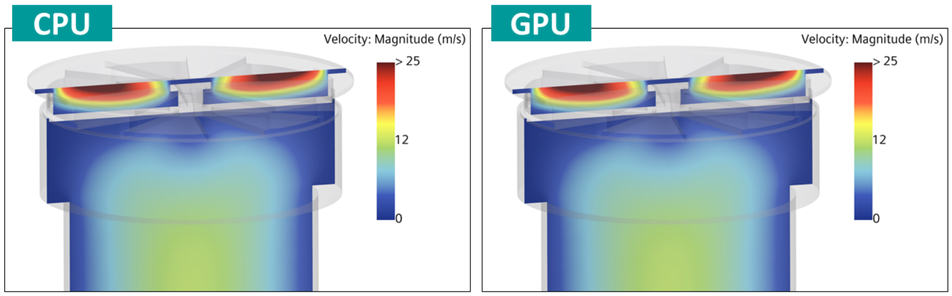




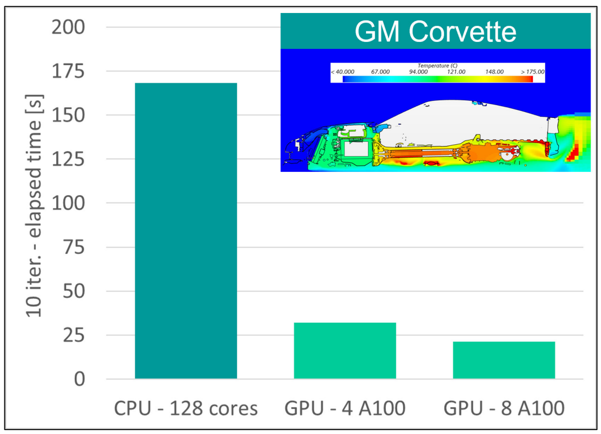
- **GPU-native segregated fluid isothermal and partial slip model**
  - Significantly speed up (up to 5x faster) microfluidics and rarified flow applications with GPU-native segregated fluid isothermal and partial slip models
    - Maxwell Slip
    - Von Smoluchowski



  - CPU-equivalent flow solutions ensured by maintaining a unified code base

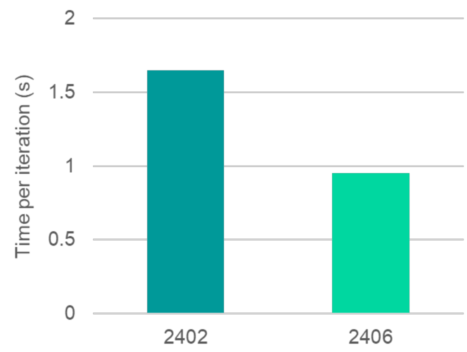


- **GPU-native S2S radiation model**
  - Speedup (up to 8x faster) full vehicle thermal management (VTM) simulations with a GPU-native S2S radiation model
  - CPU-equivalent solutions ensured by maintaining a unified code base



The 8x reduction in run-time is evaluated by comparing a CPU solution on 128 AMD EPYC 7532s to a GPU solution on 4 and 8 NVIDIA A100 cards.

- **Improved -benchmark options for GPU usage**
  - Easier use of in-built benchmarking for coupled flow cases on low GPU counts
    - These cases may require more than one CPU process per GPU card
    - A single benchmark run can now be configured to run multiple sets of CPU processes per GPU
    - "-gpgpus" option added to allow separate benchmark inputs for each number of CPU processes evaluated
- **Clearer GPU error messaging for out-of-memory errors**
  - Better understanding of error messages with more informative output
    - If a scenario is encountered where GPU memory has run out, GPU memory utilization is reported as a percentage and explicitly highlighted as an out-of-memory error
- **GPU-native Derived Part monitoring**
  - Improved performance of Derived Part reporting/monitoring with GPU-native implementation
    - Valid for monitoring on probes and plane sections
    - Reduced turnaround time due to less CPU-GPU data migration



Performance improvement monitoring 72 reports through plane sections

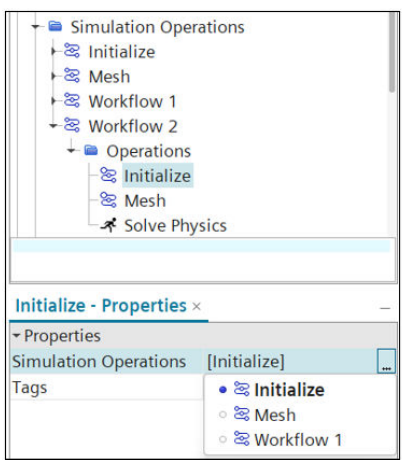
- **GPU Coupled Flow performance improvements**
    - Reduced turnaround time for coupled flow problems thanks to AmgX enhancements
    - Up to 10% improvement for steady state automotive aerodynamics

Deployment

- **Scheduled Message Passing Interface (MPI) versions support changes for Simcenter STAR-CCM+ 2410**
    - To be certified on Linux: Intel MPI 2021.12
    - To be certified on Windows: Intel MPI 2021.12
    - To be retired on Linux: Cray MPI 7

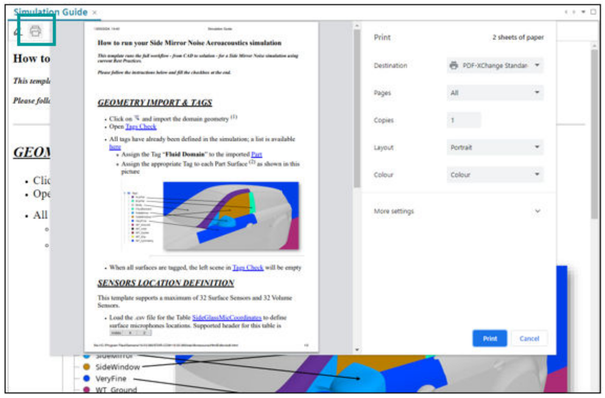
User Experience

- **Trigger sequences of Simulation Operations**
    - Automate sophisticated workflows with the possibility to trigger simulation operations sequences
        - Trigger different sequences based on desired scenario
        - Better organized operations
        - Easier to troubleshoot



- **Print Simulation Guide**
    - Quickly review and share information relevant to the simulation, with the possibility to print (also to PDF) the simulation guide

    - Check the simulation guide content without opening the simulation file



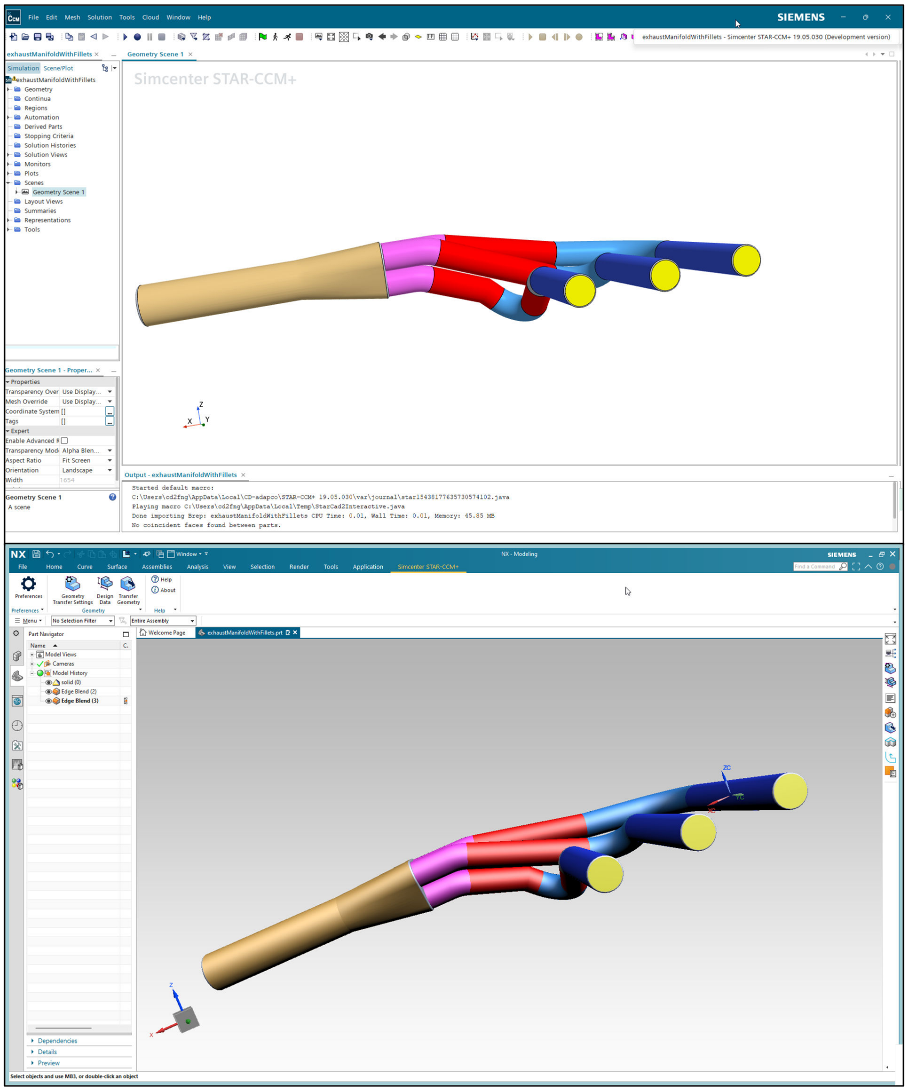
CAD Integration

CAD-Clients

- **Supported CAD Packages**

CAD Clients	Supported CAD Versions
Client for NX (Linux and Windows)	NX 1926 to 2406, Simcenter 3D 1926 to 2406
Client for CATIA	CATIA V5-R2019 (R29) to V5-R2023 (R33)
Client for Creo	Creo Parametric 6.0 to Creo 10.0
Client for Inventor	Autodesk Inventor 2019 to 2023

- **CAD model colors import with CAD Clients**
    - Faster and easier simulation setup with color transfer from CAD packages using CAD Clients
        - Leverage color related setup in CAD packages to easily get the appropriate information such as boundary conditions
        - Increase visual consistency between simulation and CAD models



CAD-Exchange

- **Supported CAD Packages**

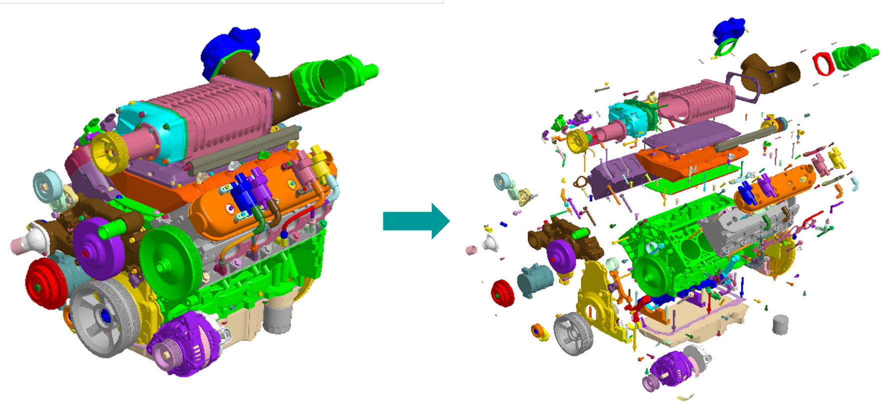
Siemens CAD Reader	Supported Versions
ACIS	Up to 2023.1.0
Autodesk Inventor	Up to 2024
CATIA V4	Up to 4.2.5
CATIA V5	Up to V5 - 6R2023 SP1
CATIA V6/3DExperience	Up to R2023x
Creo- Pro/E	Up to Creo 10
IGES	5.1, 5.2, 5.3
JT	Up to v10.9
NX	Up to NX 2306
SolidWorks	Up to 2023

Solid Edge	Windows - Up to 2024
CGR	Up to V5-6R2022
STEP	AP 203, AP 214, AP 242
IFC	IFC2x3, IFC4
Parasolid	Up to 35.1
Rhino	Up to 7

