SIEMENS
Ingenuity for life
Version
2020.1
Siemens Digital Industries Software
Simcenter STAR-CCM+
New features and enhancements
Engineer Innovation
www.siemens.com/mdx

New Features and Enhancements in Simcenter STAR-CCM+ 2020.1

Realism

- Increase model sophistication
- Include all relevant physics
- Elevate confidence in results

Productivity

- Save engineering time
- Increase simulation throughput
- Improve hardware utilization

Exploration

- Explore more designs
- Gain analysis insight
- Accelerate design decisions

Continuity

- Implement best practices
- Enable enterprise collaboration
- Facilitate closed-loop design

Top new features and enhancements for this release are:

- Job Manager for Simulation Submission [1]
- Layout Views[1]
- CGNS auto-export model[1]
- New Parallel Polyhedral Mesher[1]
- Adaptive mesh refinement [1]
- Automatic Coupled Solver control[1]
- Airgap remeshing for full 3D FE EMAG
- ECFM-CLEH for In-Cylinder
- Field Histories [1]
- Collaborative Virtual Reality [1]

1 Posted on IdeaStorm
A total of 45 new features and enhancements from IdeaStorm in this version.

Enhancements to Simcenter STAR-CCM+ 2020.1 are presented by category:

Platform
CAD Integration
Geometry
Mesh
CAE Integration
Physics
Design Exploration
Data Analysis
Application Specific Tools
User Guide

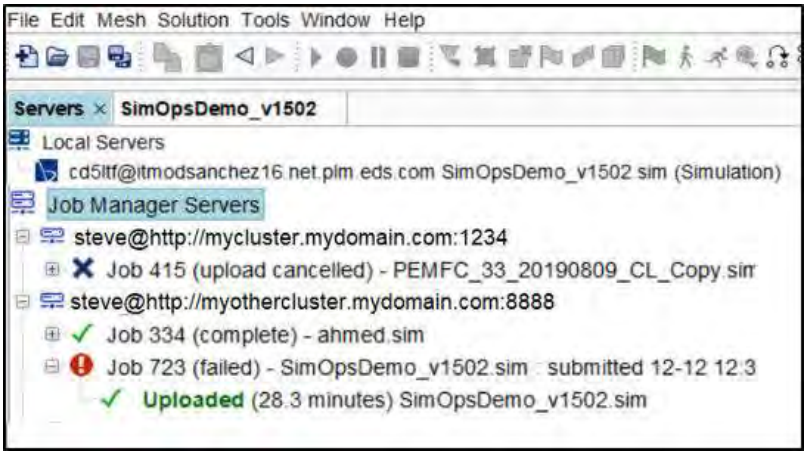
Platform

Deployment

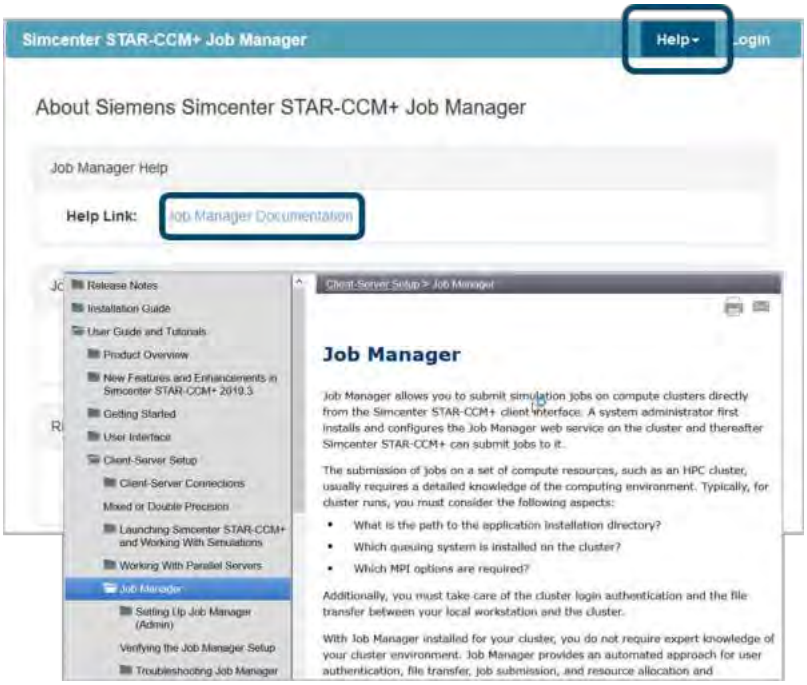
- Newly certified operating systems (OS)
  - CENTOS 8
  - openSUSE Leap 15.1
  - SLES 15.1
- Licensing update
  - Simcenter STAR-CCM+ is now compatible with Simcenter Flex credits

Runtime

- **Job Manager for simulation submissions**
  - Allows you to easily submit jobs to available compute resources
    - Leverage IT administration Job Manager set-up
  - Automatic job submission for Simcenter STAR-CCM+ simulations, complementing availability for Design Manager projects
    - Automatic and bi-directional file transfer
    - Easy management for remote servers
  - Monitor remote jobs with live access to output log within the Simcenter STAR-CCM+ user interface
  - After run completion, any artifact exported from the simulation during the execution (hardcopies, scene files, etc) can be downloaded to the local system automatically
  - Following a modification to the simulation, resubmit the job easily using the same submission set-up
  - Limitation: Initially, no support for Job Manager instances on HTTPS

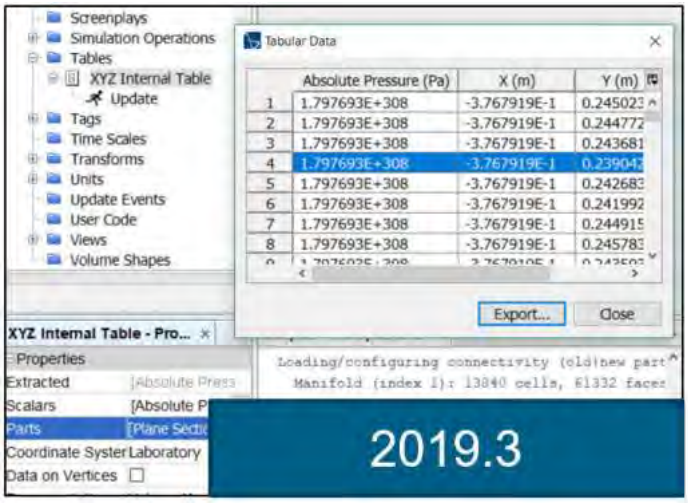


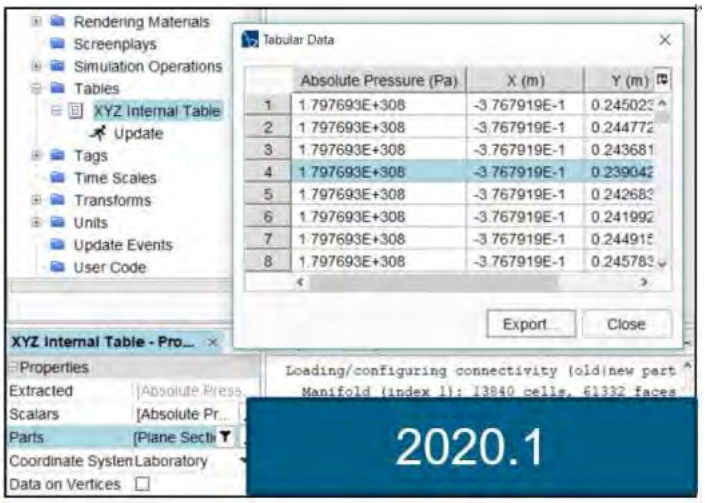
- Directly access Job Manager documentation from web interface



User Experience

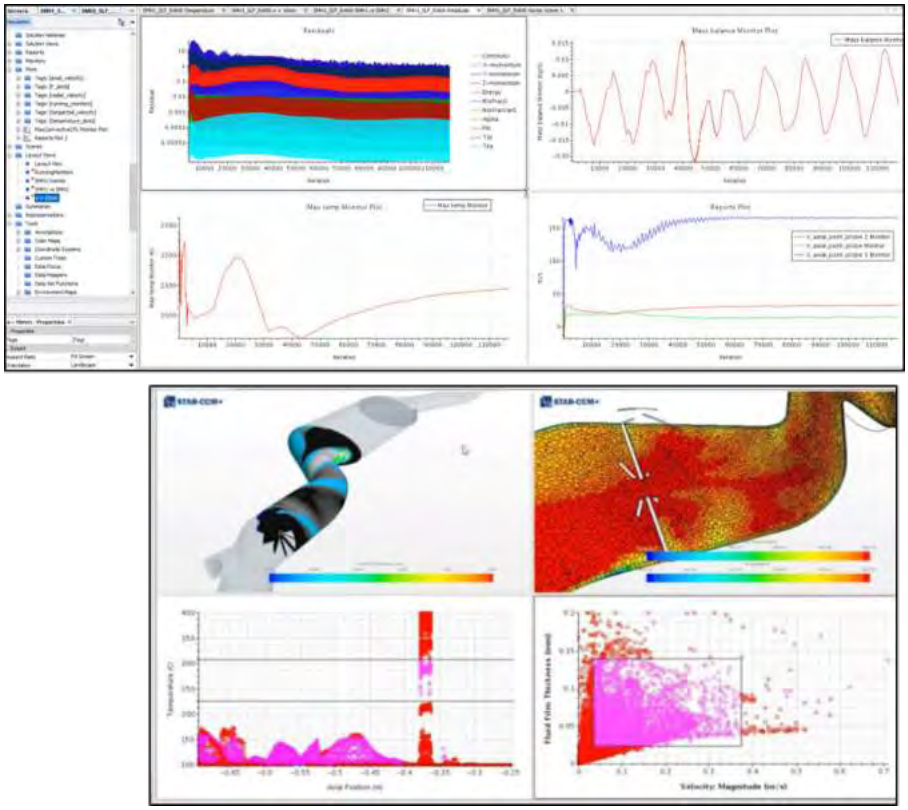
- **Siemens Digital Industries Software color theme**
  - Clear, common, and coherent user experience across products in Siemens Digital Industries Software portfolio
  - The color theme of the Simcenter STAR-CCM+ user interface is aligned with other products in the portfolio
    - The change is cosmetic and impacts colors such as those in the background, selection, or hover over items.
  - There are no default font or logo changes





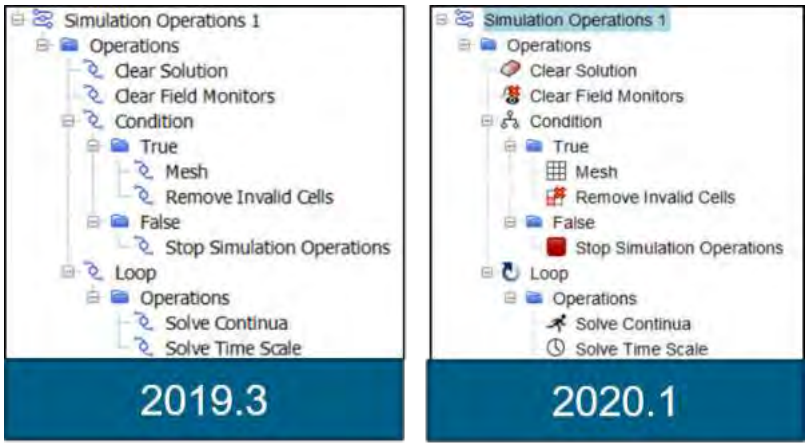
- **Layout Views D438, D1019, D4987, D5233**
  - Save time when composing dashboard-style views of scenes and plots
  - Ability to split the screen before adding view objects (for example: set up a 2x2 grid)

  - Arrange view objects such as:
    - Plots, Scenes
    - Design Manager: Snapshots, Plots
      - Does not currently support Design Tables



- Export hardcopy of the Layout View
- Support for scenes and plots across multiple simulations
- The existing capability to store and restore Layouts, under Tools, remains available, until further notice

- **Simulation Operations improvements**
  - Iconography for Operations
    - Identify the purpose of individual operations more easily with icons representative of the operation type



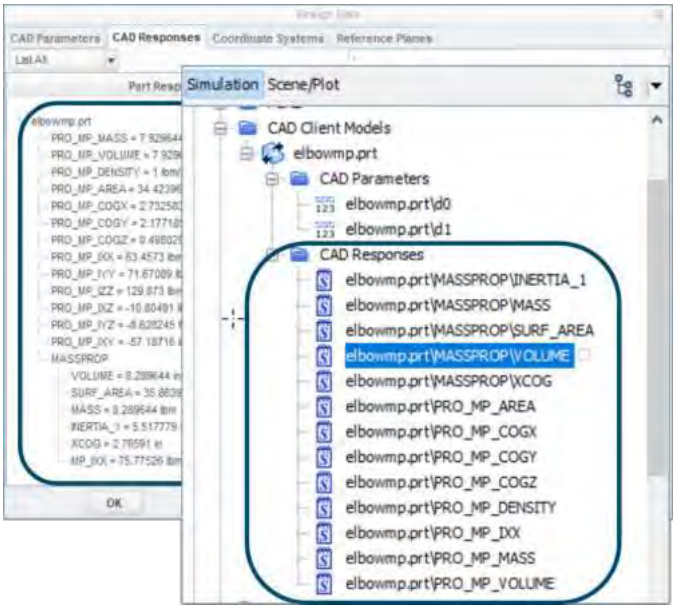
  - Map Data Operation **D3447**, **D5351**
    - New Map Data Operation triggers execution of selected Data Mappers
      - Simplifies set-up for mapping workflows, and is essential for use cases requiring mapping of data prior to first iteration
  - Mesh Operation interactive cancellation

        - When you interrupt the execution of a Simulation Operations sequence interactively, the Mesh Operation, if currently executing, will abort the mesh generation
- **Comments and Tags on System Field Functions**
    - Previously, Field Functions only accepted Comments and Tags on User Field Functions; support has now been extended to System Field Functions
        - Use Tags to link objects that do not group logically; use Comments to capture simulation knowledge
- **Writing efficient queries**
    - New User Guide section on 'writing efficient queries' for performance. Targeted for use in query-based selections and filters of large model simulations with many objects (for example, many CAD parts)
        - Filters group objects using logical rules
        - See *Considerations for Efficient Dynamic Queries* within "User Interface > Working with Simulation Objects > Using Query-Based Selection"
- **Set File parameter from command line**
    - The `-param` command-line option now supports File parameters
    - Change global parameter values without opening the GUI
        - Use the `.ini` input file to supply multiple parameter values at once
- **Parametric expressions for under-relaxation factors**
    - Under-relaxation factors for solvers can now be defined with Parameter values (more details in the Physics section)