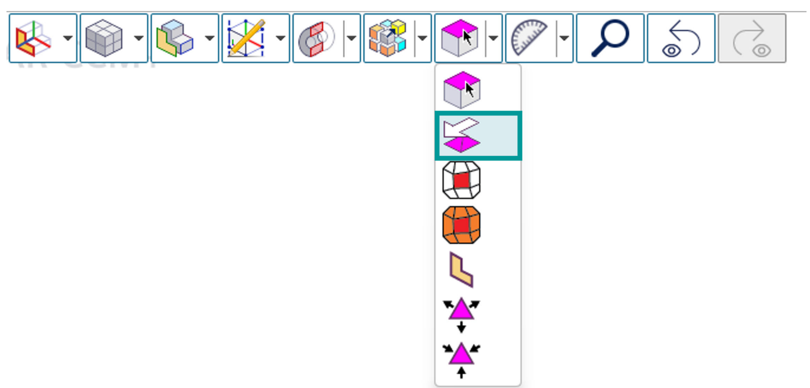
Geometry

3D-CAD

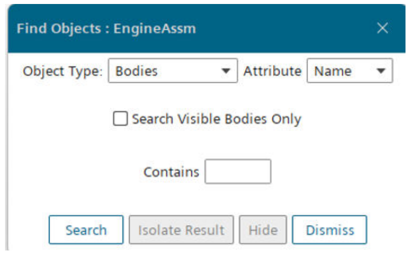
- **Multiple Instanced body support**
  - Improved efficiency while preparing geometry that include instanced bodies
    - Uses pre-existing CAD instance information
    - Modifications applied to any instance can be propagated to all instances
    - Operations that support instancing:
      - Repair features
      - Sketch commands
      - Body operations
    - Reduced memory consumption proportional to the number of instances present in the geometry
- **Additional operations support for Convergent Modeling**
  - Flexibility in handling and modifying facet and convergent geometries directly within the 3D-CAD environment
    - Transform - translate, rotate, scale, and mirror facet bodies
    - Boolean Imprint - Create imprints between facet bodies
    - Boolean Subtract - Subtract facet bodies
    - Boolean Unite - Unite facet bodies into a single body
    - Create sheet bodies
    - Check validity of facet bodies
- **Exploded View**
  - Save time identifying hidden components within the geometry that require defeaturing by exploding the view
    - Control the exploded view by actively using the scaling factor
    - Flexibility in defining scaling
      - Scale in X,Y,Z directions independently
      - Explode all dimensions uniformly



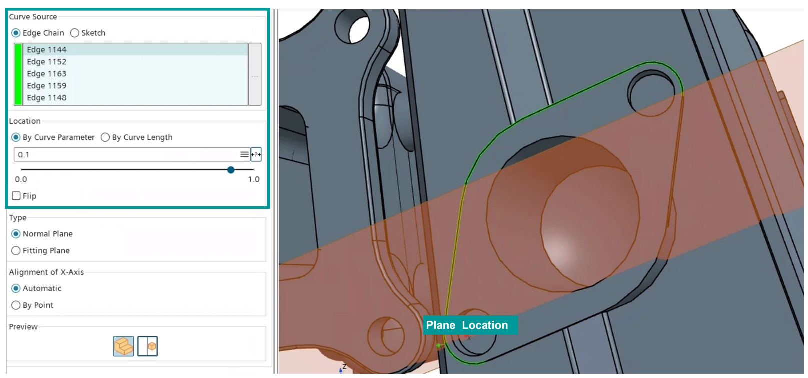
- **Entity Selection by Painting**
  - Quick and easy method to select neighboring entities by using "Selection by Painting" mode
    - Drag the mouse in one continuous motion to select neighboring entities
    - "Selection by Painting" works on all 3D-CAD entities
      - Bodies
      - Body Group
      - Faces
      - Edges
      - Vertices



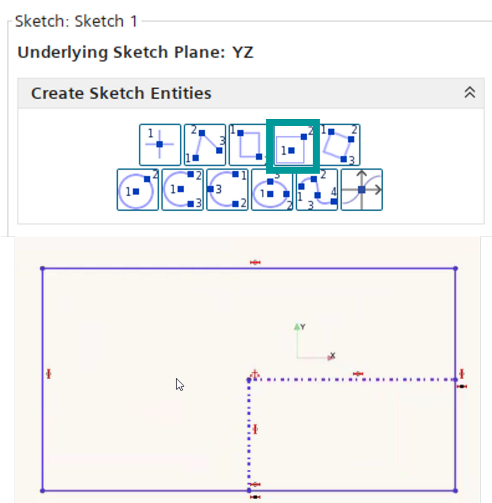
- **Find Objects**
  - Save time navigating 3D-CAD model and feature tree with quick identification of objects of interest
    - Easy method to find objects of interest within 3D-CAD
    - Quickly identify entities mentioned in error messages
    - Ability to isolate results
    - Supports all entities in 3D-CAD
    - Can be accessed from:
      - Head-up toolbar
      - Right click menu
      - 3D-CAD model node



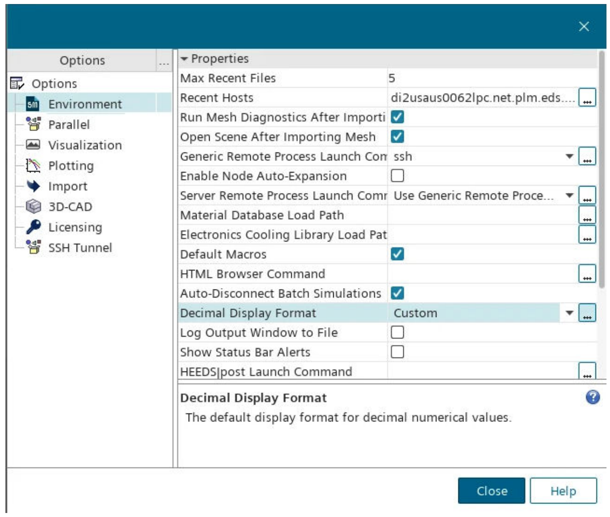
- **Ability to create reference planes from multiple curves**
  - Improved usability by supporting the use of multiple curves during creation of reference planes
    - Reference planes can be created by using:
      - Edge Chain - connected edge chain curves
      - Sketch - 2D/3D sketch with multiple curves
    - Location of reference plane can be defined by:
      - Curve Parameter
      - Curve Length
    - Orientation of reference plane can also be flipped

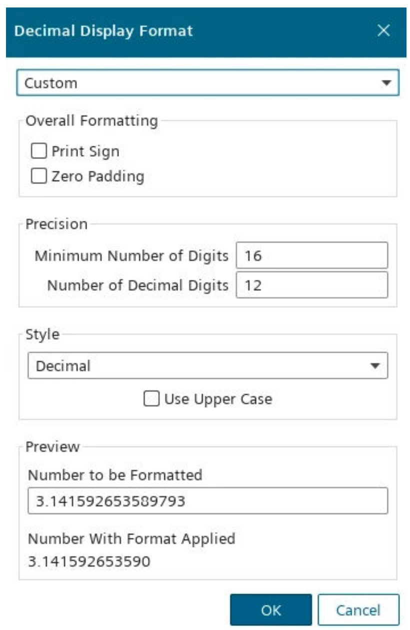


- **Create Rectangle based on a Center and a Point specification**
  - Quick and easy method to sketch rectangles that maintain symmetry around a center point in 2D Sketch with the Create Center Point Rectangle option

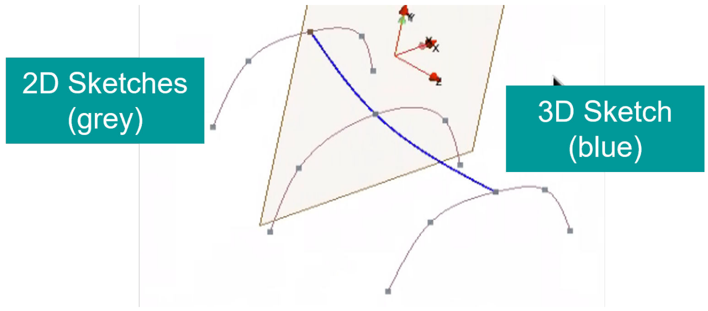


- **Improved Measurement Tool**
  - Increased precision of default measurements with ability to define required precision
    - Found in global options
  - Display X,Y,Z coordinates of vertices
  - Added a clear existing measurements shortcut (CTRL+SHIFT+Spacebar)



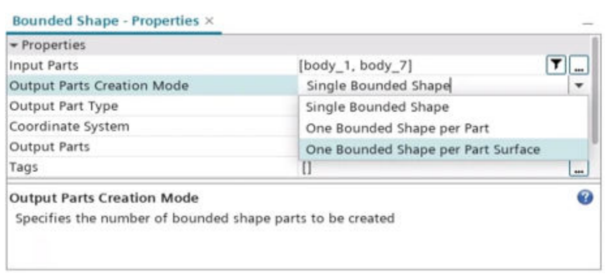


- **Enhanced 3D Sketch**
  - Improved usability of 3D Sketch by allowing the use of 2D Sketch points to be used in definition of the 3D Sketch



Parts

- **Part Surface mode in Bounded Shape Operation** [ID-0020405]
  - Save time by reducing the number of bounded shape operations by using the per Part Surface mode
  - Added flexibility with the ability to create a bounded shape per Part Surface
    - More efficient process for mesh refinement setup
    - Reduce the number of operations required

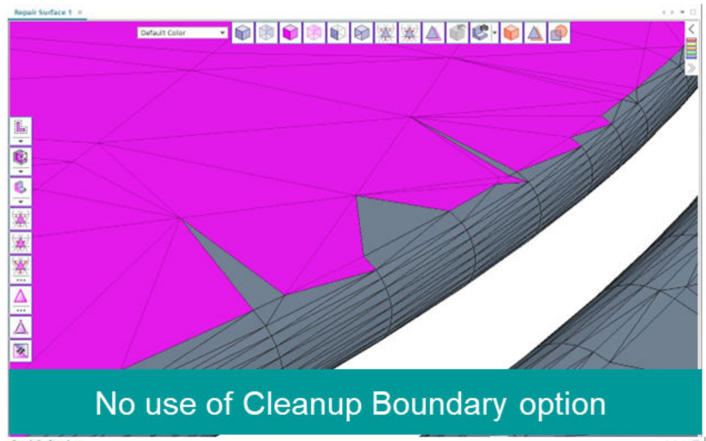


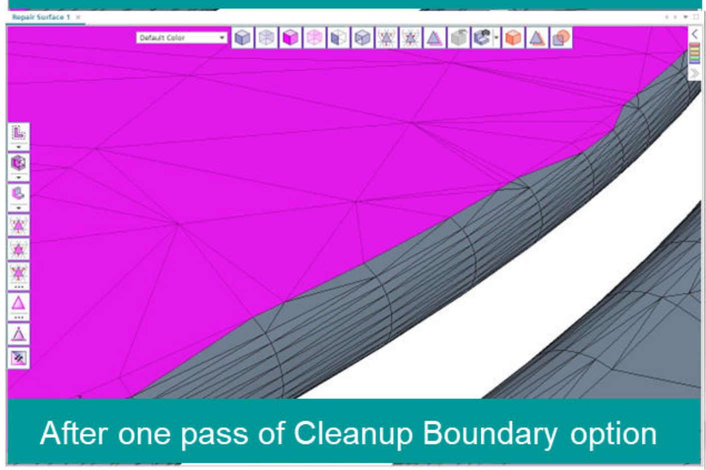
- **Parameter selection in mesh controls**
  - Improved automation capabilities by leveraging global parameters in mesh controls
    - Use Parameters as inputs on the following mesh controls:
      - Prism Layer Mesher & Advancing Layer Mesher
        - Prism Layer Thickness Ratio
      - Volume Extruder and Directed Mesher
        - Number of Layers
        - Stretch Value
        - Thickness Ratio

Mesh

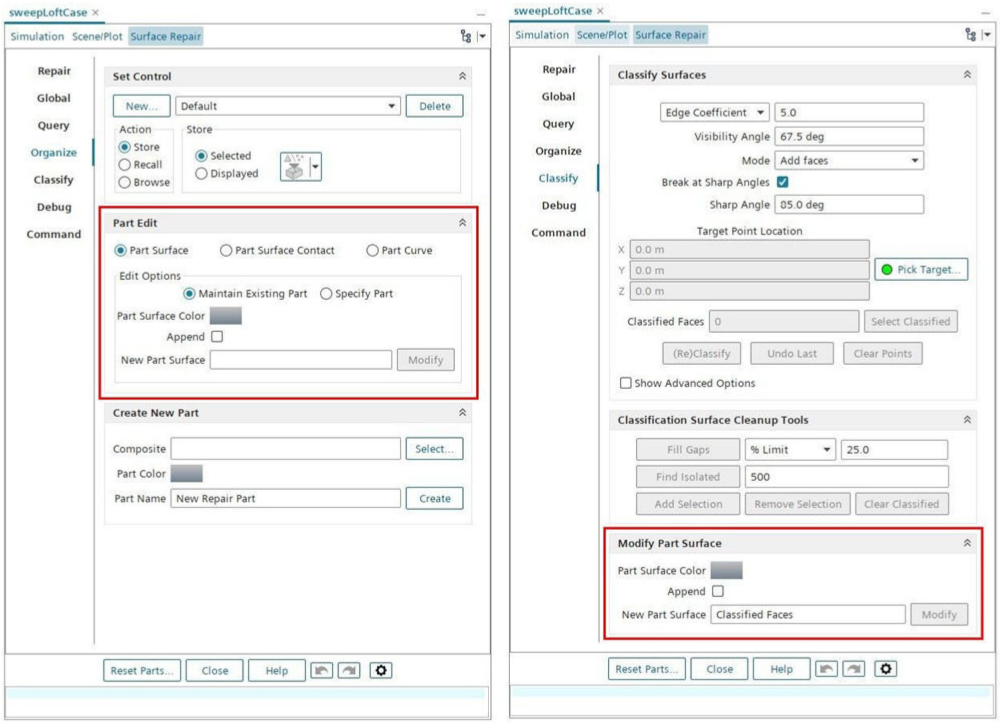
Surface Repair

- **Improved classification of faces via *Cleanup Boundary* Tool**
  - Allows creation of a smoother and more even boundary adding or removing face triangles
  - Saves time from manually selecting faces or reclassifying faces



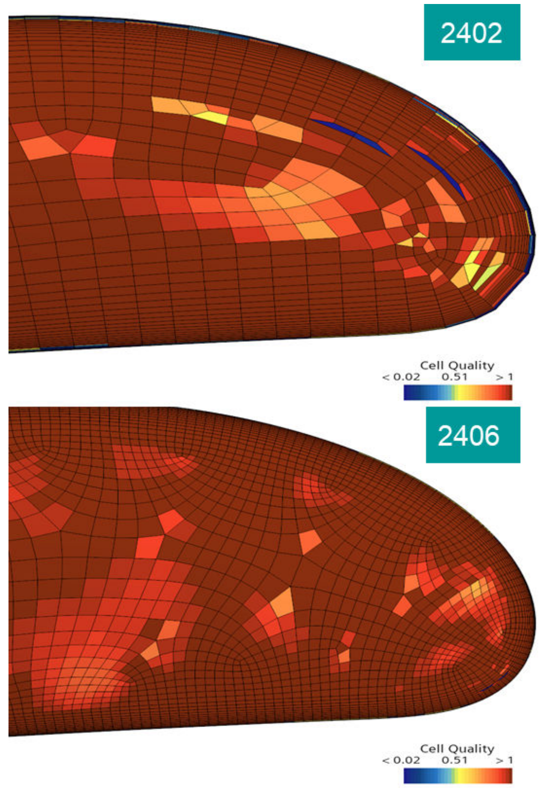


- **Append part surfaces option for *Modify* tools**
  - Names of original Part Surfaces are maintained whilst appending a suffix
  - Available in *Organize tab* and *Classify tab*
  - In Classify tool newly created part surfaces keep the appended plus the original name



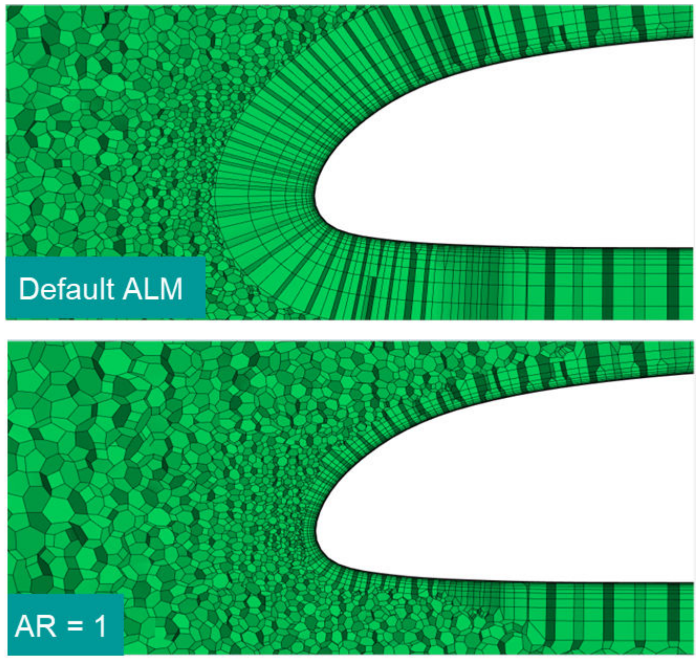
Surface Mesh

- **Automatic curvature refinement along anisotropic part curves**
    - Creates a better surface mesh distribution leading to overall increased mesh quality
    - No user input required

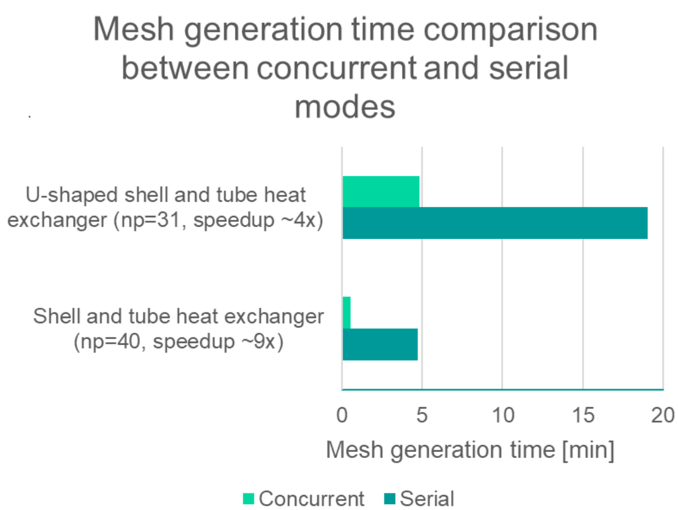


Volume Mesh

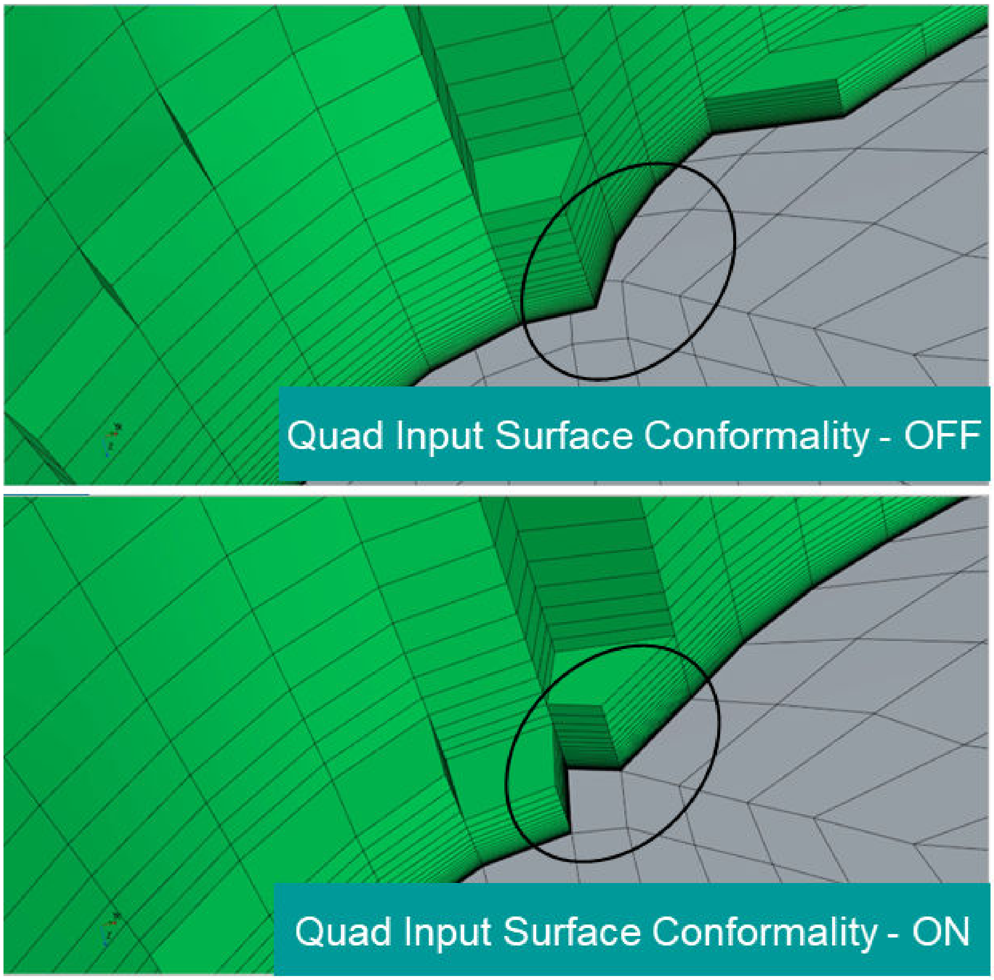
- **Aspect Ratio (AR) control for Advancing Layer Mesher (ALM)**
  - Improved handling of cell aspect ratio during boundary layer mesh generation
  - Eliminates "skinny, stovepipe" prism layers offering better solution accuracy
  - Better control of boundary layer mesh transition from prisms to core mesh
  - Custom surface control support
  - Target aspect ratio value range [0.5, 3.0]



- **Concurrent execution mode for Directed Mesher**
  - Improved turnaround time via concurrent execution mode
    - Speedup dependent on number of parts, case complexity and processors used
  - Consistent mesh quality compared to serial execution
  - New mesher execution mode option in the UI



- **Conformal poly/prism mesh with isotropic quad-dominant surface mesh**
  - Mesh conformality between input quad-dominant surface mesh and volume mesh
    - *Quad Input Surface Conformality* option enables a conformal mesh connection
  - Available only for polyhedral mesher with quad-dominant surface mesh



CAE Integration

- **CAE Interoperability Supported Versions**

Integration	Versions
CGNS Format	4.3.0
Co-simulation API	V6, V8
FMI	1.0.1, 2.0, 3.0
GT-SUITE	2020, 2021, 2022
Abaqus	2021, 2022, 2023
Simcenter Nastran	2206, 2212, 2306

  - Compatibility for Abaqus version 2023 added in this release

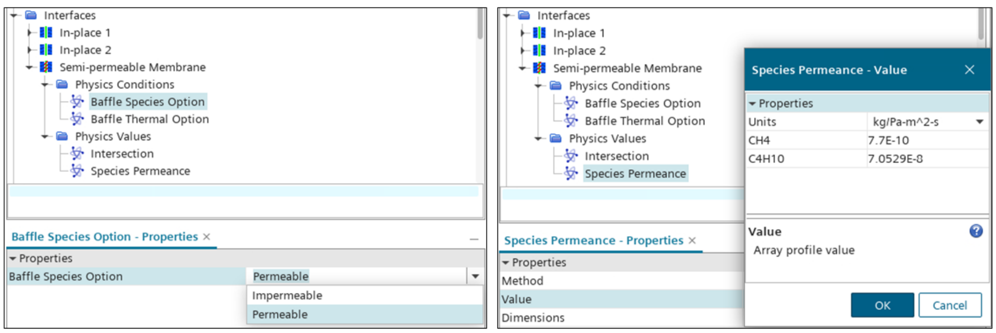
Physics

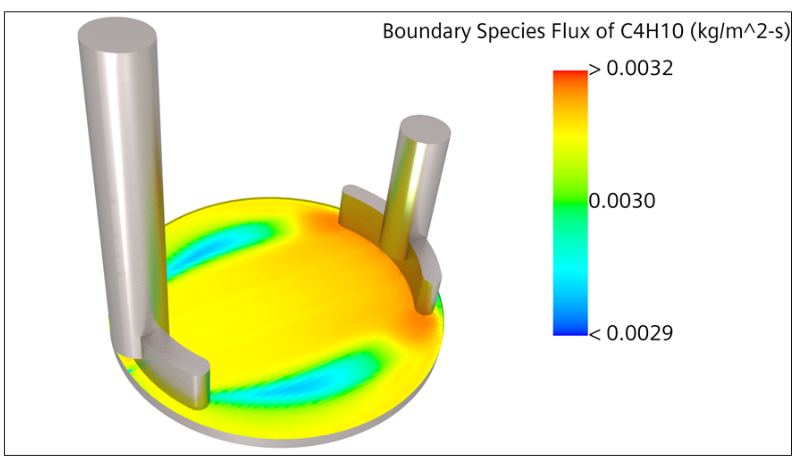
CFD

CFD

Flow

- **Permeable baffles for selected species in gas mixtures**
  - Enable modeling of gas separation processes with permeable membranes by introducing an Impermeable/Permeable species options for baffle interfaces
    - Equivalent to the Conductive/Non-Conductive baffle thermal option
    - Embedded calculation of species mass flux through the baffle interface by defining selective species permeabilities





- **Porous phase substance replaceable when "in Use" by Reaction Component Manager**
  - Improved workflow for battery chemistry analyses via on-the-fly replacement of porous phase substance components
    - A *Replace with* action is now available on right-click for porous phase substances independently of whether it is being used or not in the simulation