CAD Integration

CAD-Clients

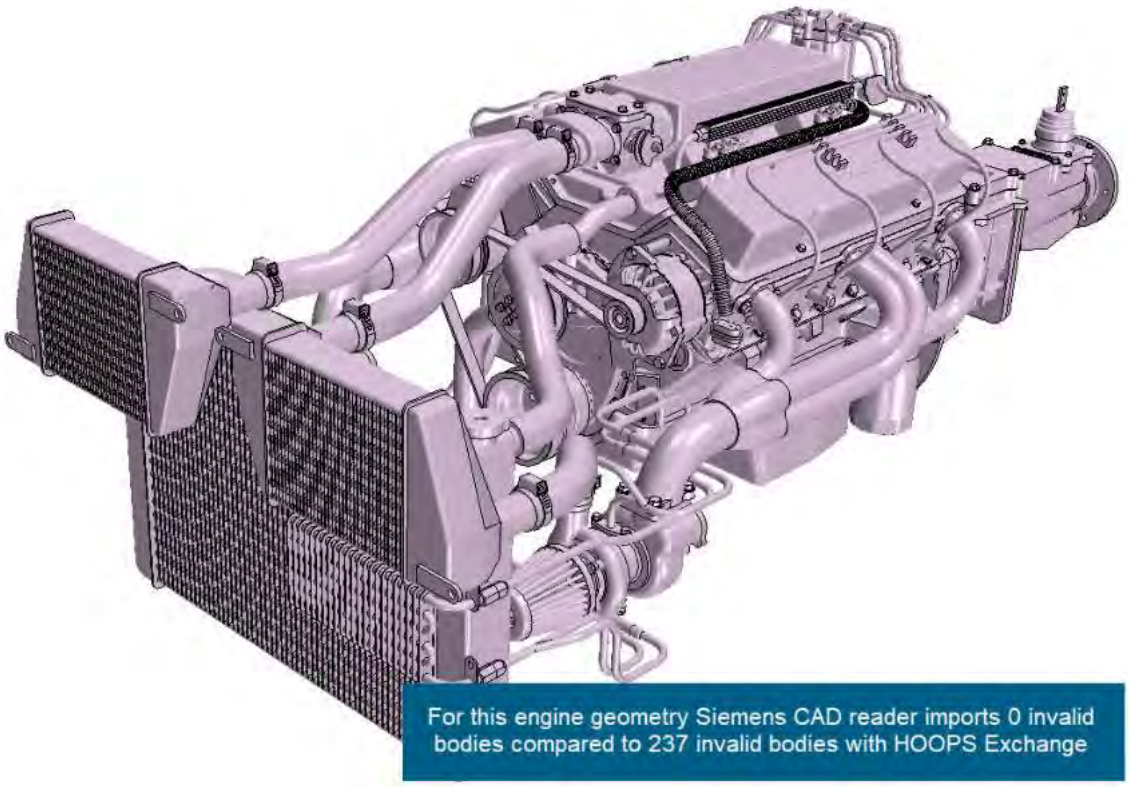
- **CAD Clients version upgrade**
    - Simcenter STAR-CCM+ Client for CATIA
        - Support for CATIA R29
    - Simcenter STAR-CCM+ Client for Inventor
        - Support for Inventor 2019
- **Creo mass properties import**
    - Greater automation capabilities with all Creo mass properties transfer under the CAD responses node



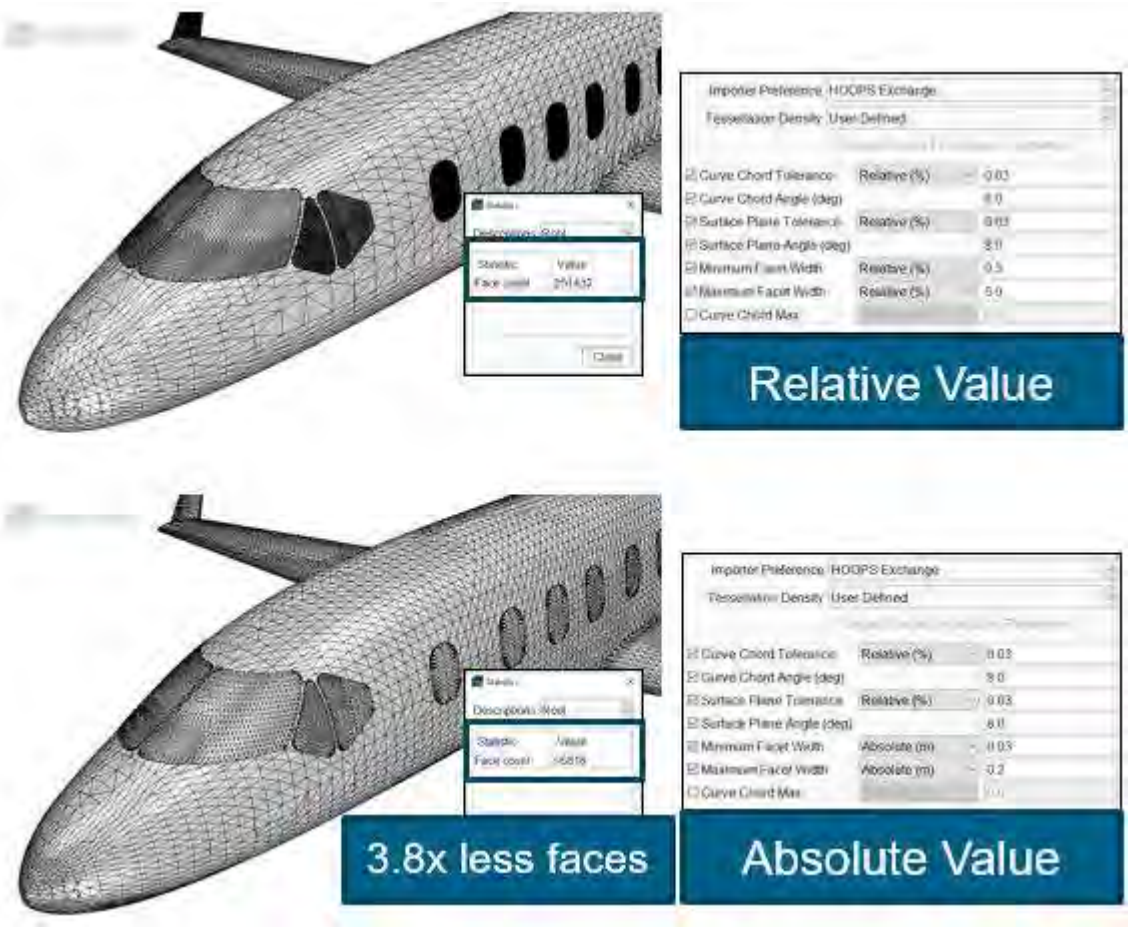
- **Important Note: Planned end of CAE Mode for CAD Clients**
  - The CAE mode for CAD Clients has been deprecated starting in Simcenter STAR-CCM+ 2020.1 and is planned to be removed in version 2021.1
  - Please contact your Simcenter customer support representative for further information

CAD-Exchange

- **Siemens CAD Reader**
  - Additional CAD reader from Siemens now available to import CAD models, "Siemens Translator"
    - Increased accuracy and robustness for CAD import seen in testing
    - Better alignment with NX releases with faster support of new versions
  - May be set as the default for all CAD imports or used on a case by case basis
    - Global option (Tools > Options > Import)
    - Local option in “Import Surface Option”
    - CAD format support
      - NX: Up to NX12 for Linux, NX1872 for Windows
      - JT: Up to 10.1
      - Solid Edge: Up to 2019 for Windows
        * No Linux support
      - CATIA V5: Up to V5-6 R2018 SP2 (R28)
      - STEP: Up to AP 203, AP 214, AP 242
  - CAD-Exchange license not needed for Siemens CAD Reader
  - Existing CAD Exchange reader remains default
    - Change in default may be considered in future releases



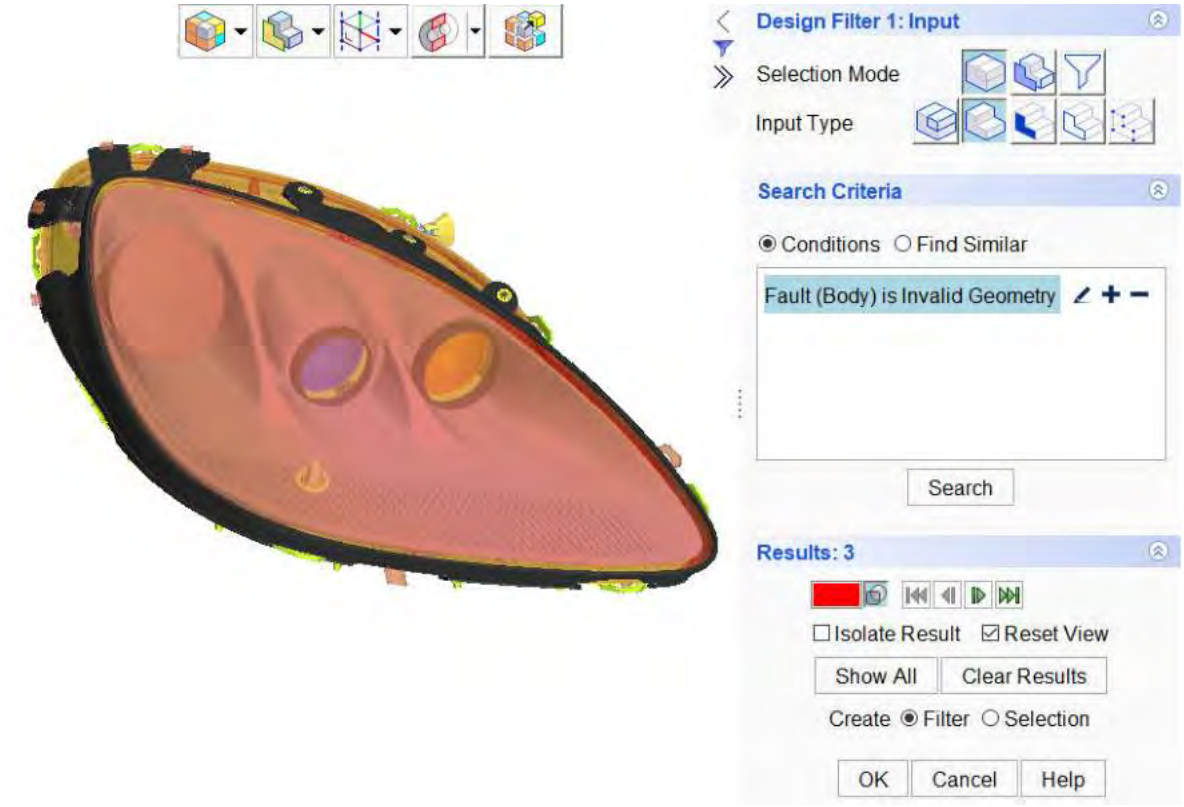
- **CAD Import upgrade for CAD Exchange**
  - Updated version support for CAD import
    - NX (V11.0 to NX 12.0, and 1847)
    - Parasolid (Up to v31.1)
    - Autodesk Inventor (Up to 2020)
    - SolidWorks (Up to 2019)
    - Creo - Pro/E (Upto Pro/E 19.0 to Creo 6.0)
    - CATIA V5 (Up to V5-6 R2019 (R29))
    - ACIS (Up to 2019)
- **Absolute Tessellation Value D3787**
  - Can reduce face count when importing geometry
  - Previously all import tessellation values specified relative to body size
    - Now absolute values can be used
      - Maintain the same minimum facet width for all parts
  - Relative continues to be default