Energy

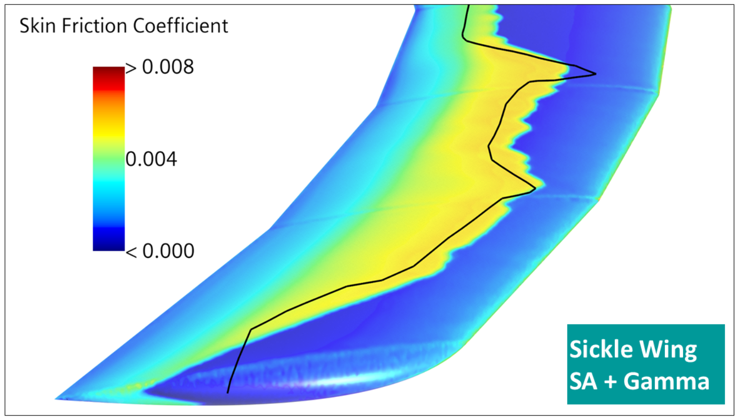
- **Surface radiation property input revision and Surface properties database**
  - Streamlined process to setup radiation properties via a completely redesigned and fully automatable workflow
    - Assignment of surface properties aligned with the solid properties (at the continuum level)
  - New material database section for surface properties supporting Radiation properties in first release
    - Flexible infrastructure to support more surface properties in future releases (i.e., corrosion, friction etc.)
- **Patch-Face Proportion available as a parameter**
  - Improved customization of VTM and CHT model templates via Patch-Face proportion value
    - Can be specified as a parameter

Reacting Flows

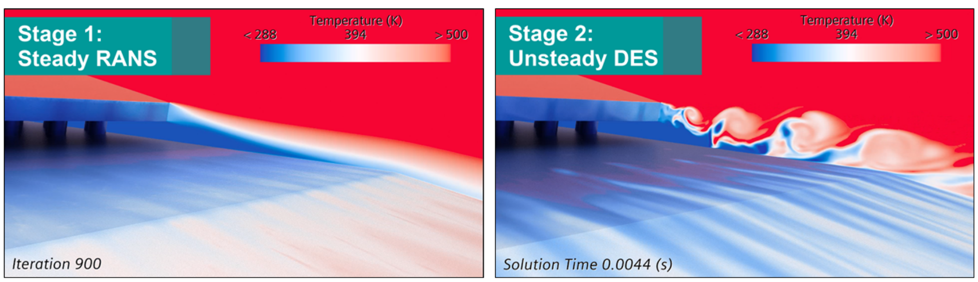
- **User-defined Equation of State (EoS) with Complex Chemistry**
  - Improve stability when modeling combustion of supercritical fluids with User EoS and Complex Chemistry compatibility
    - EoS properties can be defined using e.g. Tables to account for unique properties around the critical point
    - Extends previous compatibilities with Ideal Gas and Real Gas EoS models
- **Surface chemistry with time-varying porosity**
  - Account for consumption of battery material (jellyroll) in thermal runaway with variable solid phase porosity
    - Surface Chemistry model in a porous media can now account for time-varying porosity
    - Allows for reaction rates to be limited by bulk species concentration
    - New field function added - *Porous Phase Mass*
- **Acoustic Modal Solver: arbitrary number of n-tau sources**
  - Capture thermoacoustic impact of several flame fronts in a combustion system with multiple n-tau sources
    - Typical applications include axially staged combustion
- **Single Precision Flamelet Tables now as default**
  - Improve speed and memory with reduced table size, without impacting solution accuracy
  - The ability to generate single precision Flamelet Tables was introduced in Simcenter STAR-CCM+ 2402
  - Now single precision table generation are the default option

Turbulence

- **Gamma transition model for Spalart-Allmaras** ID-0005664
  - Extend applicability of Spalart-Allmaras (SA) turbulence model to transitional flows with a new Gamma transition model for Spalart-Allmaras
    - Improve accuracy of Spalart-Allmaras turbulence model for low Reynolds flows (Urban Air Mobility)
    - Compatible with both RANS and DES approaches
    - Similar accuracy as K-Omega with Gamma transition model with up to 10% reduction in turnaround time



- **Support for turbulence model selection and deselection in Stage**
  - Fully automate RANS-to-Scale Resolving Simulation (SRS) workflows by added support for turbulence model selection and deselection in Stages
    - All turbulence methods supported (RANS, DES, LES), as well as all RANS and LES sub-grid scale models



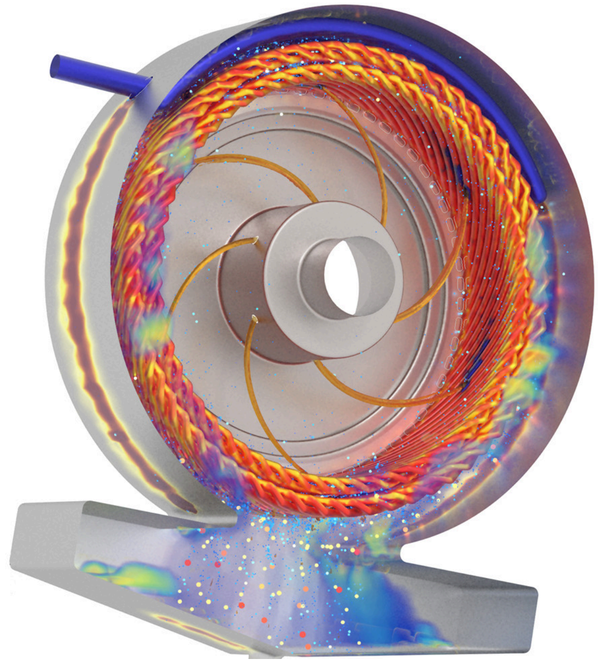
  - Robust initialization of aerospace supersonics and hypersonics with fully automated Inviscid-to-RANS workflow
    - All viscous regimes supported (Inviscid, Laminar, Turbulent)
  - Multiple physics setups in one single simulation
    - Reduced need for multiple continua and Java scripting

Multiphase Flow

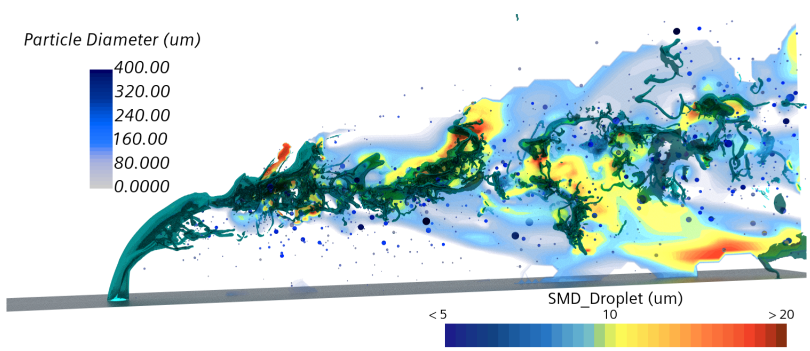
Mixture Multiphase (MMP)

- **Lagrangian Multiphase (LMP) to MMP sub-grid phase interaction**
  - Reduces computational expense of hybrid multiphase simulations by transitioning small Lagrangian droplets/bubbles to MMP phases
    - Enables hybrid multiphase approach including mixtures
    - Highly beneficial to applications such as e-motor cooling where jets of oil break up into ballistic droplets, which further break down into mixtures and even foams
  - LMP breakup or other physics can lead to a large number of particles with low Stokes numbers
    - LMP is not an efficient or well suited model for droplets/bubbles which are numerous, 10s microns in size and carried with the continuous flow

- LMP to MMP subgrid phase interaction allows transition based on Stokes number, diameter and other user criteria
  - LMP diameter is passed to S-Gamma population balance model if active



- **S-Gamma population balance model for MMP-LSI**
  - Allows further transport of droplet (and/or bubble) sizes in MMP coming from LMP (or other sources) in the presence of free surfaces
    - Original S-Gamma model was only valid for continuous dispersed flows
    - New approach allows phase inversion through a free surface from a dispersed droplet phase S-Gamma population below the free surface to a dispersed bubble phase S-Gamma population above (if both active)
  - Mirrors implementation for EMP-LSI

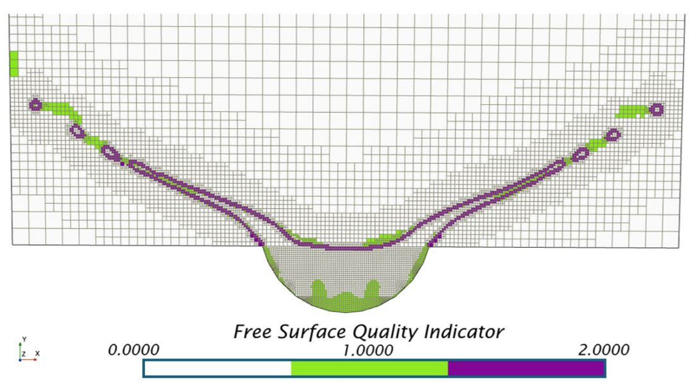


  - Allows breakup and coalescence modeling at sub-grid scale alongside resolved structures
    - Key to predicting correct droplet and bubble sizes and transport of phases
  - Includes model for bubble entrainment at free surfaces
- **LMP impingement into MMP-LSI free surfaces**
  - Allows LMP droplets to impinge into existing bodies of fluid
    - Mirrors existing capability between LMP and VOF

        - Applies when LMP droplets pass into region of high volume fraction of corresponding continuous phase
    - Ensures most appropriate model used locally
        - Avoids tracking LMP droplets in continuous MMP phase of the same substance
    - Typically LMP impingement is sub-grid, but cell clustering can be used if impingement effects are to be resolved

Volume of Fluid (VOF)

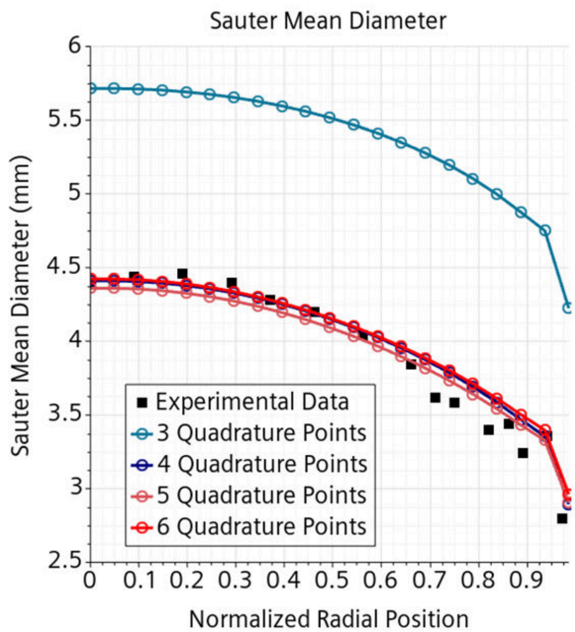
- **VOF wave model: Turbulence vorticity limiter**
    - Improves the accuracy of wave propagation in marine simulations
        - Reduces unphysical turbulence production that can develop around free surfaces after several wavelengths and associated dissipation of waves
    - Available when VOF wave model selected
    - Available for:
        - Standard and Realizable k-ϵ models
        - Standard and SST k-ω models
- **Free surface quality indicator field function and report**
    - Allows easy assessment of the quality of free surface capture in VOF simulations
    - *Free Surface Quality Indicator* field function has 3 possible values:
        - 0 - No interface
        - 1 - Smeared interface
        - 2 - Sharp interface
    - Corresponding report, *Free Surface Quality*, can be used to determine the average interface sharpness throughout selected regions
        - Report returns ratio of sharp interface cells to all interface cells (sharp and smeared)
        - An interface that is sharp everywhere will return 1
        - Can be used to trigger Volume Fraction Reinitialization



Eulerian Multiphase (EMP)

- **S-Gamma: Performance improvements and reduction of default quadratures**
    - Fewer quadrature points needed to achieve consistent results independent of quadrature point number
        - More efficient distribution requires fewer points and less trial and error

        - Reduced computational expense and memory requirements
    - Default number of quadratures reduced to 5 (from 8)
        - Typically 5 produces a good fit
    - Applies to both EMP and MMP



- **Wall boiling: Li nucleation site density model**
    - Predicts more accurate values for high levels of wall superheat compared to existing models such as Hibiki-Ishii and Lemmert-Chawla
        - Less need for limitation of nucleation site density
        - Improved convergence compared to existing models
- **Normalized Phase Mass Conservation Error and Iterations per Time Step reports**
    - Reduce time to solution whilst ensuring good convergence by using these reports to drive stopping criteria
        - Provides alternative to adaptive timestep approach using adaptive number of inner iterations
    - Two new reports are provided:
        - Normalized Phase Mass Conservation Error
            - Can be used as basis for inner iteration stopping criteria
        - Iterations per Time Step
            - Can be used to monitor resultant inner iterations