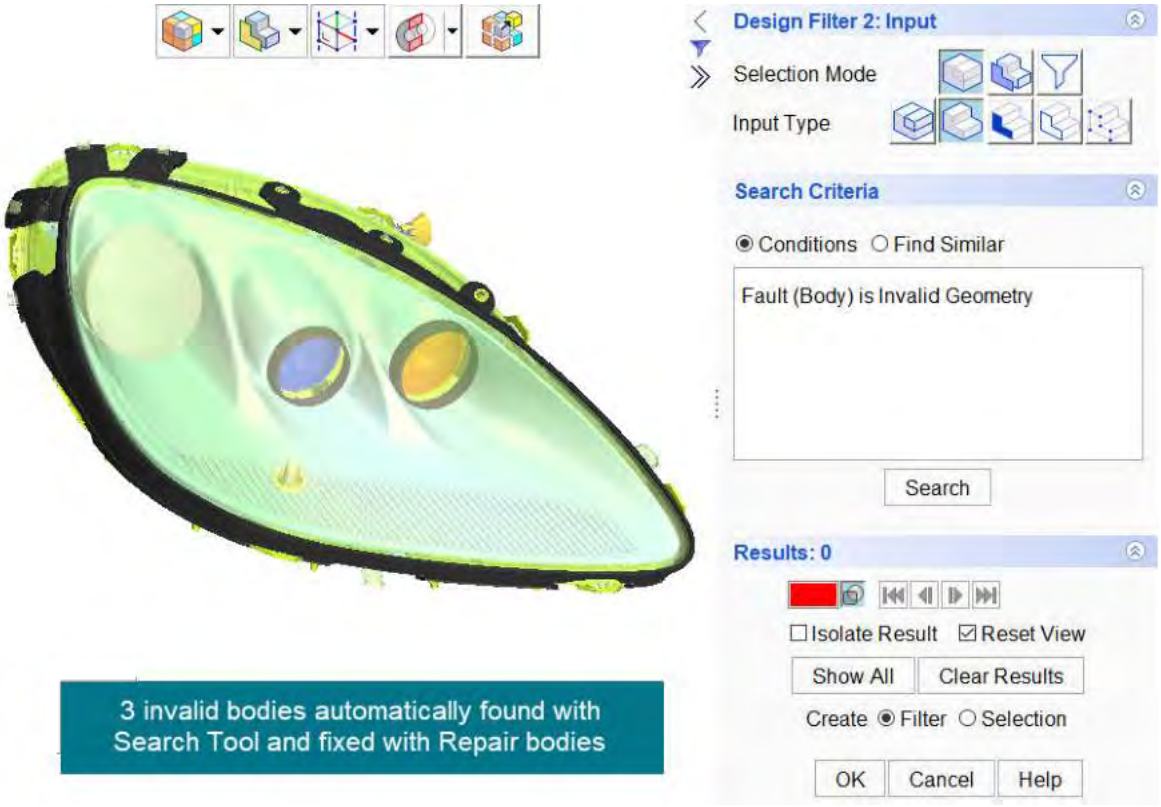
Geometry

3D-CAD

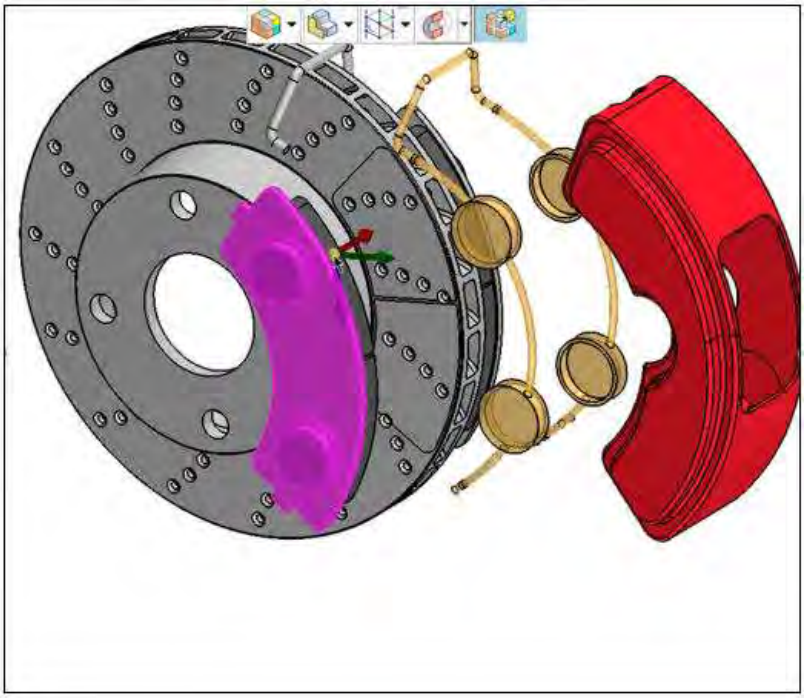
- **Search tool additions**
  - More easily navigate, prepare, and repair CAD models
  - New conditions to find Geometry faults
    - Invalid Geometry (Body, Face, Edge)
    - Invalid Facets
    - Missing Facets
  - Search Body, Face, Edge, and Vertex by name
  - Category lets you find
    - Free Edge



- **Repair Bodies & Faces**
  - Remove invalidities in the imported geometry
  - Better success rate for downstream operations like unite, sew, etc.
  - Two new Repair Tools
    - Repair Bodies, Repair Faces
  - Combine with Find Invalid Body/Face in Search Tool for efficient find and repair workflow



- **Search Tool – Isolate Result & Set Transparent**
  - Improved interaction with Search Tool results
  - Isolate a specific result, hiding all other entities
    - Control for transparency added
  - Especially useful for cases with two sets of results, such as clash or interference
  - Quickly swap color/transparency
- **Model Reimport D839, D5195**
  - Easily incorporate design changes in an existing simulation
    - Minimal user input to swap assembly
  - New right-click action, Model Reimport
    - Compare, review, and replace entire assembly
    - Review the results with side by side linked scene
    - All features in 3D-CAD are re-executed on updated assembly
- **Explode View**
  - Easily visualize and pick faces and bodies hidden inside an assembly
  - Drag a Body or Body group dynamically in the scene
    - Translation along the global direction
    - Any operations can be done when the model is in exploded view
    - Right click option “Explode View” to reset the view



- **Imprint Faces**
  - Flexibly imprint specific faces of two bodies
  - Improve performance by limiting imprint to selected faces of large bodies
  - Allows faces to be imprinted:
    - Between Faces of two Bodies
    - Between Face pairs from Filters
- **Radial repetition in Circular Pattern**
  - Extended parameterization capabilities for design studies
    - Possibility to repeat Circular Pattern in radial direction
      - Specify Number of Layers and Layer Spacing
- **Object Selector from panel D2857**
  - Better user experience selecting entity from tree to panel
    - New button to open Object Selector from panel
      - Object Selector docked between panel and scene
      - Only relevant entities displayed for selection
      - Body Group and Design Filter selection also supported in the panel
- **Geometry Property enhancement**
  - Geometry Properties now show minimum and maximum distance between two selected items (e.g., vertices, edges, faces, bodies)
- **Flatten operation**
  - "Delete Body Group" option is added to existing Flatten Operation
    - The Body Group on which the operation is executed will also be deleted
- **Fill Surface enhancement**
  - Allow Fill Surface to take combination of free edges and sketches (2D & 3D) from different bodies

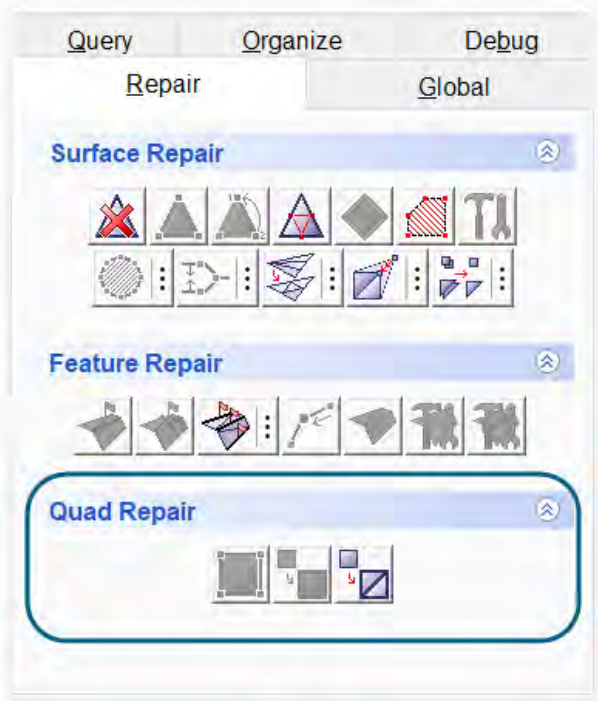
Parts

- **Delete Empty Parts**
  - New right click option to delete any empty parts in an assembly/composite
- **Transform operation—Create Output Part**
  - Retain the original part involved in a transform operation
    - No need to create a duplicate part ahead of transform operation
  - New Property “Create Output Part(s)”
    - Output of Transform operation will be a new part
    - The input part will remain in the original location
    - Off by default
    - Resulting part can be used in volume pattern operation
- **Local Surface Wrapping improvement**
  - Improved robustness for cases where the volume of interests are same in local and global wrap
    - More robust stitching of local to global wrapper when there is no drastic changes to the parts in local wrapping
  - Improved local surface wrapping algorithm
    - Several iterations of identifying clean perimeter edges for local wrap to stitch
      - March inward or outward to find a clean perimeter
  - Extract Surface Mesh
    - For a geometry part, allows you to extract the surface mesh from the volume mesh and assign it to an existing description
    - Avoids need to export the surface mesh and import it manually to parts

Mesh

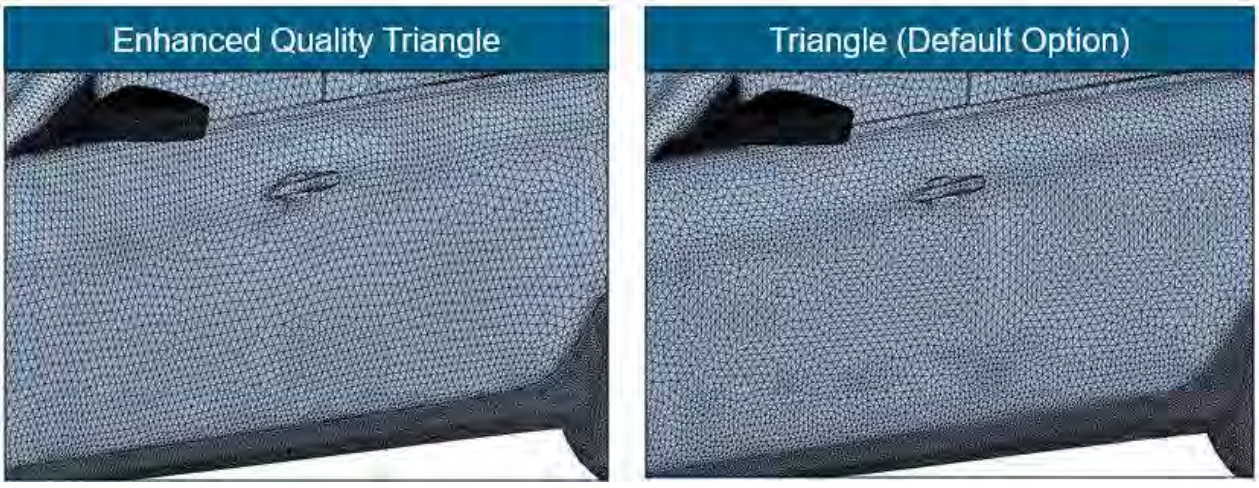
Surface Repair

- **Quad repair**
  - Create, fix, or improve quad surface mesh
  - Workflow similar to triangle surfaces
  - Surface Repair tool is made quad-aware by updating:
    - Repair, Global, Query & Organize tools
    - Interaction in the scene with quad surface
    - Surface & Feature Diagnostics
    - Search tool



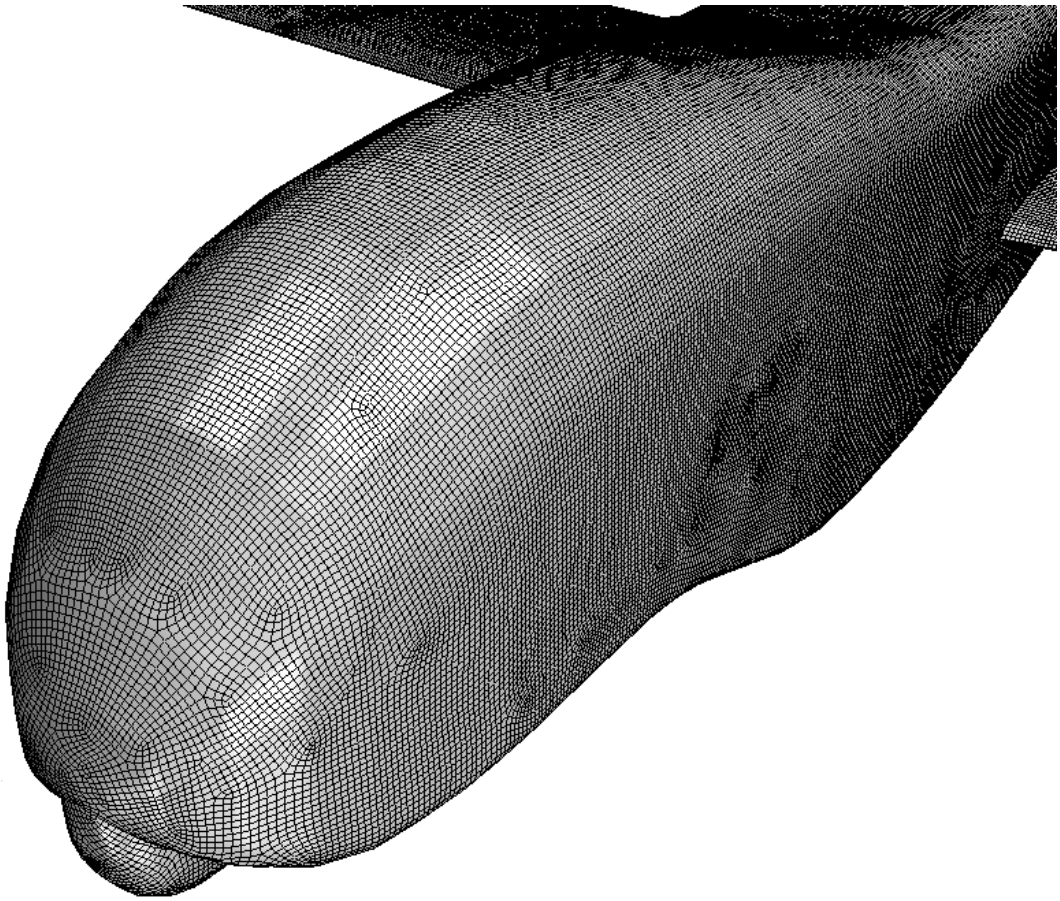
Surface Mesh

- **Enhanced Quality Triangle Remesher**
  - Higher-quality surface meshes
    - Face size closer to user specification
    - Improved curvature alignment, face quality, and geometry capture
  - New Meshing Method for Surface Remesher - "Enhanced Quality Triangle"
  - Depending on model, option will increase remesh time by 1.5 to 3x
    - Available as global and custom control



- **Quad Dominant Remesher**
  - Quad mesh for ALM can be created, repaired, and visualized before volume meshing
  - New Meshing Method for Surface Remesher - "Quad Dominant"
    - Automatically meshes surface with quads and triangles
    - Available as global and custom option