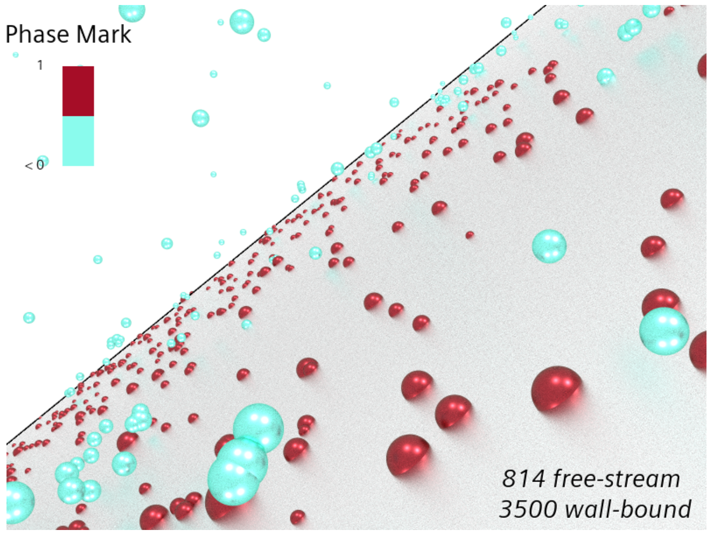
Fluid Film

- **Habchi boiling model**
    - Improved accuracy for modeling boiling in Fluid Film beyond critical heat flux
        - Includes Leidenfrost effect resulting in longer (more physical) film residence times beyond transition compared to existing model
    - Two options for Fluid Film boiling are now available
        - Habchi (new model)

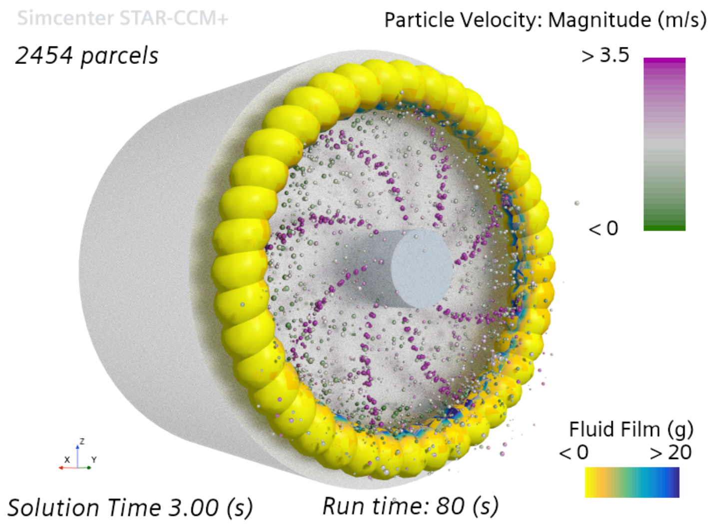
        - Rohsenow (pre-existing model)

Lagrangian Multiphase (LMP)

- **Transfer model from free-stream to wall-bound phase** D4715
    - The benefits of wall-bond modeling are now available to a larger set of water-management cases with both free-stream and wall-bound representations of droplets
    - New options and models enable the transition to the wall-bound phase
        - Lagrangian-Lagrangian Phase Interaction
        - Deposition model
        - Transfer to Wall-Bound Phase mode in the Boundary Conditions menu
        - Parcel Transfer Injector for free stream to wall-bound phase automatically created with activating Deposition model



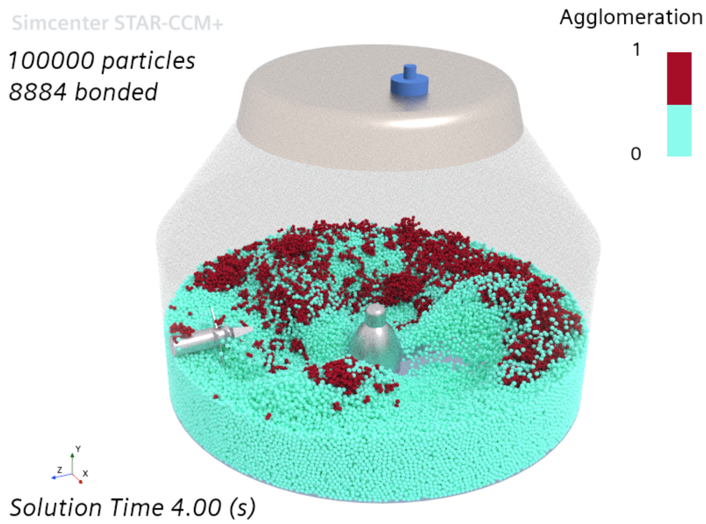
- **Cyclic Injector Specification for Table injectors**
    - Simplified workflow for converting the outcome of VOF simulation into the input of faster LMP simulation using the new Cyclic Injector Specification option
        - VOF simulation or experimental data provides droplet initialization data for one rotation or cycle
        - LMP simulation reuses the same data in a cyclic manner
    - Applications: E-motor cooling; fuel, paint, and agricultural sprays with cyclic output from nozzles



- **Postprocessing injectors using Solution History**
  - Advanced post-processing of the initial state of injected particles by selecting the injector as an input to the Solution History
    - Useful for comparing the state of particles at different locations with the state of particles generated by the injectors

Discrete Element Method (DEM)

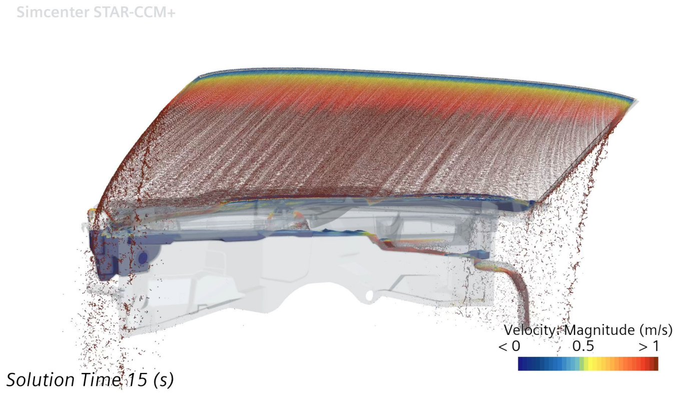
- **Particle Agglomeration model**
  - Accurate modeling of particle agglomeration and deposition via the upgraded Parallel bonds contact model
    - Two bond formation options
      - Time Window, existed previously
      - User Defined, the bond forms only at specific local conditions
    - Bonding material can differ from particle material, two options for Bond Stiffness
      - Particle Material Based, existed previously
      - User Defined, for a wide range of granulation applications
    - Parallel bonds renamed to Particle Agglomeration
    - Bonding between particles and boundaries enabled



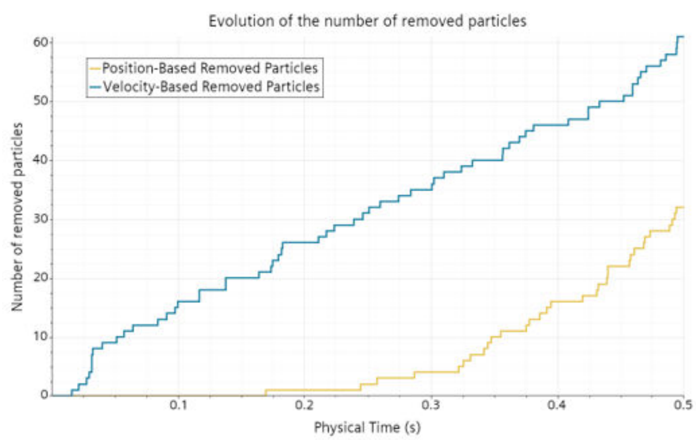
- **Contact Time field function**
  - Access additional useful information about particle state via new field function
    - The Contact Time field function returns time elapsed since the beginning of the particle-particle or particle-wall contact
    - Available for all particle types and shapes
  - Improved realism when modeling contact time-dependent physics such as particle agglomeration
- **Injection Table option for Particle Orientation**
  - Ability to transfer the particle state from one simulation file to another when particles are non-spherical
    - New Injection Table option for Particle Orientation method
      - Reads the three table columns with values of angles that define particle orientation
  - Improved control over the initial orientation of non-spherical particles

Smoothed-Particle Hydrodynamics (SPH)

- **Inlet boundary conditions**
  - Enable analysis of applications with liquid injections with the support of inlet boundary conditions
    - Velocity Inlet and Mass Flow Inlet
    - Compatible with Constant, Time evolution, and Field Functions
    - Rotating and static inlet boundaries
    - Target applications: vehicle water runoff, powertrain lubrication by injection



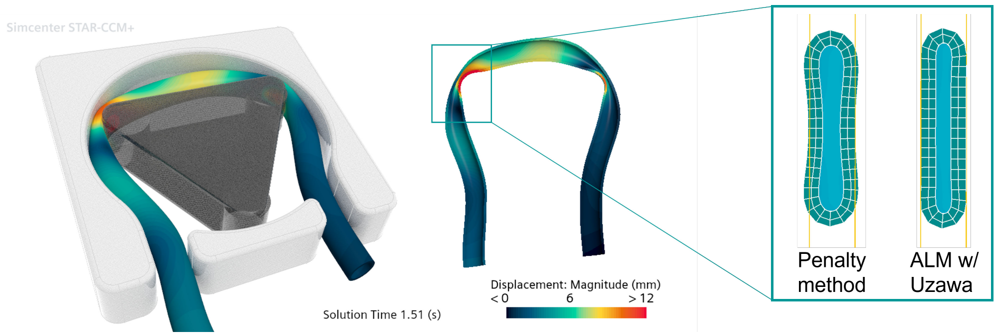
- **Reports for removed particles**
  - Enhanced monitoring tools to assess the simulation convergence through new reports for removed particles
    - Report for Particle Remediation Removed Particles
    - Position-Based and Velocity-Based



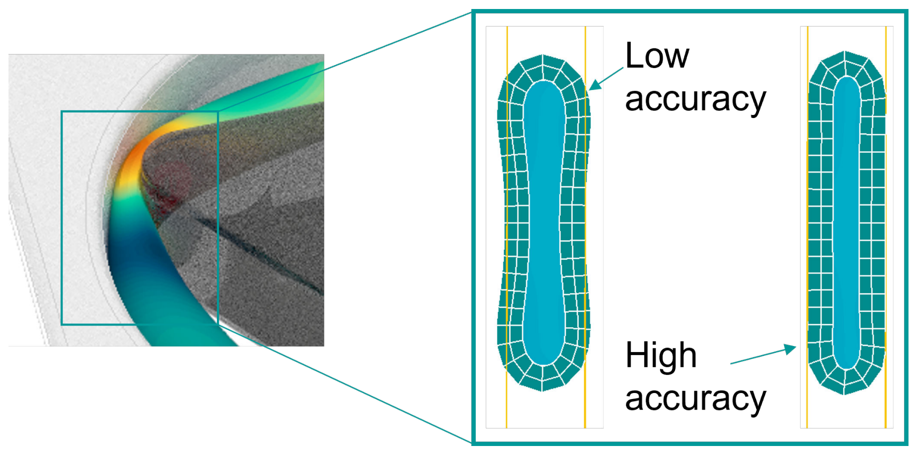
- **Enhanced Moment report**
  - Increased accuracy for the Moment report
    - No dependency on the surface mesh resolution
- **Visualization of Velocity on solid boundaries**
  - Faster simulation analysis with the visualization of velocity vector and scalar field on solid boundaries
    - Wall velocity depends on the solid boundaries type (slip or no-slip walls)

Solid Mechanics

- **Advanced contact enforcement (ALM with Uzawa)**
  - More accurate and robust contact enforcement through Augmented Lagrangian Multiplier (ALM) method combined with Uzawa algorithm
    - High accuracy independent of penalty parameter
    - Robust even in case of sudden contact changes
    - Optional automatic update of penalty parameter for faster convergence rate



- **Improved contact discretization (Mortar discretization)**
  - New Mortar discretization scheme improves convergence rate and robustness for difficult contacts with high accuracy demands
    - Improves convergence rate for contacts with very high penalty parameters
    - Can be used with Penalty or Augmented Lagrangian Multiplier (ALM) Uzawa method



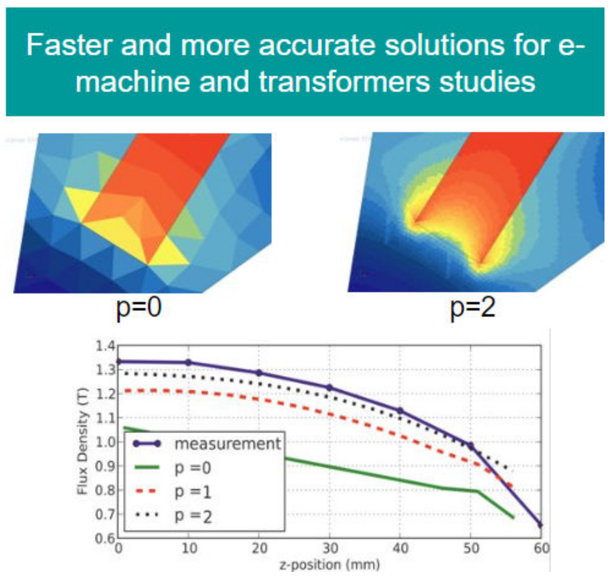
- **Faster convergence for plasticity with linear strains**
  - Faster convergence rate for models using the J2 plasticity with isotropic hardening
    - Convergence now quadratic (previously linear)
    - On average 50% and up to 80% less iterations
- **Surface Load Linearization now including Dynamic Stabilization**
  - Quadratic convergence for solids in Fluid-Structure-Interaction setups when using Surface Load Linearization and Dynamic Stabilization
- **Coriolis force due to displacement in rotating structures**
  - Improved accuracy when simulating large rotating structures with Coriolis forces caused by local displacements
- **One-way Fluid-to-Structure coupling for a rigid solid motion and morphing for the fluid**
  - More flexibility when setting up one-way coupled fluid-structure interactions where solid deformations can be neglected
- **Prevent input of unphysical material parameters for Neo-Hookean model**
  - Improved ease-of-use when working with hyperelastic Neo-Hookean model through automatic sanity-check on material parameter input
- **Block nonlinear geometry + nearly incompressible + linear elasticity**
  - Combination of incompatible physics models is blocked to avoid wrong modelling assumptions

- **Thermal Shells – FE Solid Energy model with shell-only parts**
  - Enables efficient thermal modelling of thin-walled structures
  - Limited to setups with exclusively shell-parts and edge-to-edge interfaces

Electromagnetics and Electrochemistry

Electromagnetics

- **Higher Order Finite Element Electromagnetic solver (Tetrahedral elements and Time domain)**
  - Improved accuracy, reduced mesh count and reduced time to solution thanks to introduction of higher order FE methods
    - Higher order solver available for the FE Magnetic Vector Potential model
      - Currently supported only for time domain and tetrahedral meshes
    - FE shape function order adaptivity allows local refinement without changing the mesh
    - Mid-side vertices and other techniques allow for capturing intra-cell variability without increasing mesh count



- **Local Point Support for Nonlinear Anisotropic Permeability**
  - More accurate calculation of the permeability and the Frechet derivative for nonlinear anisotropic materials via integration at the local point level
    - Significantly improved convergence for p-order 0 and hexahedral meshes
    - Better convergence for any mesh type and p-order 2
- **Mapped Contact Interfaces for single region electrodynamic potential (EDP)**
  - Faster Conjugate Heat Transfer (CHT) simulations involving EDP with mapped contact interface compatibility
    - Previously, Mapped Contact Interfaces could not be used if any region had an EDP model active
    - Now, Mapped Contact Interfaces can be used in instances where only one region has EDP active
    - Use of Mapped Contact Interfaces allow for faster interface intersection times and better face matching compared to direct contact interfaces

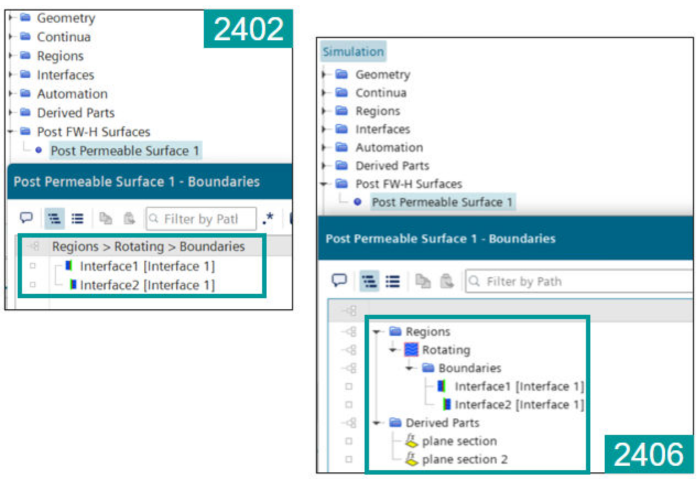
- Multiple regions with EDP and Mapped Contact Interfaces are not yet supported

Electrochemistry

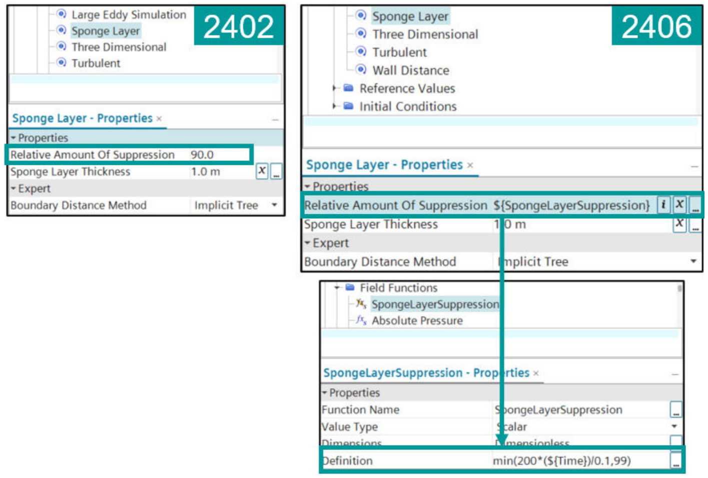
- **3D Cell Design - aging models**
  - Capture the impact of battery aging with new physics-based cell degradation models
    - Two main aging models introduced: Solid-Electrolyte Interphase (SEI) film growth and Lithium plating film growth
    - Further details can be found under Batteries.

Aeroacoustics

- **Permeable Post FW-H on Derived Parts**
  - Faster FW-H source surface definition thanks to the ability to use derived parts for the model setup
    - Removes the need to define interfaces only for FW-H purposes for the meshing and setup process
    - Greater flexibility for users when creating Permeable Post FW-H surfaces

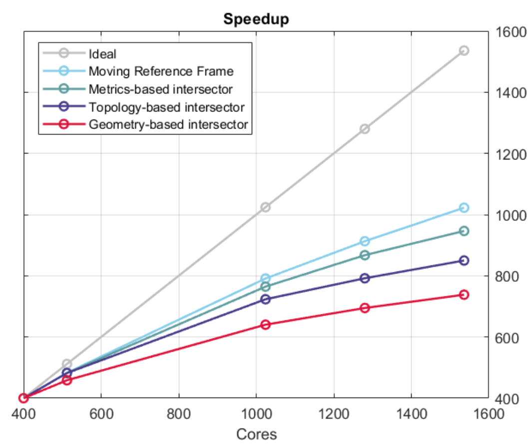


- **Sponge Layer parameterization**
  - Improved stability and usability thanks to more options for the Sponge Layer
    - "Relative amount of suppression" parameter now takes the following inputs:
      - Field Function
      - Parameter
      - Table
    - Better model automation with the parameter that can easily be templated

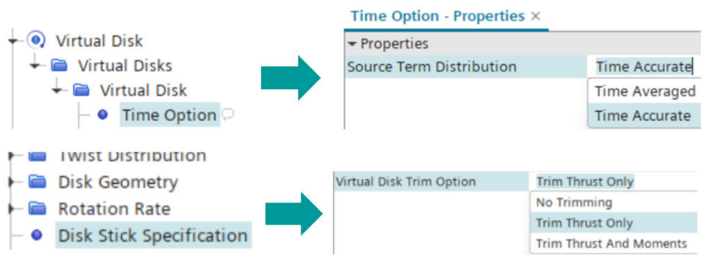


Motion, Mesh Adaption, and Mapping

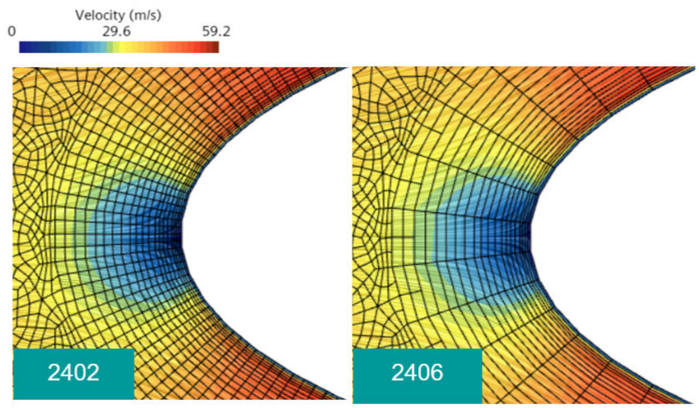
- **Faster sliding mesh interfaces**
  - Faster and more scalable interface calculation and smaller memory footprint
    - Efficient use of computational resources
    - Significantly better scalability on higher core counts
    - Applications: Unsteady drag prediction of rotating automotive wheels, electric motor cooling, VTM fan, mixing vessels
    - The "Closed Adjacent Cells" option is not available for the MBI

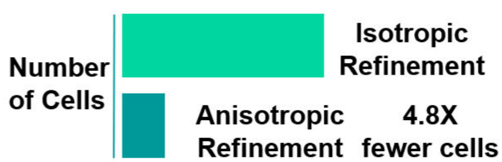


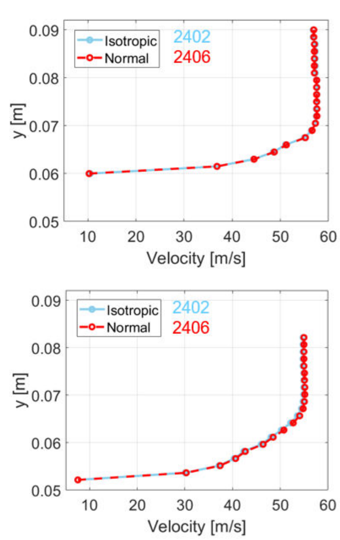
- **Trim with blade element method during unsteady simulation**
  - Faster and more efficient unsteady simulation of rotorcraft by allowing trimming with blade element method
    - Support for unsteady and steady blade element method
    - Shortened workflow by removing the need for re-runs with adjusted trim angles
    - Faster turnaround time compared to rigid body motion
    - Applications: rotor-body interference investigation, engine inlet design

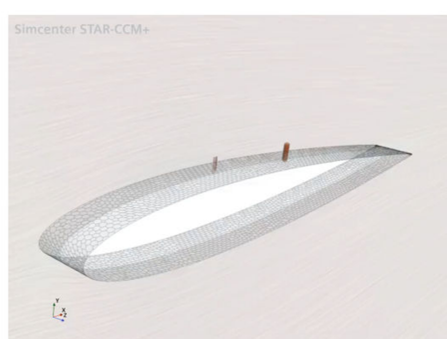


- **Anisotropic mesh refinement in the boundary layer during AMR**
  - More efficient boundary layer capturing by allowing anisotropic refinement of prism layer during AMR
    - Support for isotropic, tangential, normal, as well as criterion-based refinement
    - Lower number of cells and reduced simulation time



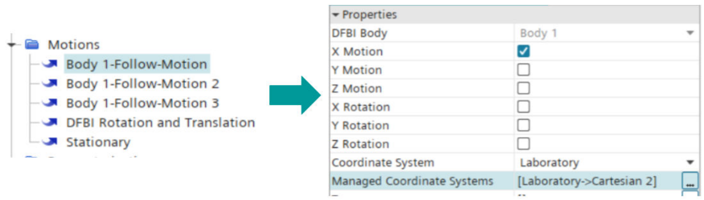






- **Coordinate system motion management**

  - Managing relative motion of coordinate systems through definition of how they should follow a body (e.g., a ship)
    - Simplified post processing visualization
    - Streamlined management of Derived parts' (e.g., of a ship) motion