- Surface mesh with quads can be imported in dbs file format

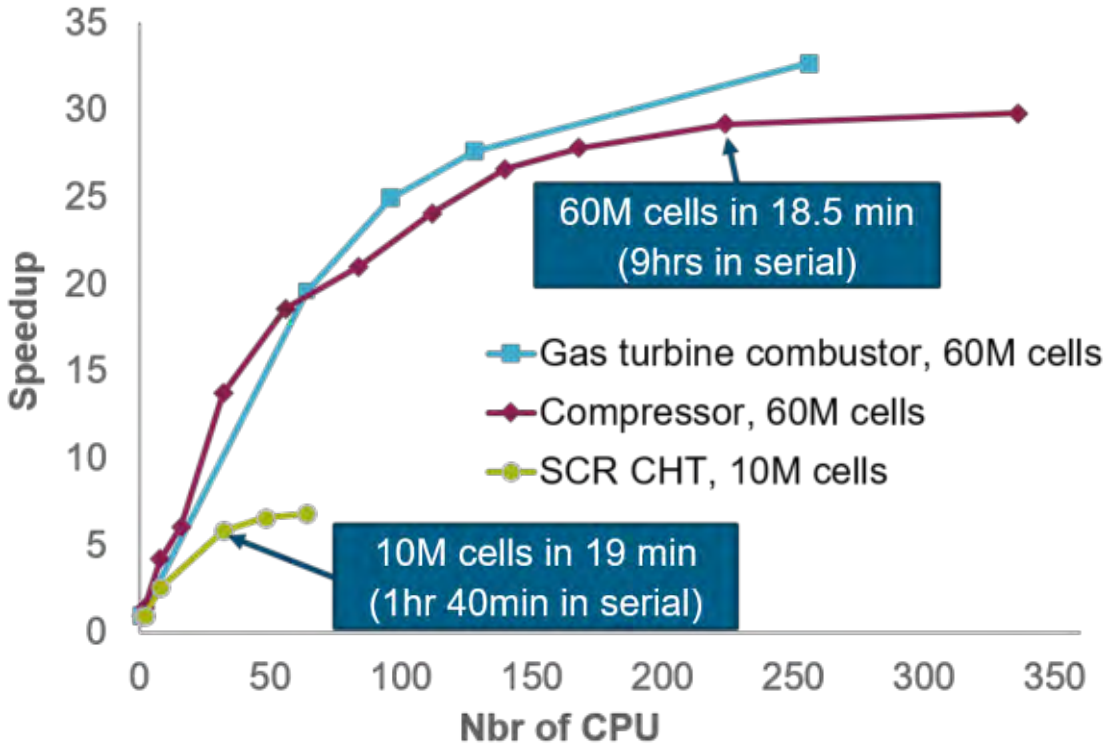


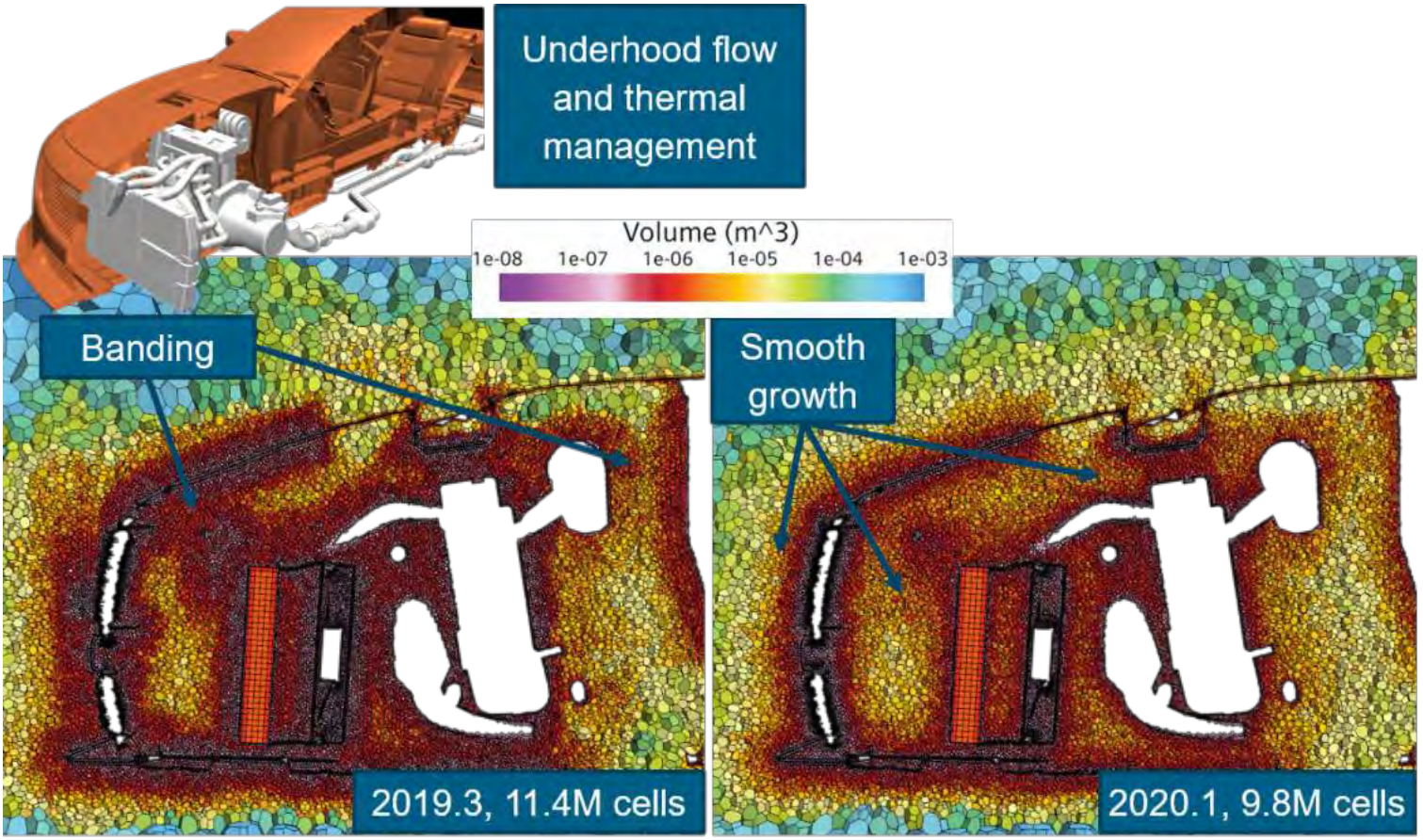
Volume Mesh

- **New Parallel Polyhedral and Tetrahedral Mesher D2617, D3324**
  - Tetrahedral and Polyhedral mesher rewritten to drastically improve scalability and resulting mesh quality
  - Improves scalability and parallel behavior compared to previous mesher
    - Scaling > 30x observed for 60M cell cases on 250+ cores; create 60M cells in less than 20 min.
    - Very similar mesh regardless of core count
      - Change in cell count typically < 0.1%
  - Undesired artifacts removed
    - Previously lines could be produced where mesher divided the mesh generation on different cores
    - Previously a band of small cells was often created between close surfaces with small surface cell area
  - Cell growth is smoothed from surfaces and refinements as well as between volume refinements
  - Previously cells in volume refinements were semi-structured; now the mesh in these zones is distributed in a manner more consistent with the structure of the surrounding polyhedral mesh
  - Simplified user control
    - Previously mesh distribution was controlled by Mesh Density, Growth Factor, Volumetric Control Blending, and optionally Volume Growth Rate and Maximum Cell size
    - Now only Volume Growth Rate and Maximum Cell Size are used
      - Volume Growth Rate defines the growth from all boundaries and any types of refinement

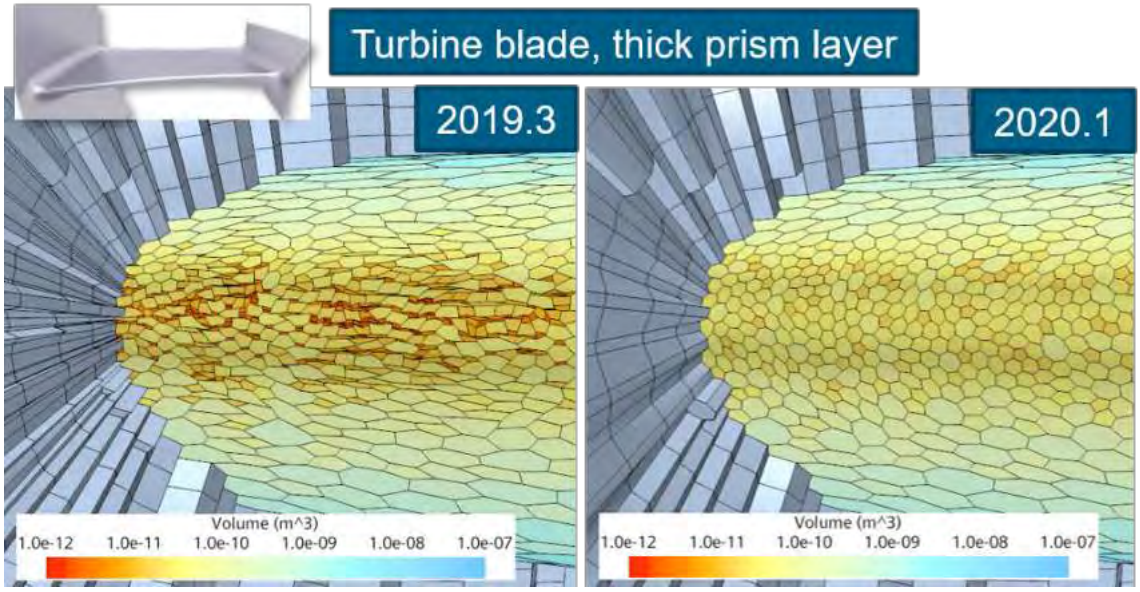
- Previously Volume Growth Rate had a cutoff at 1.2, preventing slower growth. Now a value below 1.2 is honored, and slower growth rates can be achieved
  * Note that in pre-existing simulations with a growth rate less than 1.2 this change may result in higher cell counts than before

◦ Important note: When remeshing using the polyhedral mesher in this version, you will get a different mesh than before. You may need to adjust your settings.





- **Automatic seaming in Directed Mesher**
  - Easier directed meshing of cylindrical discrete geometries
    - Previously feature curves had to be created along guide surfaces where such did not exist prior to directed meshing—for example, for imported surface meshes and wrapped geometries
    - Now feature curves are not required as the seam is automatically created
- **Improved prism layer quality**
  - Improved prism layer cell quality for polyhedral and tetrahedral meshes with thick prism layers on highly curved edges or with prism layers in narrow passages where proximity or compatibility refinement is not used
    - More even cell size distribution—fewer low quality cells



- **Less layer retraction in Advancing Layer Mesher**
  - Less prism layer cells deleted in concave corners when using Advancing Layer Mesher
- **Airgap remeshing solver**
  - New physics model "Airgap remeshing", for automatic remeshing of airgaps in electric machines
    - Executes airgap meshing operations before solver step to create updated conformal mesh
    - Only compatible with electromagnetism
    - See section Physics - Electromagnetism for further information

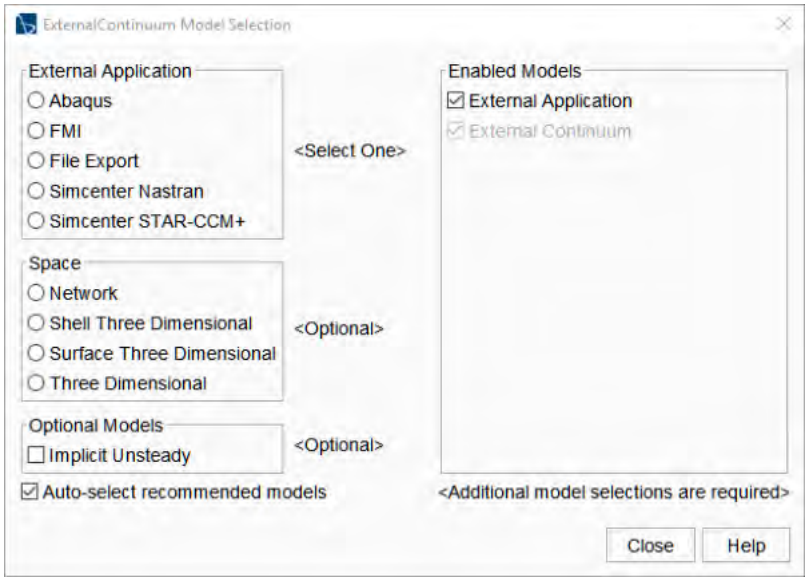
- **3D Meshing with batch for 2D in parallel D4282**
  - It is now possible to execute an Automated Mesh Operation for parts that are badged for 2D meshing in parallel
- **Mesh optimizer update**
  - Mesh optimizer has been updated to reduce the number of low volume change cells
- **Important Note: Planned End of Region-Based Meshing**
  - Region-based meshing has been deprecated starting in Simcenter STAR-CCM+ 2020.1 and is planned to be removed in version 2021.1
  - The recommended practice is to use parts-based meshing. See the section “Simcenter STAR-CCM+ > Pre-Processing > Meshing > Parts-Based Meshing” in the Simcenter STAR-CCM+ User Guide
  - Please contact your Simcenter customer support representative for further information

CAE Integration

- **Changes to supported third party versions for co-simulation**
  - Simcenter Amesim
    - Support added: 17 and 2019.1 (new recommended version)
    - Support continued: 16.1
    - No longer supported: 14.2 and 15.1
  - GT-SUITE
    - Support added: 2019 (new recommended version)
    - Support continued: 2017 and 2018

    - No longer supported: 2016
  - Abaqus
    - Support continued: 2016 and 2017 (recommended version)
    - No longer supported: 6.14

- **CGNS export in simulation tree D2682, D3432**
  - Improves flexibility and ease of use for one-way, loosely coupled co-simulations
  - CGNS export in the simulation tree addresses key requirements behind the two ideas mentioned above, and resolves the short comings of the AutoExport based workflow. It is now possible to:
    - Create multiple CGNS exports
    - Specify for each export the target file, fields, regions and/or boundaries (part based entities are currently not supported), export frequency and more
  - Provides far more flexibility than what was previously possible with the AutoExport based workflow
  - CGNS export in the simulation tree is enabled through the creation of a physics continuum with the following models:
    - External continuum
    - External Application
    - File Export
    - Surface Three Dimensional (for surface data) or Three Dimensional (for volume data)



- **Improved representation of FMUs in the simulation tree**
  - Improved readability & structure in the tree
  - Additional information displayed
- **Abaqus Co-Simulation support for coupled restart/remesh events**
  - In previous releases it was possible to restart a co-simulation and to remesh the fluid domain during a co-simulation run. However, it was not possible to restart and to remesh at the same time—this limitation has been removed.