Design Exploration

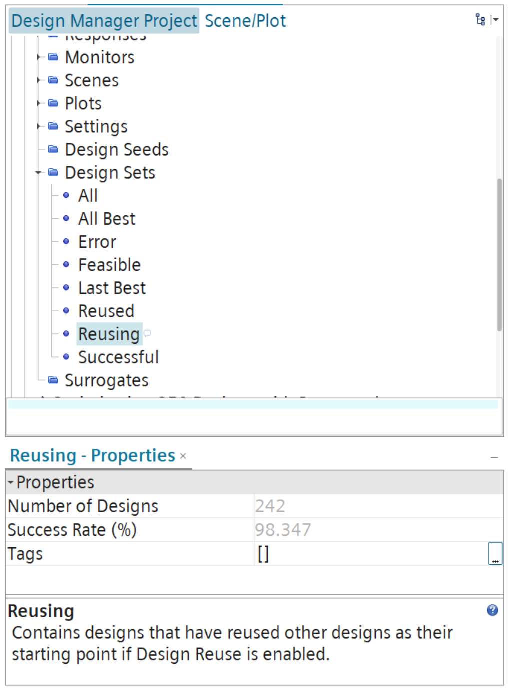
Adjoint

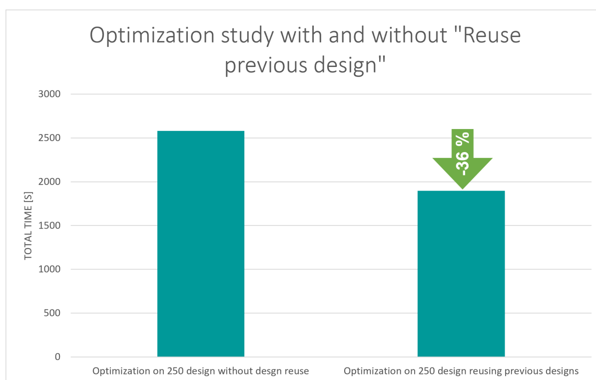
- **Adjoint sensitivities for global parameters used in 3D-CAD**
  - Easily evaluate sensitivities of CAD parameters by introducing the computation of adjoint sensitivity for global parameters used in 3D-CAD
    - Leverages the Compute Parameter Sensitivity functionality of the adjoint solver, released in version 2306
    - Requires Geometric Sensitivity mesher enabled and set up for the parameters of interest
    - Sensitivities are accessible via the sensitivity operator
- **Per-surface subgroup functionality for surface sensitivity computation**
  - Focused optimization of design components by leveraging the Per-Surface subgrouping for the computation of sensitivities
    - Applicability for CAD parameters and SQP gradient-based optimization
      - When a boundary is set to active, a new Active Surface Sensitivity node allows users to define the option Displacement or Fixed via sub-grouping
      - Sensitivity of CAD parameters is only computed when the active condition is Displacement
    - Applicability for Surface sensitivity computation
      - In Surface Sensitivity Filter Parameters, Fixed Surface is renamed to Excluded Surface
      - If the filter option is set to Excluded Surface, surface sensitivities are zeroed
- **New field function operator clamp(x_min, x, x_max)**
  - Easily constrain adjoint parameter optimizations with a new field function operator
  - Returns x_min or x_max when x is out of the range (x_min, x_max)
  - The operator is differentiated to be compatible with adjoint workflows

Design Manager

- **Reuse previous Designs**
  - Accelerate turnaround time by leveraging existing results from a previous design.
    - Automatically initialize the next design with the result of the closest available design
      - Based on a parameter space distance
    - Easily identify reused designs and designs reusing results with specific Design Sets

  - Available for Sweep, Design Of Experiment and Optimization studies



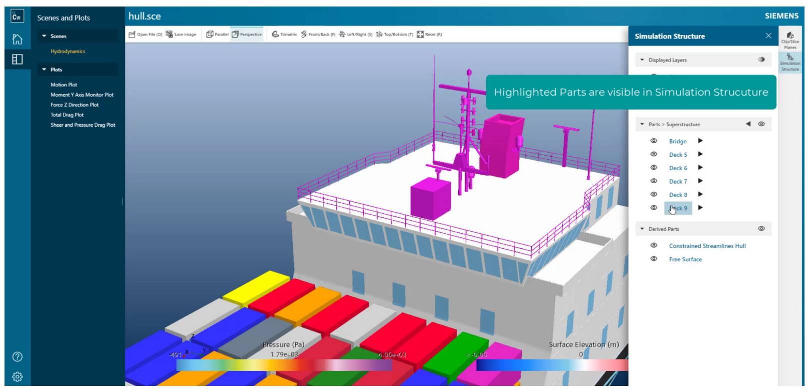


- **Clear History**
  - Design focused results visualization by removing the initialization related history
    - - Reduce likelihood of misinterpretation of results by focusing only on the relevant information
      - Store only necessary data over time
      - Particularly useful when used with the "Reuse previous designs" feature
      - Supports monitor and plots

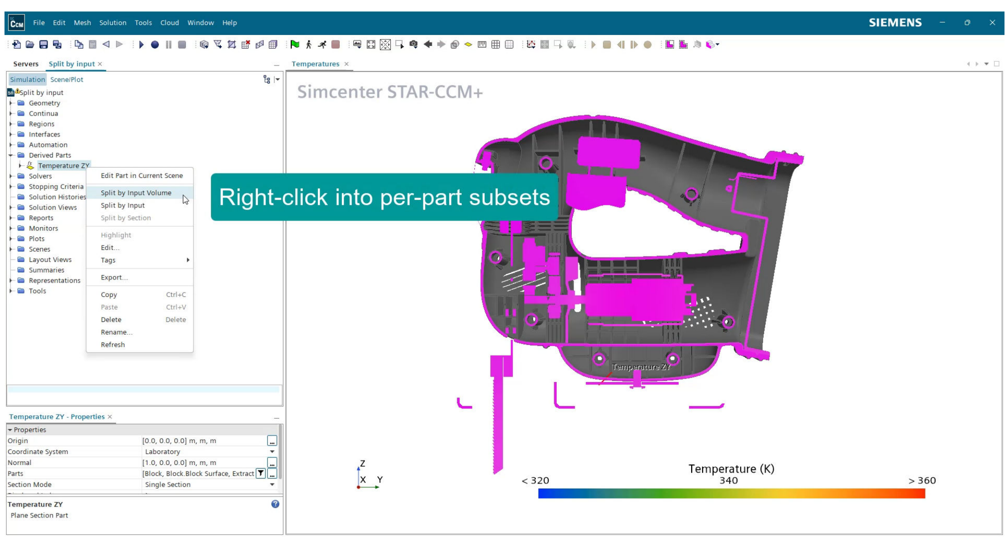
Data Analysis

- **Virtual Reality support for Simcenter STAR-CCM+ Web Viewer**
  - Leverage virtual reality to visualize and share simulation results with anyone at any time
    - Easily step into Viewer File (.sce) directly from the Web Viewer
    - No additional software required

- Greater collaboration with novel hybrid approach
  - Navigate in browser and seamlessly transition to Virtual Reality to increase product knowledge
  - Hide objects in the browser and take snapshots in Virtual Reality which are instantaneously available as downloads
  - Send Viewer Files (.sce) to colleagues and share Virtual Reality insights
- **Highlighting support in Simcenter STAR-CCM+ Web Viewer**
  - Better comprehend simulation results through highlighting
    - Greater scene content investigation
    - Analyze deepest level of details through highlighting and hiding workflow
    - Accessible in both Simulation Structure and Scene for more flexibility

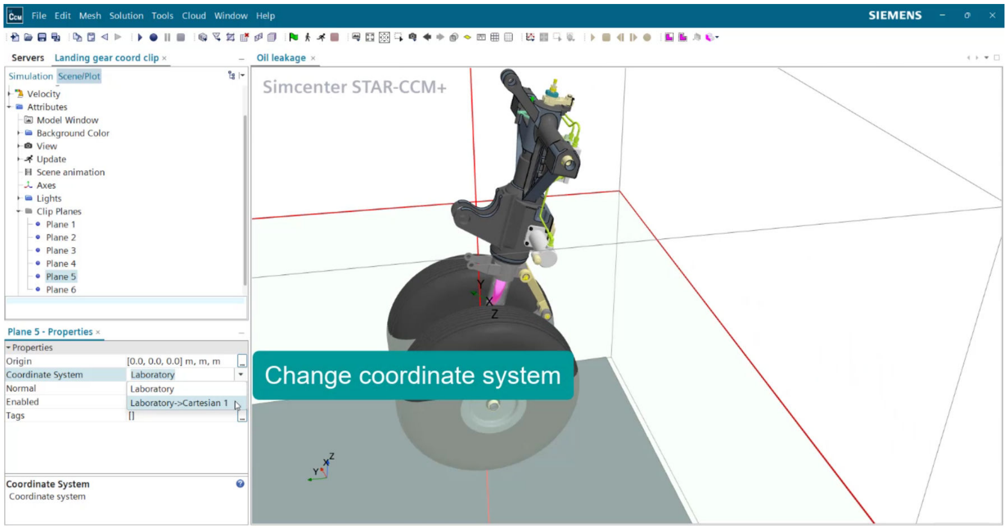


- **On-demand split derived parts into subsets**
  - More efficient per part workflow for Derived Parts through easy splitting
    - Break up single Derived Part into per part subsets with a single right-click action
    - Different splitting options available based on Derived Part type

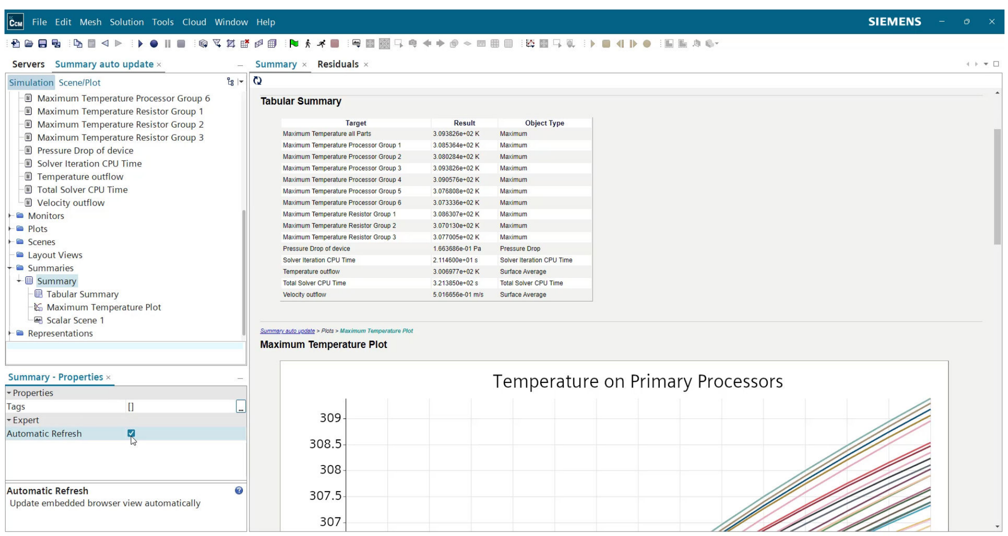


  - Effectively leverage subsets for report and visualization
    - Subsets are automatically stored in Group
    - Multiple sequential splitting options possible
- **Create and edit clip planes in a local coordinate system** D1266
  - Better comprehension of results with user-defined coordinate system support for clip planes

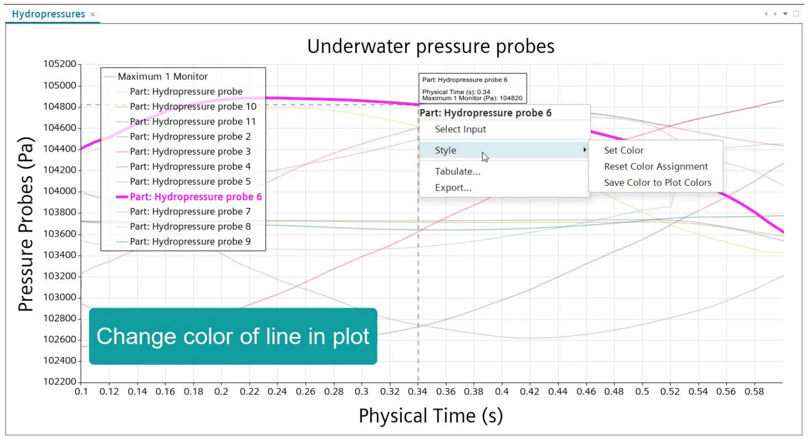
- Enhanced control and easy alignment of clipping planes through utilization of local coordinate systems



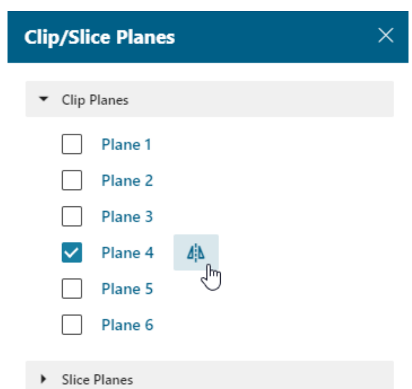
- **Keep Summary up-to-date with automatic updating mechanism**
  - Quickly and effortlessly monitor simulations through automatic updating of Summary
    - Content of Summary updates automatically with update policies of inputs once simulation is stopped



- **Interactive color customization for plots**
  - Enhanced usability through plot-centric color management
    - Control color of lines directly from the plot
  - Easily find input parts for plotted line
    - Menu selection from plot line available to identify input part