Physics

CFD

Multiphase Flow
Computational Rheology
Computational Solid Mechanics
Electromagnetics and Electrochemistry
Aeroacoustics
Motion, Mesh Adaption, and Mapping

CFD

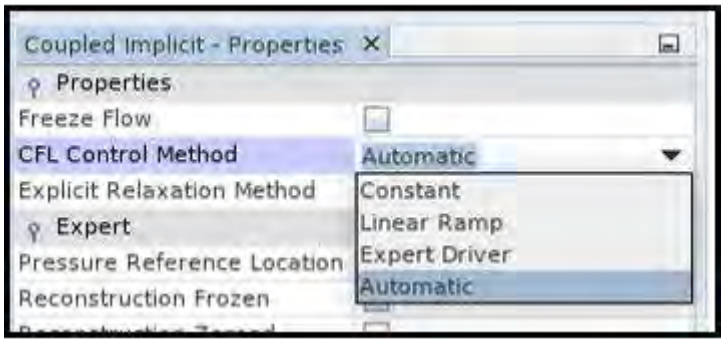
Flow

- **Automatic control for the Coupled Solver D5339, D5312**
  - Alternative to expert driver and the new recommended approach when using Coupled Solver
  - Improves ease-of-use with reduced number of settings and user decisions
    - No need for trial and error for finding optimal setup
  - Improves robustness by making the setup of cases less complicated
    - Cases run without additional user input
  - Default setup with automatic control converges faster than previous fine-tuned setup

	Runtime (mins)
Expert Driver	47
Automatic CFL and URF	35.8

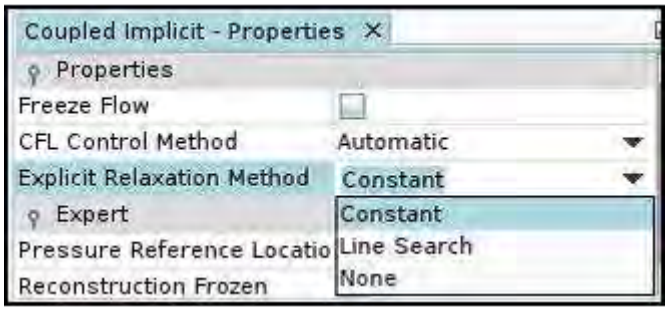
  - Automatic CFL and Explicit Under-relaxation controls
    - Driven by intelligent algorithm and line search
  - New layout: more concise and comprehensive
    - Two main settings
      - CFL Control Method, with 4 options: Constant, Linear Ramp, Expert driver and Automatic
        * The default is **Automatic** with **Target AMG** set to 4

          Improve performance by slightly increasing the Target AMG cycles



- Explicit relaxation Method (EUR), with 3 options: Constant, Line Search and None
  * The default is **Constant** with **EUR** set to 0.3

    Improve robustness by reducing the EUR

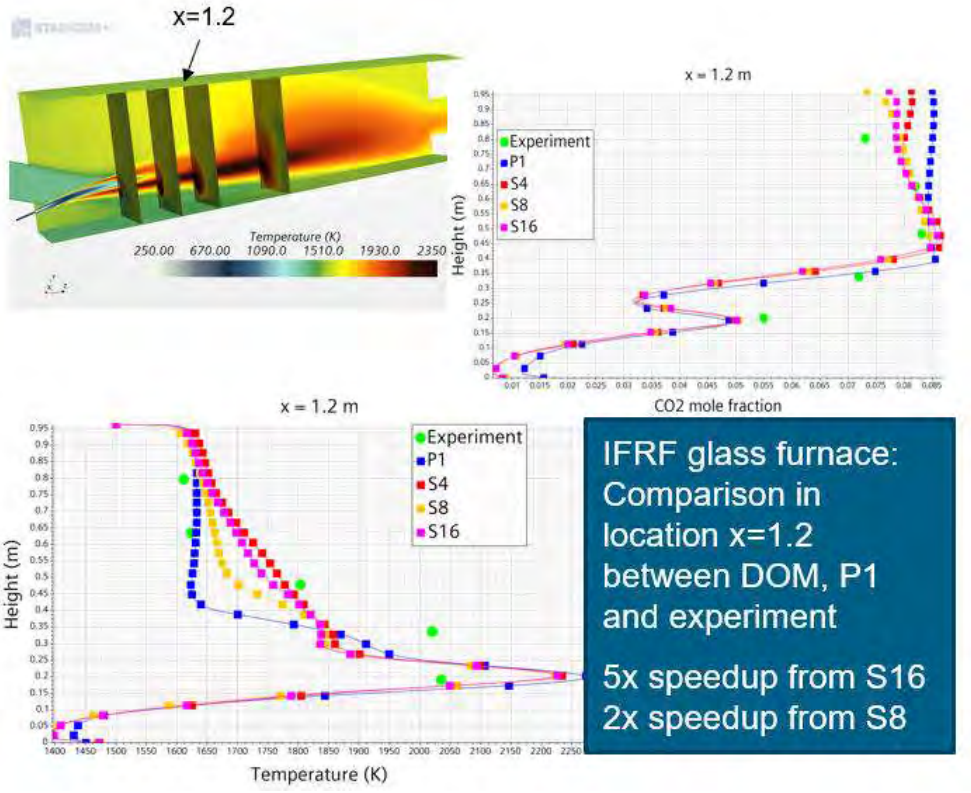


- **Global parameter for Under Relaxation Factors (URFs) D771**
  - Improves ease of use and automation through parameterized simulation setup
    - Reduces the need for Java scripts
  - Aids in improving robustness through Java free initialization with lower URF
  - Parameterized URF's can be used to
    - Improve convergence per time step
      - Start low for stability and increase to higher as time step gets smaller
    - Perform parametric studies on URF
      - In order to increase performance
- **Anisotropic Diffusion for passive scalar in porous media D736**
  - Improves physical realism for passive scalars in unresolved geometries (porous media) with anisotropy
    - Such as catalysts or fuel cells
  - Capability to define a passive scalar with anisotropic diffusion
    - Supports both Porous Region approach and Phasic Porous Media
- **PISO compatibility with Mixing planes**
  - Improves usability allowing for cases with mixing planes or blower interfaces to run with PISO
    - Improving the efficiency of the solution in cases with small timesteps
- **Pressure gradient stability for PISO**
  - Improves stability for segregated flows
    - Enable convergence in cases that were previously diverging
      - Reduces velocity spikes
  - Improved the PISO algorithm solution
    - Consistent Pressure and PPrime gradient calculation was made default for PISO simulations
  - Beneficial mainly for Internal Combustion Engine cases

- **Removal of Green Gauss gradient method**
  - The previously deprecated Green Gauss method has now been removed
    - The Hybrid Least Squares method still uses Green Gauss in the selected hybridization areas
- **Least Squares Quality with exact method**
  - Robustness improvement for gradient calculation
  - Improves accuracy for detection of "bad" cells
    - Remedied negative values of LSQ
    - Less cells required to be remediated
- **Improved binning algorithm for structured meshes**
  - Further improvements in the binning algorithm for structured meshes
    - Improve physical realism
  - Mainly beneficial for turbomachinery cases

Energy

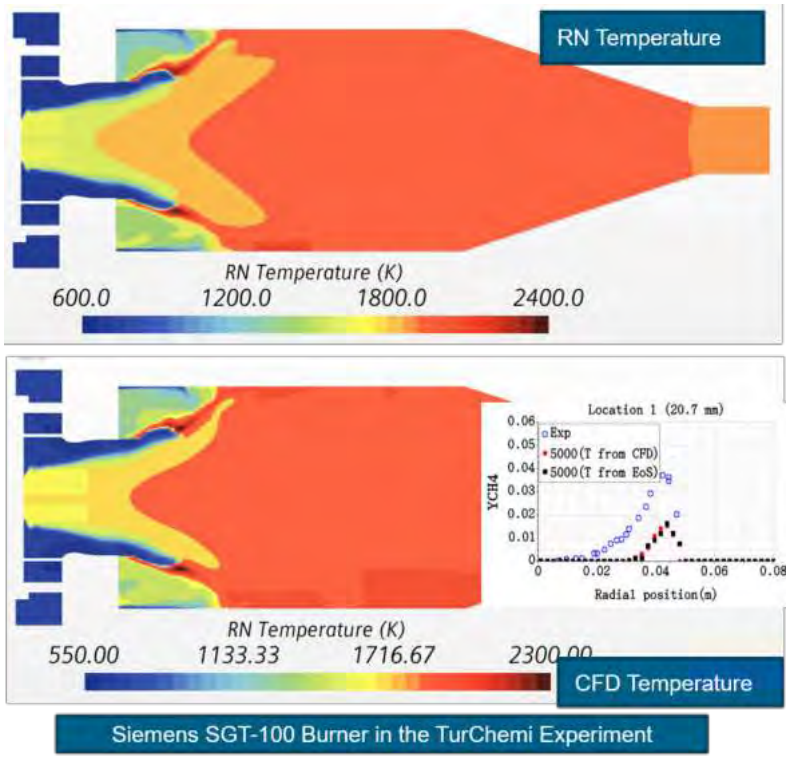
- **P1 participating media model**



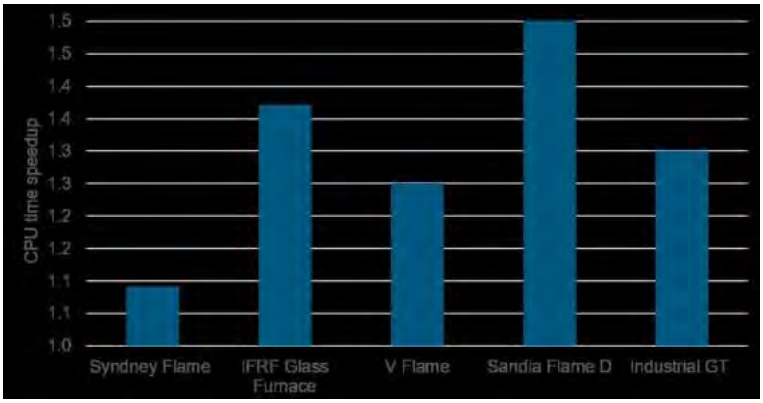
  - Reduced turnaround time with efficient approach for modeling rtadiation involving participating media
    - Up to 5x speedup compared to DOM S16
  - Facilitates usage of high-fidelity spectral models
    - Multi-band or k-distribution
  - Suitable also for circuit breakers, combustors, fires, IC engines
  - Good accuracy for cases with medium to high optical thickness
  - High accuracy for entire range of optical thickness if no wall is present (e.g. open flame) or wall emission is much smaller than medium emission
  - Does not model refraction

Reacting Flows

- **Flamelet models now compatible with Mixing Plane and Blower Interface types**
  - Improved Physical Realism
    - In order for Gas Turbine Combustion performance to be correctly predicted it is necessary to include some of the downstream components
    - This typically means including the guide vanes and first stage of the downstream Turbine using a mixing plane approach
    - Flamelet models can now be used in combination with mixing planes and blower type interfaces
- **Reactor Network modeling with new Energy Equation formulation**
  - Improved accuracy of emissions predictions when using the Reactor Network Model
    - A more accurate equation of state is used for each reactor in the Reactor Network model leading to correct calculation of the chemical reaction terms



- **Complex Chemistry speed-up of 1.25-1.5x**
  - Quicker results with Complex Chemistry by tabulating thermal properties of reaction rates rather than wasting CPU cycles recalculating them
    - This is a behind the scenes update that has no accuracy penalty
- **ISSIM Spark Ignition for Complex Chemistry**
  - Improved physical realism with a new spark ignition model



        - Extremely accurate ignition model which includes an electric circuit model and flame kernel growth
        - This accounts for multi-spark ignition and the flame holder effect
- **Improvements to Surface Chemistry**
    - Improved accurate and fast surface chemistry solver
        - The underlying ODE solver used to calculate the surface chemistry has been enhanced to improve robustness, speed, and efficiency
            - Should the new ODE solver fail the old solver is automatically reverted to
            - This is a behind the scenes update with no user changes required
    - Improved physical realism with Global Surface Chemistry formulations
        - Surface chemistry reactions of the type 'Langmuir Hinshelwood' are now supported
        - By activating the Langmuir-Hinshelwood option the coefficients for these reaction formulations can be added as a surface mechanism
    - Improved physical realism with Reaction Diffusion balance for Surface Chemistry Reactions media in porous media
        - Reaction Diffusion Flux Limiting Option prevents over-estimation of reaction rates
        - When this option is enabled the minimum of the diffusion rate and the reaction rate is used to calculate the surface reaction rate
- **Accurate Volume of Fluid Interphase reactions**
    - Improved physical realism with new interphase reaction model formulation
        - Automated prevention of interface smearing when using interphase reactions in a VOF simulation
        - Interphase reactions are restricted to the interface of the two materials

Turbulence

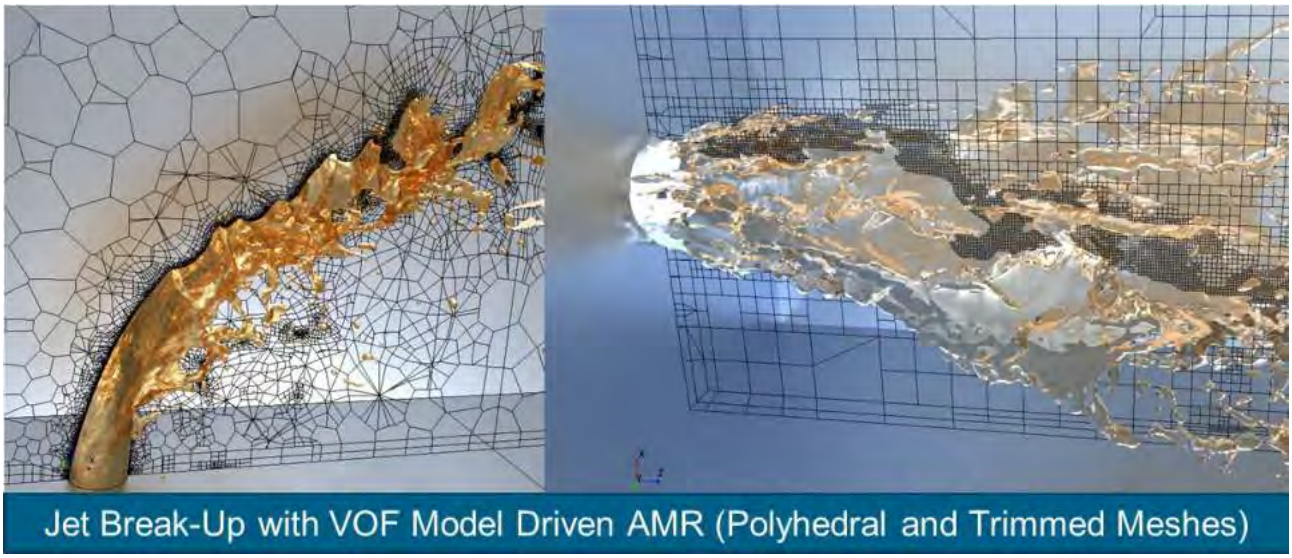
- **Modified formulation for the near-wall specific dissipation rate**
    - Reduces mesh sensitivity for meshes with first cell in buffer layer
    - Improves solution accuracy through improved wall treatment
- **Compatibility between Conservative Mappers and LES**
    - LES was previously incompatible with Conservative Mappers
    - To enable ICE applications especially, these models have now been made compatible

Multiphase Flow

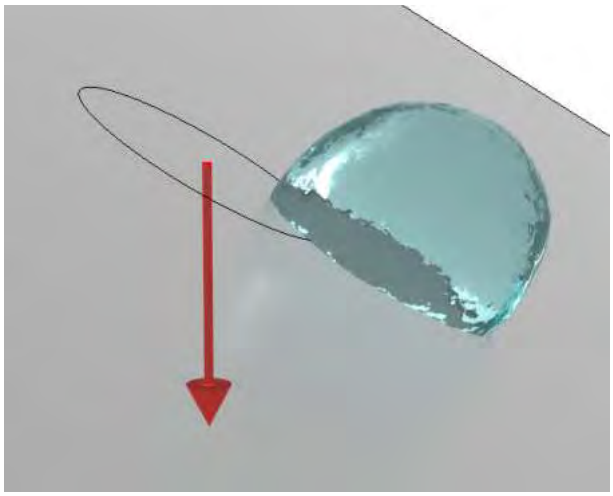
Volume of Fluid (VOF)

- **Model based refinement for Adaptive Mesh Refinement (AMR) D472,D4371**
    - Note: Please refer to the Motion, Mesh Adaptation, and Mapping section for information on adaptive mesh refinement
    - VOF free surface model based refinement
        - Provided in addition to standard field function driven refinement
        - Refines cells in front of interface direction of travel—prevents free surface entering into region of coarse mesh
        - Preserves sharp interface without refining indefinitely
    - Reduced computational expense
        - Reduces requirements for fine mesh except where required
        - Can be used alongside adaptive time-step, allowing refinement in space and time

- Complements hybrid multiphase approach
  - Refined mesh for VOF only where needed
  - In other regions, models such as Fluid Film and Lagrangian do not need such a fine mesh
- Improved ease of use
  - Reduces the need for user defined mesh distribution
  - Start with a coarse mesh, let the solver define mesh density
- Typical applications include tank sloshing, jet break-up, and vehicle water management



- **Contact angle hysteresis D3894**
  - Accurately model pinning of droplets using VOF
    - Allows droplets to remain stationary if forces such as gravity and aerodynamic forces insufficient to overcome surface tension by applying hysteresis effect
      - Calculates contact angle using current model such as Kistler for dynamic contact angle
      - Between advancing and receding contact angle;
        * Dirichlet boundary condition applied
      - Else;
        * Neumann boundary condition applied



  - Also beneficial to more accurately model rivulets where gravity or aerodynamic forces are non-parallel to the rivulet flow direction
    - In such examples the rivulet velocity normal to the rivulet flow direction can also become stationary as a result of hysteresis
  - Typical applications include water management on vehicles and in fuel cells
- **Interface Turbulence Damping (ITD) for K-Epsilon models D3328**
  - Improved accuracy where there is significant shear between phases
    - Prevents excessive momentum transfer between phases
    - Damps turbulence in the vicinity of the free surface for k-epsilon models

        - Allows for the presence of an unresolved boundary layer
    - Improved stability
        - Removal of spurious mixing and small timescales
    - Previously only available for the k-omega family of models
- **Evaporation/Condensation**
    - Under Relaxation Factor (URF) added to improve stability

Mixture Multiphase (MMP)

- **Evaporation/Condensation**
    - Under Relaxation Factor (URF) added to improve stability
    - Improved linearization for both Heat Transfer Limited and Diffusion Limited regimes

Eulerian Multiphase (EMP)

- **Fixed bins for A-MUSIG post processing D4607**
    - Allows users to post-process A-MUSIG size distributions in their own pre-defined bins
        - Improved ease of use without loss of functionality
        - A-MUSIG solver unchanged and continues to solve on adaptive bins
        - Enables easier comparison of results with other sources of data (experiment/other software)
        - Useful where populations of 'standard' sizes need to be assessed
    - Example applications include bubble columns and evaporators

- **Reference Pressure Location D1070, D4670**
    - Reference Pressure Location(s) now available for EMP
        - Previously only available for single phase and VOF/MMP
    - Improved stability
        - Avoids numerical issues when automatically positioned and calculated reference pressure placed at badly chosen arbitrary position
    - Improved ease of use
        - Anchor pressure consistently when running a set of design points
    - Benefits closed cases and simulations with no pressure boundaries
- **Lift Force Model**
    - Additional options for accounting for lift force in bubbly flow provide improved stability
    - Optional model for Lift Coefficient
        - Sugrue - Suitable for modeling turbulent bubbly flow
    - Optional model for Lift Correction
        - Podowski - Damps the lift force near the wall to zero

Fluid Film

- **Surface tension - default contact angle**
    - The default contact angle has been changed to 90 degrees (previously 0 degrees)
        - Represents a neutral value, neither hydrophobic or hydrophilic
        - The previous value represented a very hydrophilic contact and was not typical of most scenarios with surface tension
    - Improved ease of use
        - Default values represent a reasonable starting point for many applications

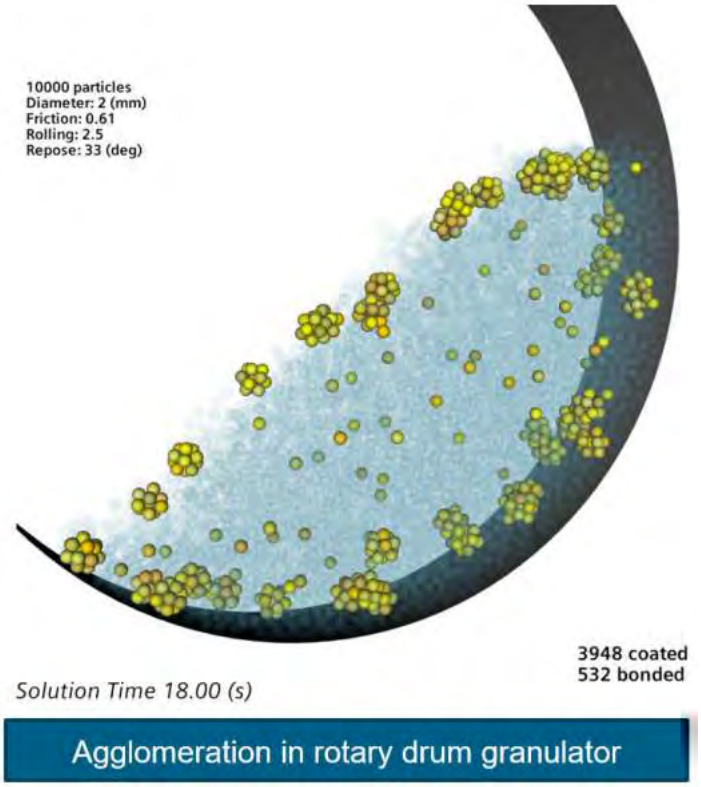
Lagrangian Multiphase (LMP)

- **Improvement of Impingement Heat Transfer model**
  - Improved accuracy in estimating impingement heat transfer for droplet bouncing off wall boundaries
  - Choice of method for estimating particle-wall contact time
    - Aiko (was available previously)
    - Birkhold
    - Field Function (user defined)
  - Accurate heat transfer prediction for wider range of material types for droplet and wall
    - Can account for the Leidenfrost effect
  - Typical applications include Selective Catalytic Reduction and ICE

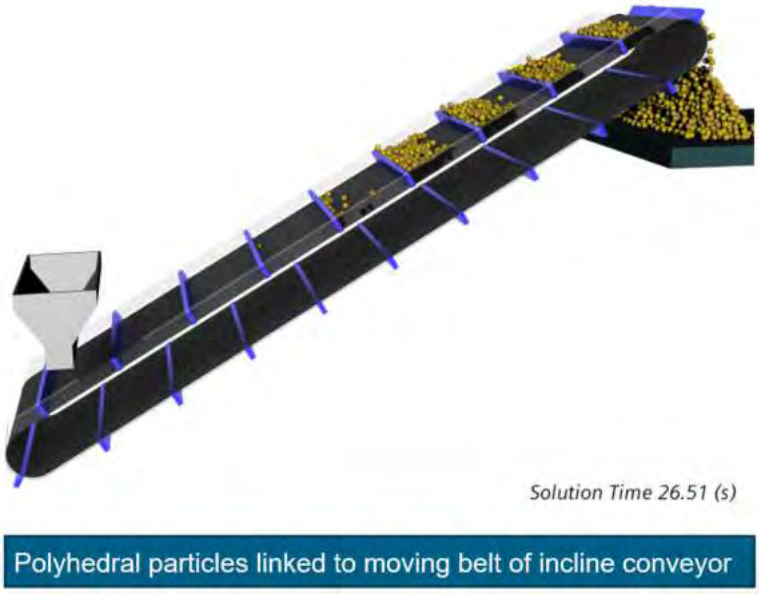
- **Injector reports D2298**
  - Improved accuracy in quantifying the design and simplified post-processing workflow
  - Injectors now can be an input to reports, plots, and scene displayers
  - Enables comprehensive statistical analysis of the injected particles and parcels for all types of injectors
    - Can provide information to be used for improving convergence and speed
  - Typical applications include fuel sprays, vehicle water management, cyclones

Discrete Element Method (DEM)

- **Cohesion dependence on passive scalars**
  - Improved accuracy and realism in modeling powder/tablet coating and mixing, and in powder granulator applications
  - Cohesion parameter can depend on properties of particles participating in collision
    - Including properties stored in Lagrangian passive scalars
  - Enables dynamic update of cohesion strength as a function of
    - Amount of coating / binding liquid deposited on colliding particle
    - Coating residence time
    - Coating thickening and drying time
    - User defined condition for forming strong permanent bonds



- **Improvements to Particle-Wall Link model**
  - Improved realism when simulating applications with particles attached to moving boundaries
    - Orientation of non-spherical particles is fixed relative to local surface normal
  - Compatibility of Particle-Wall Link model with DFBI
    - Improved accuracy and speed for DFBI-DEM applications
      - Excavator, dragline bucket, with bottom layer of particles linked to the wall accounting for “far field" boundary conditions
      - Ice sheet attached to channel boundaries in ice-breaking marine applications



Computational Rheology

- **Temperature limits for Viscous Energy Solver**
  - Improved stability
    - User can now specify temperature limits to avoid unphysical solutions developing during convergence
    - Two new reference values available:
      - Minimum Allowable Temperature
      - Maximum Allowable Temperature

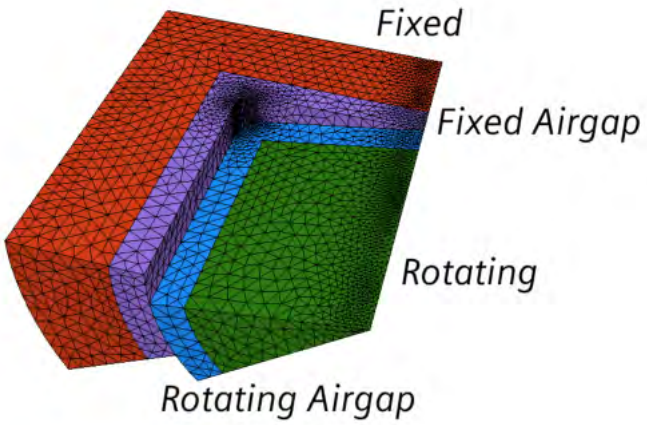
Computational Solid Mechanics

- **Vector field functions to define the principal axes of anisotropic materials**
  - Definition of the principal axes of anisotropic materials is no longer limited to a single coordinate system
    - Makes it possible to setup cases where the principal axes of an anisotropic material are following a curved geometry
    - Allows you to simulate a large range of cases involving anisotropic materials which could not be solved before
  - The principal axes are specified under the Physics Values node of a region
- **Support for activation/deactivation of physics continua**
  - Additional functionality has been added to support cases with multiple Finite Element regions belonging to multiple physics continua but being connected together through a conformal interface
  - Special treatment was required because the nodes/DOFs at the interface did not belong to just one physics continuum
- **Consistent area and volume calculation**
  - The Nonlinear Geometry model and the Solid Displacement motion are orthogonal models and one can be selected without the other
    - In previous releases this caused inconsistencies in the calculation of area and volume for cases where only one of the two models was active
  - This inconsistency has now been fixed
- **The input for segments now supports filters**

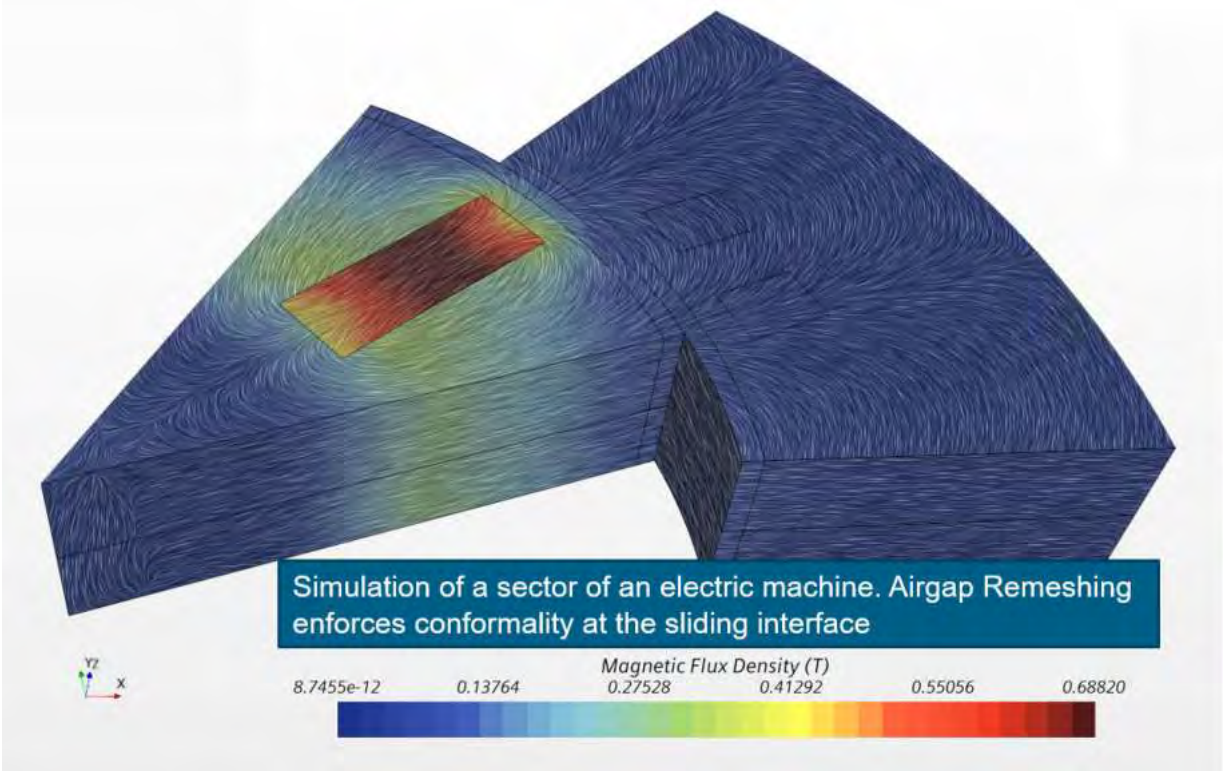
Electromagnetics and Electrochemistry

Electromagnetics

- **Airgap remeshing**
  - Allows simulations of cases where regions are in relative motion (e.g. stator and rotor of an electric machine) but solvers require conformal sliding interfaces at every timestep
    - Conformal interfaces are required by the FE Magnetic Vector Potential solver
    - Ensures that the conformality is kept at the sliding interface without having to remesh the entire domain each timestep
  - Enables full 3D simulation of electric machines
  - The geometry must be divided into four groups of parts:
    - (1) fixed parts, (2) rotating parts, (3) fixed airgap parts, (4) rotating airgap parts
    - (1) and (2) are meshed only once, (3) and (4) are remeshed at each timestep