- **Extended statistics functionality with Monitor Derivative Report**
  - Calculate the derivative of any Source Monitor
- **New Pressure Option available in the force report**
  - Pressure Option excluding hydrostatic pressure now available in reports
  - Supporting marine cases
- **Improve coloring workflow in Surface Displayer through default change**
  - Easier changing of surface colors with a streamlined workflow
- **More insight through invertible Clip Planes in Simcenter STAR-CCM+ Web Viewer**
  - Invert one or multiple Clip Planes to fully control visibility of objects

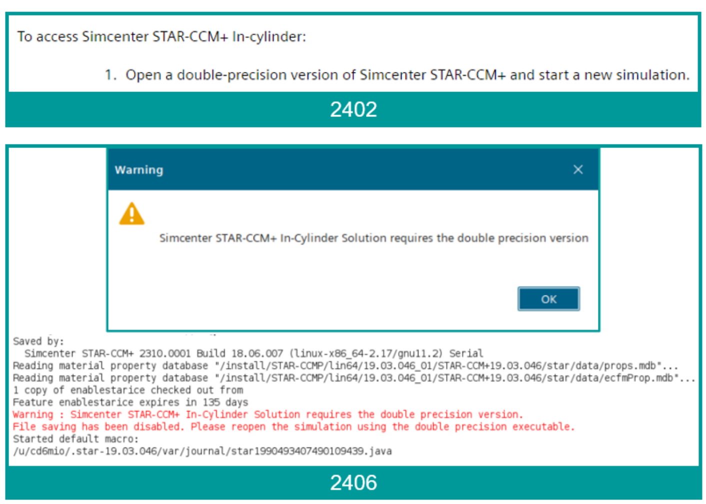


Application Specific Tools

In-cylinder solution

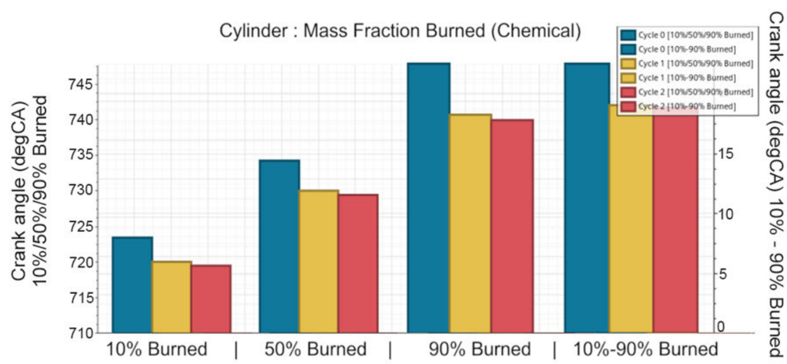
- **Support of parts that are not morphed**
  - Significantly reduce turnaround time thanks to domain parts excluded from the moving grid

        - Enables coupling of parts, which will be meshed static, not participating in the morph & map operation
        - Targets use cases for which motion is not involved, e.g. intake plenums, pre-chamber, fuel injectors
        - Makes use of separate mesh operations allowing for coarser meshing where resolution is not needed
    - Improved ease of use by streamlining an error-prone procedure
        - Simplifies specification of initial and boundary conditions for the static parts
        - 70% fewer clicks compared to the equivalent manual workflow
- **Turbulent flame quenching for ECFM**
    - Accurately model Turbulent Jet Ignition (TJI) with the ability to account for turbulent flame quenching in broken reaction zones
        - New expert property *Turbulent Quenching* available with ECFM combustion model
        - Possibility to choose *Internal* method where quenching is controlled by *Reaction Zone Thickness Multiplier* or *User Defined Turbulence Flame Quenching* for more detailed implementation e.g. Using Field Functions
- **Introduction of mixed precision version check**
    - Reduced opportunity for errors in simulation pipeline thanks to a new version usage check
        - Ensures that the double-precision version of the executables is used, essential for In-Cylinder Solution
        - Displays appropriate warning in pop-up window and simulation log
        - Avoids errors and divergences during the simulations
        - Does not check files saved with mixed-precision versions, at least once



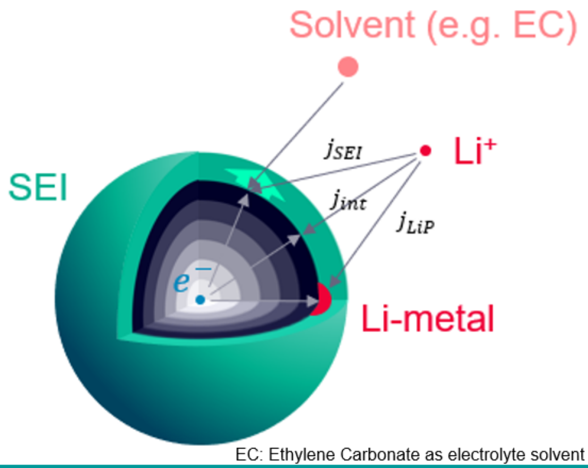
- **Cone Angle Sampling Polynomial Exponent in In-Cylinder injection panel**
    - Increased productivity thanks to model parameter available in the In-Cylinder user interface
        - Allows for customization of the spray plume generated by solid cone and hollow cone injectors
        - The exponent specifies the underlying polynomial used in the sample density of parcels
        - No longer required to resort to the main simulation tree to modify the underlying parameter
        - Increased value lead to spray plumes with distribution biased towards the centerline of the injector nozzles, while unity denotes a uniform distribution

- **Support of non-zero oxygen in initialization of Exhaust Gas Recirculation**
  - Greater fidelity via an improved specification of species composition with Specified Burn Rate model
    - Addresses the limitation of the model with regard to a zero oxygen requirement in Exhaust Gas Recirculation
    - Enables automatic specification for all species of Specified Burn Rate eliminating the need for manual adjustments
    - Ensures consistency across operating points and mixture characterization
- **Introduction of second axis in histogram plots of mass fraction burned and combustion duration**
  - Accelerate review of post-processing results thanks to an improved histogram plot
    - Complements the mass fraction burnt and combustion duration work, delivered in 2402
    - Plots the 10-90% combustion duration bars on a separate right Y-axis
    - Adopts a better range for the values of the left Y-axis, improving readability by amplifying differences between the bars reflecting mass fraction burned



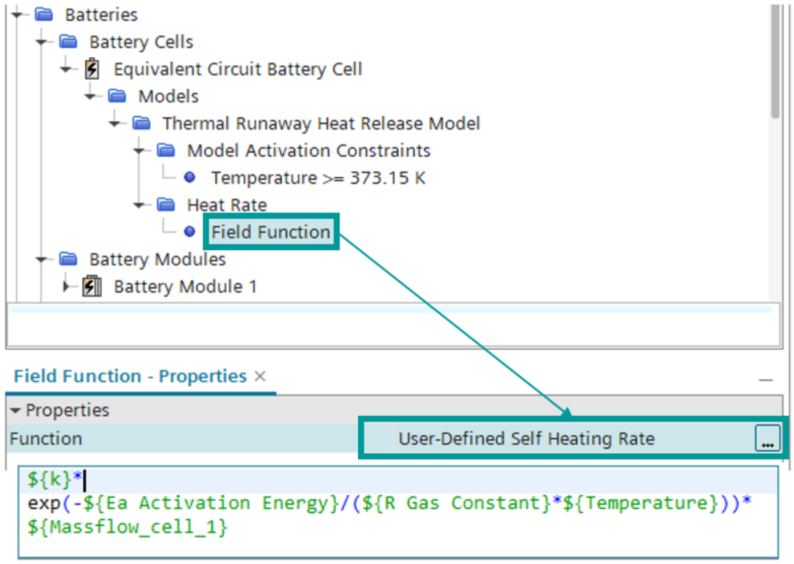
Batteries

- **3D Cell Design – Physics-based aging models**
  - Increased behavior fidelity with the "Sub-grid Particle Surface Film" model for cell degradation
    - Two main aging mechanisms:
      - Solid-Electrolyte Interphase (SEI) film growth
      - Lithium plating film growth
    - Helps in deducing cell capacity and impedance evolutions
    - Simulates local degradation evolution of the cell
      - Locate critical aging areas with dedicated field functions
  - All models were validated against experimental results as part of the EU Commission-funded project MODALIS (MODelling of Advanced LI Storage Systems)



An active material particle sketch with surface film growth for SEI and Lithium plating

- **Cell thermal runaway -Solid phase time-varying porosity**
    - Improved fidelity in cell solid material combustion in thermal runaway events with the time-varying porosity model
        - Handles porosity and solid volume fractions changes due to solid mass consumption/ production
        - Updates porosity and solid volume fractions internally via a dedicated solver
        - User-defined initial conditions for porosity and solid volume fractions
        - Compatible with the Surface Chemistry model
- **Batteries thermal runaway – Additional cell self-heating definition options**
    - More flexibility and control for the user with two additional options for the self-heating definition
        - Local self-heating rate (Q) expressed with a user-defined field function
            - Evaluating local temperature field (3D T) and outputting local heat generation field
        - Local self-heating rate expressed with a table of the cell's heat as a function of the cell's local temperature (Q(3D T))
    - Great productivity improvement with a single self-heating rate expression to deploy to all cells in battery pack



- **Remove constraint with Circuit Model being selected for Thermal Runaway simulation**
  - Simplifies the setup for pack thermal runaway simulations by removing the unnecessary Circuit Model
- **Enhance Copy/Paste feature for User Defined Battery Cell object**
  - Improved productivity with enhanced Copy/Paste capabilities
    - User Defined Battery Cell object can be copied and pasted within simulation file and across simulation files including properties, conditional models and constraints

E-Machines

- **Higher Order Finite Element Electromagnetic solver**
  - Improved accuracy, reduced mesh count and reduced time to solution in e-machine electromagnetics simulations thanks to the introduction of higher order FE methods
  - More details under Physics > Electromagnetics and Electrochemistry > Electromagnetics
- **Direct oil cooling with LMP to MMP sub-grid phase interaction**
  - Reduced computational cost for oil sprayed e-machine cooling simulations thanks to the new LMP to MMP sub-grid phase interaction model
  - More details under Electromagnetics.

Turbomachinery

- **Turbo slicing: Support of blade sketches for radial blades**
  - Enhanced robustness for periodic faces calculation by using blade sketch profiles in radial configuration
    - For Radial and Radial Diffuser Blade Type
    - Both blade sketch profiles and leading/trailing guide curve sketch are required
    - Other input options are similar to the Blade Faces method

User Guide

- **User Guide**
  - Easier familiarization with Signal Processing through enhanced documentation
    - User guide now enriched with easy to understand content from Simcenter Testlab
- **New Tutorials**
  - Electromagnetism
    - Higher Order Magnetic Vector Potential: Axial Flux Motor
  - Multiphase Flow
    - Eulerian: Aeration Tank Degassing — replaces the previous "Eulerian: Degassing Boundary" tutorial.
    - Eulerian: Mixture Settling — new tutorial that simulates a multi-step separator. Replaces the previous "Eulerian: Mixture Settling" tutorial.
- **Retired Tutorials**
  - Multiphase Flow
    - Eulerian: Degassing Boundary
    - Eulerian: Mixture Settling
- **Modified Tutorials**
  - Conjugate Heat Transfer and Thermal Stress: Exhaust Manifold – updated with new workflow for running the simulation
  - Parts-Based Shells: Exhaust Pipe – updated to include workflow for multiple part shells
  - FSI Remeshing and Tessellated Geometry Parts Contact: Rubber Sleeve – updated to include contact gap visualization
  - Surrogates: Reliability of an Industrial Exhaust System – added an adaptive sampling study type to generate a better qualified surrogate
  - Pareto Optimization: Static Mixer – added a postprocessing dashboard
  - Pareto Optimization: 2D Airfoil Design – added a postprocessing dashboard
  - Abaqus File-Based Coupling: Exhaust Manifold, Abaqus Co-Simulation: Thermal Coupling, Abaqus Co-Simulation: Mechanical Coupling – revised to use Abaqus 2023
  - DFBI and AMR: Boat In Parameterized Waves – several improvements to setup
  - Photon Monte Carlo Radiation: Headlamp – extended to include volumetric radiation
  - Surface-to-Surface Radiation: Thermal Insulator – updated with new workflow
  - Multiband Surface-to-Surface Radiation: Solar Collector – updated with new workflow
  - Eddy Break-Up: Coal Combustion – updated with new workflow
  - Reacting Channels: Steam Methane Reforming – updated with new workflow
  - Uniflow Two-Stroke Engine – modified to reflect addition of plenums to in-cylinder model
  - Smooth-Particle Hydrodynamics (SPH): Gearbox Lubrication – updated to reflect changes in the SPH module

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