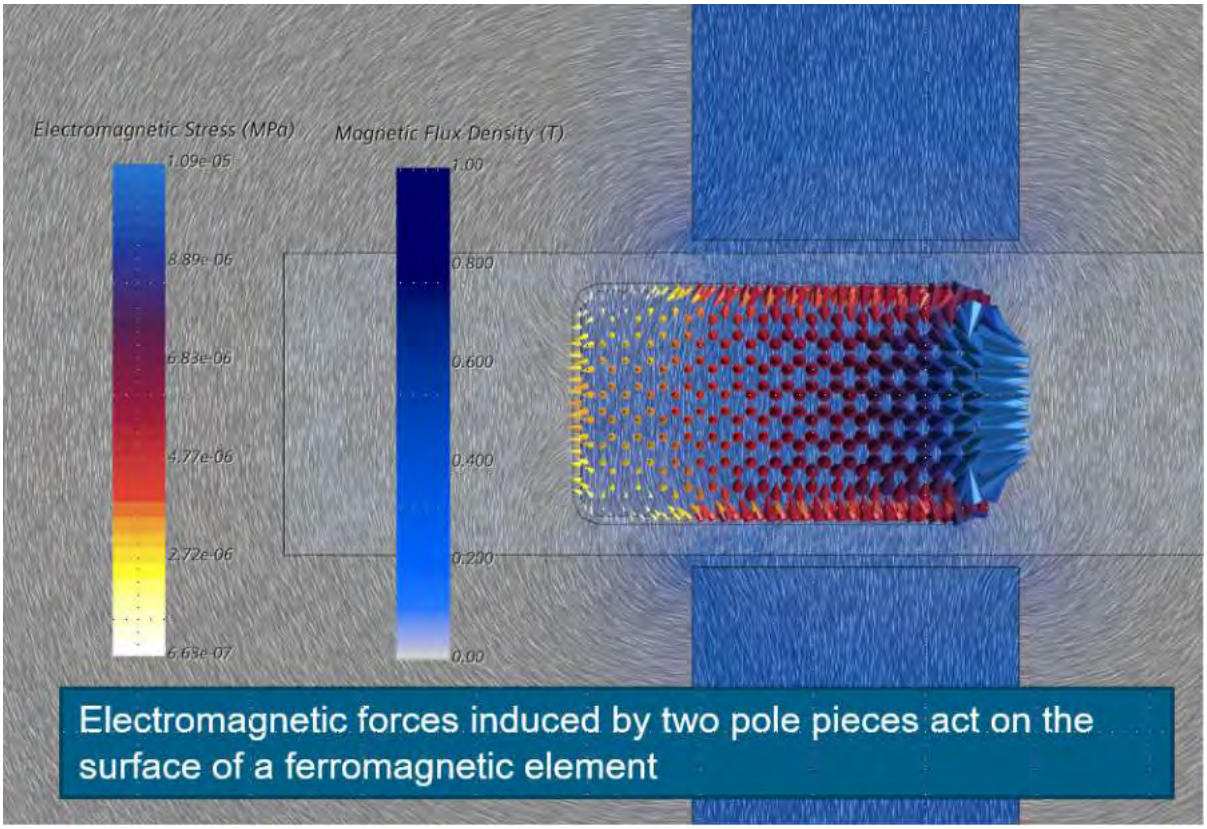


- The meshing pipeline must be divided into two portions:
  - A one-time meshing (for non-airgap regions) and Airgap Remeshing
  - The Airgap Remeshing operations involve 3 steps: (i) motion-based transform operation on the rotating airgap, (ii) imprinting the 2 airgap parts together, (iii) volume meshing the airgap

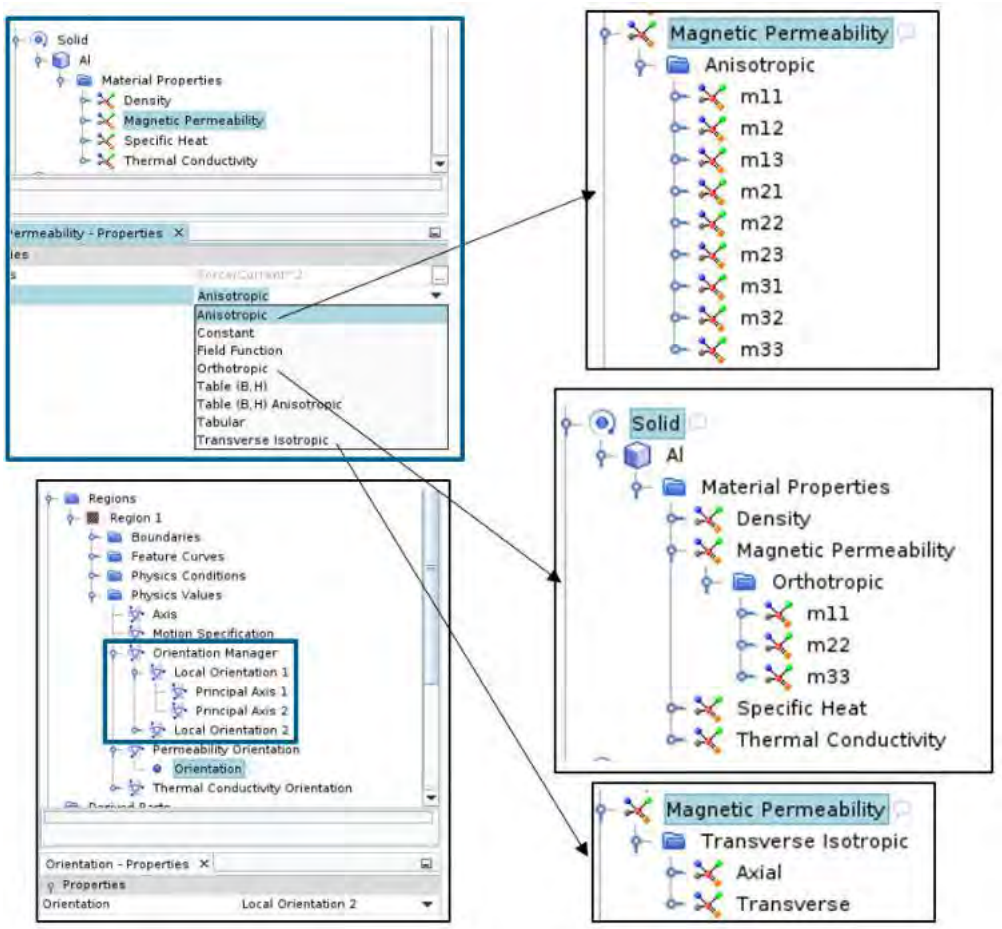


- **Transient Electromagnetics and DFBI motion**
  - Improves workflow
    - Simplifies the setup of transient cases where the induced electromagnetic forces drive a DFBI-type motion
    - Useful for simulations of electromagnetic valves, actuators, magnetic levitation devices, and electric machine star-up
  - Electromagnetic Force and Moment has been added to the list of forces in External Forces and Moments of a body in DFBI > 6-DOF Bodies.
    - If selected, the electromagnetic forces will contribute to the rigid body motion

- Accounts for DFBI motion (rotation and translation) into the calculation of the magnetic motion induced electromotive force
  - In previous versions the induced electromotive force was accounting for in Rigid Body Motions only



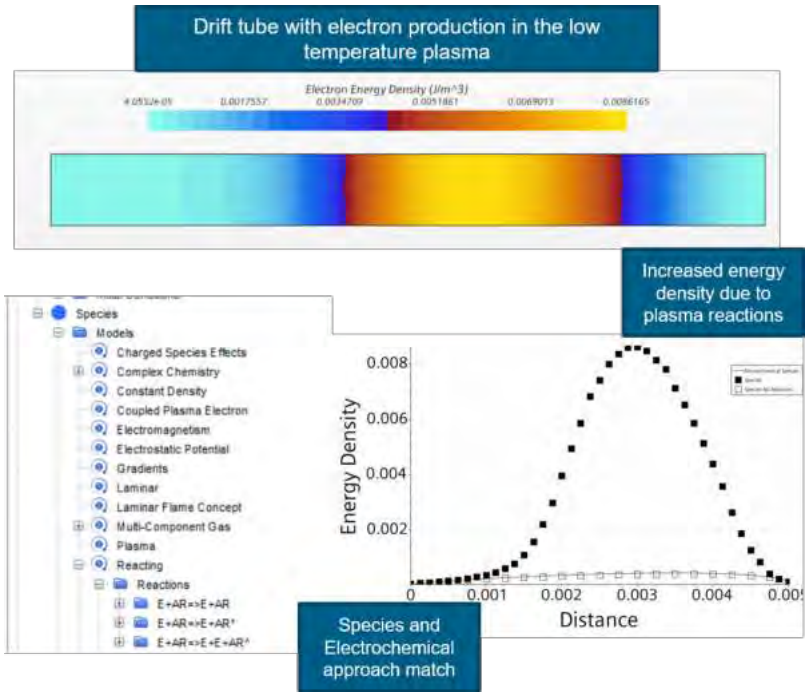
- **Specified Temperature (ST) model compatibility with FE Magnetic Vector Potential and Transverse Magnetic Potential models**
  - The ST model is now compatible with the FE Magnetic Vector Potential and the Transverse Magnetic Potential models
  - Improves ease of use in cases where the thermal problem does not need to be simulated
    - For example, when the timescale of the thermal problem is much larger than the EMAG one, or the electromagnetic solution does not affect the thermal problem
- **Orientation Manager for Anisotropic Methods**
  - Improves setup of cases with anisotropic electromagnetic material properties (that is, electrical permittivity, magnetic permeability, and electrical conductivity) especially with multi-part solids
    - Avoids repeated specification of orientation per tensor profile
    - Local orientation can be shared by all tensor profiles
    - Better naming of tensor profile methods (Anisotropic, Orthotropic, Transverse Isotropic)
  - Tensor components specified at physics continuum/material property level
  - Orientation specified at the region level via an orientation manager



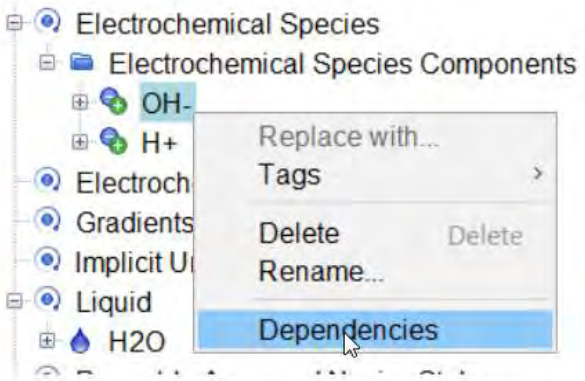
- **Support for Porous Baffle Interface in FE Magnetic Vector Potential model**
  - Improves workflow
    - Adds support for Porous Baffle Interface in the FE Magnetic Vector Potential model
    - Useful for simulations of low voltage circuit breakers where some components might be used for flow control and can be modeled as porous
- **Warning message in 3D Finite Volume Magnetic Vector Potential when a spatial variation or a jump in magnetic permeability is detected**
  - Improves User Experience
    - When using the FV Magnetic Vector Potential model, a warning message alerts the user if:
      - Magnetic permeability jumps across an interface by more than 10% or
      - Magnetic permeability across two adjacent regions is not a scalar, or is a space- or time-dependent scalar, or is specified by user-defined field functions
    - The warning suggests the use of the FE Magnetic Vector Potential model
- **Wall Option at Interface Boundaries when the other side has no FE Magnetic Vector Potential model**
  - Improves setup
    - Registers Wall Option at Contact Interfaces when on the other side no FE Magnetic Vector Potential model is selected
      - This allows the user to impose for instance Anti-symmetric BC for the FE Magnetic Vector Potential (as is already possible with the FV Magnetic Vector Potential model)
    - Previous versions of the code would not allow this, effectively imposing a symmetric condition on the FE Magnetic Vector Potential

Electrochemistry

- **Low temperature plasma with reacting flow**
  - Improved physical realism
    - Low Temperature plasmas can now be modeled successfully
    - This requires combining the following Physics models:
      - Plasma Reactions
      - Coupled Plasma Electron Model
      - Charged Species Effects
    - Specifically Charged Species Effects optional physics model has been added
      - This allows Segregated Species to carry a charge and experience the migration imposed by the Electric Field



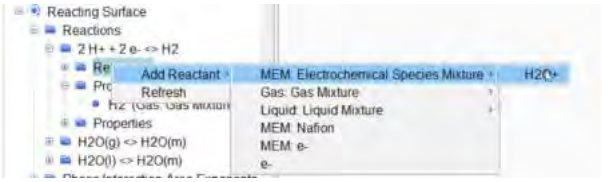
- **Dependency support for Electrochemical Species and Surface Reactions**
  - Improves User Experience
    - Electrochemical species now support the use of dependencies
    - This can be used to understand where a species is being used within the simulation tree to find out for example how many surface reactions it is being used with



- **Solid Ion concentration now accounted for at interfaces for Electrochemical Reactions**
  - Improves accuracy
    - In previous versions when calculating the Nernst Equilibrium potential (see below) the solid ion concentration was not taken into account when computing the product term
    - The product term now includes the solid ion concentration correctly

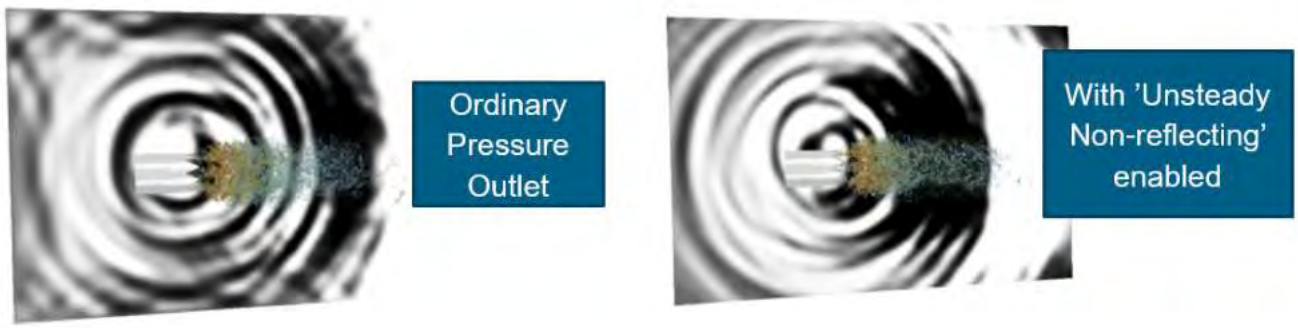
$$U_{eq} = E^0 - \frac{R_u T}{v_e F} \ln\left(\prod_i c_i^{v_i}\right)$$

- **Electrochemical Species now display the parent phase when being added to a Electrochemical Reaction**
  - Improves set-up
    - When adding a Electrochemical Species to a Electrochemical Reaction the parent phase is now displayed
    - This makes it easier to set up multi-phase, multi-reacting electrochemical problems such as in a PEMFC



Aeroacoustics

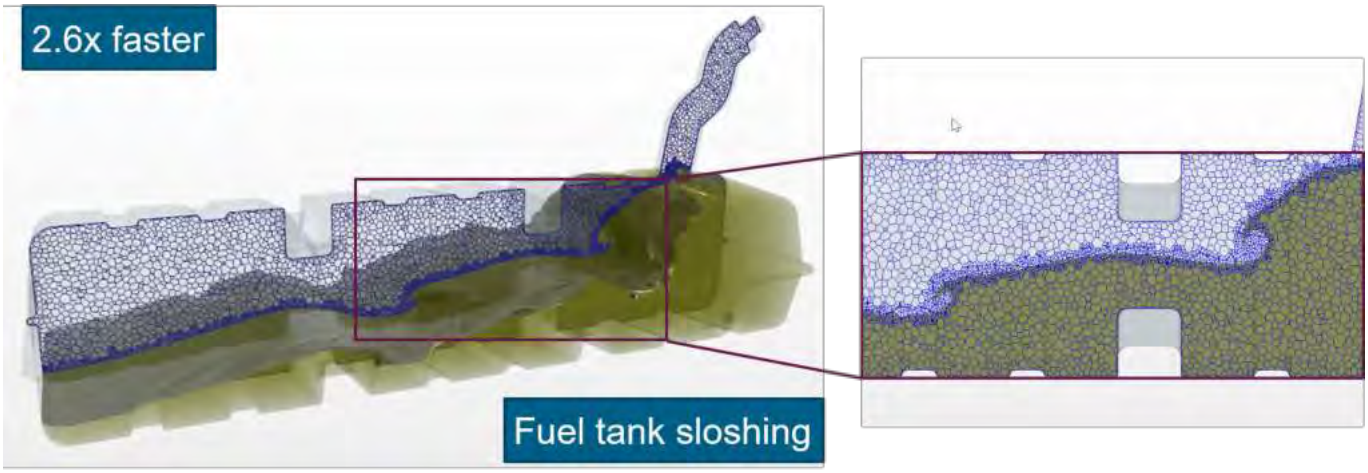
- **Non-reflecting pressure outlet boundary condition D590**
  - Improves solution quality by allowing acoustic waves to leave the computational domain without artificial reflections
    - Standard Pressure Outlet boundaries are fully reflective
  - The new 'Unsteady non-reflecting' option reduces acoustic reflections and prevents pressure drift



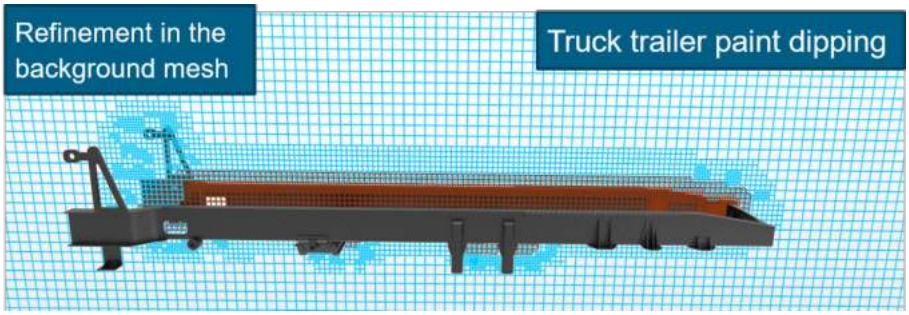
Motion, Mesh Adaption, and Mapping

- **Adaptive Mesh Refinement D472, D4562**
  - Solution based dynamic refinement and coarsening of mesh reduces computational expense while providing same accuracy as static mesh
    - Available for polyhedral and trimmed meshes

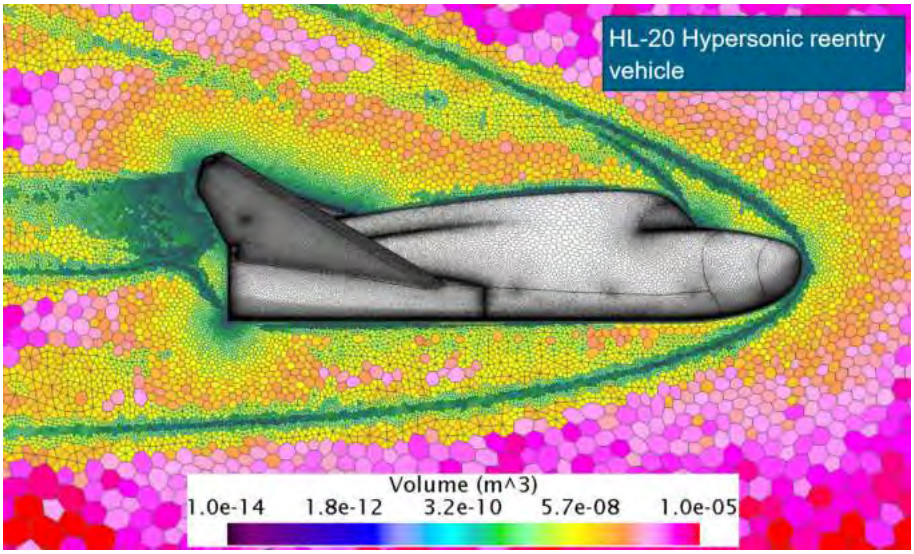
    - Support for steady and transient simulations
    - Automatic re-partitioning for parallel performance
- Cuts down manual meshing time by avoiding the need to know the flow solution in advance
- Mesh adaption criteria
    - A number of different refinement techniques are available including pre-defined model based criteria that make it easy for mesh adaption without having to create field functions of relevant scalar/vector fields
    - Model-based criteria for multiphase VOF refines the mesh based on the free surface



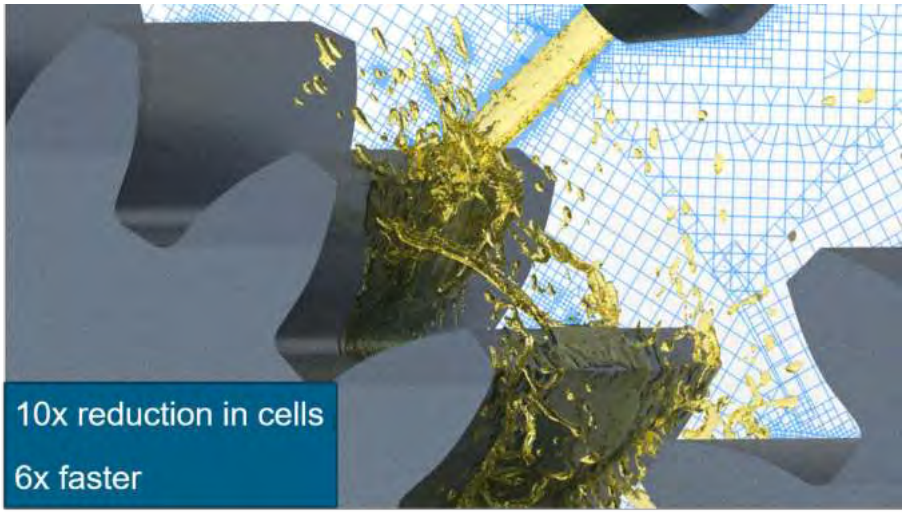
    - Model-based criteria for Overset meshes ensures that background and foreground meshes have compatible cell sizes



    - User-defined field functions. Examples: gradient of Mach number to capture a shock, Laplacian of total pressure to capture wake behind a vehicle



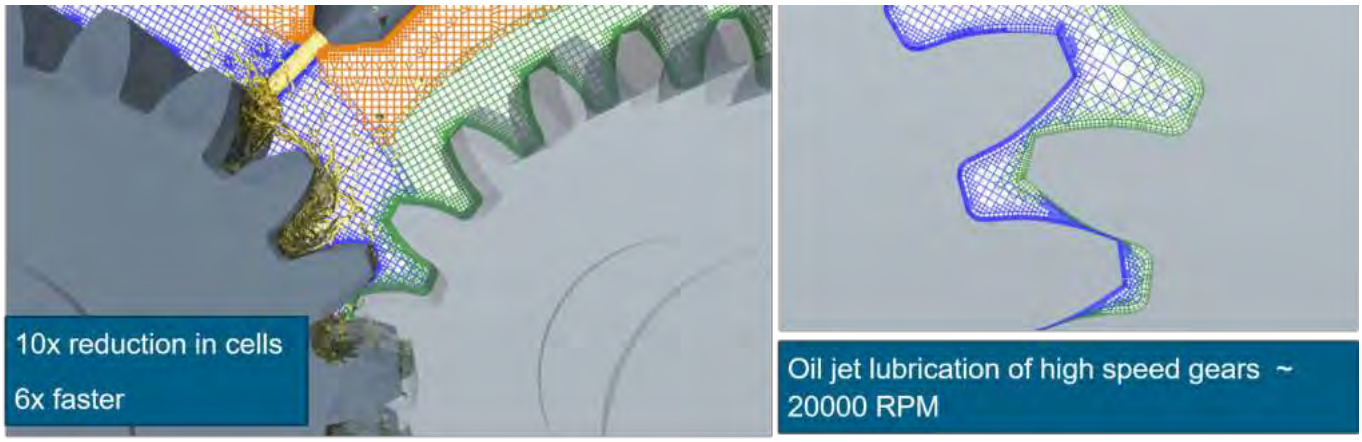
- You can combine different adaption criteria. In case of multiple refinements, the criteria requesting smallest size wins. For coarsening, all the criteria must agree to coarsen.



  - Limitation in 1st release:
    - Mesh at surface is refined to tessellated representation and not projected back to CAD meaning that curvature may not be captured accurately if the mesh is refined significantly more than the starting mesh
    - Anisotropic refinement of core mesh and prism mesh not available
    - Models not supported: Eulerian Multiphase, Lagrangian, Reactions, Aeroacoustics, PISO unsteady, Electromagnetism, Co-simulation, Finite-element based solutions, Fluid-film, Harmonic balance, Multi-component Liquids/Gases

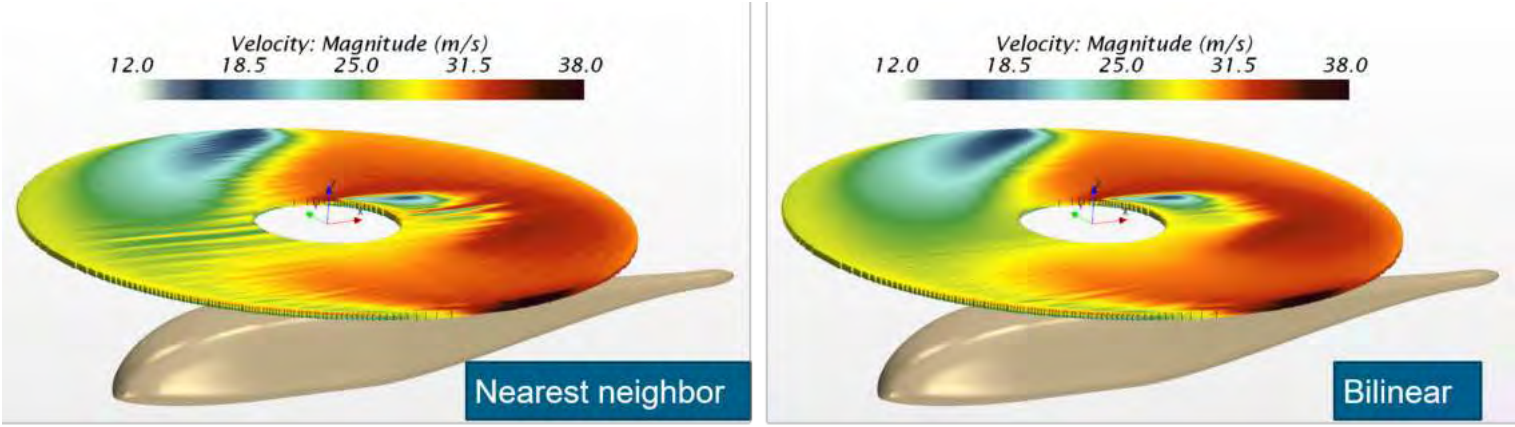
- **Overset model-driven mesh adaption D3082**
  - Improved ease of set up of overset regions
    - Ensures automatic matching of cell size between meshes at the overset interface
  - Reduced computational expense
    - Reduces cell count by maintaining coarser background cells and refining cells only at the overset interface
  - Overset model-driven mesh adaption

- Automatically refines lower priority mesh around overset interface
- Works in combination with other model-driven and user-defined refinement criteria



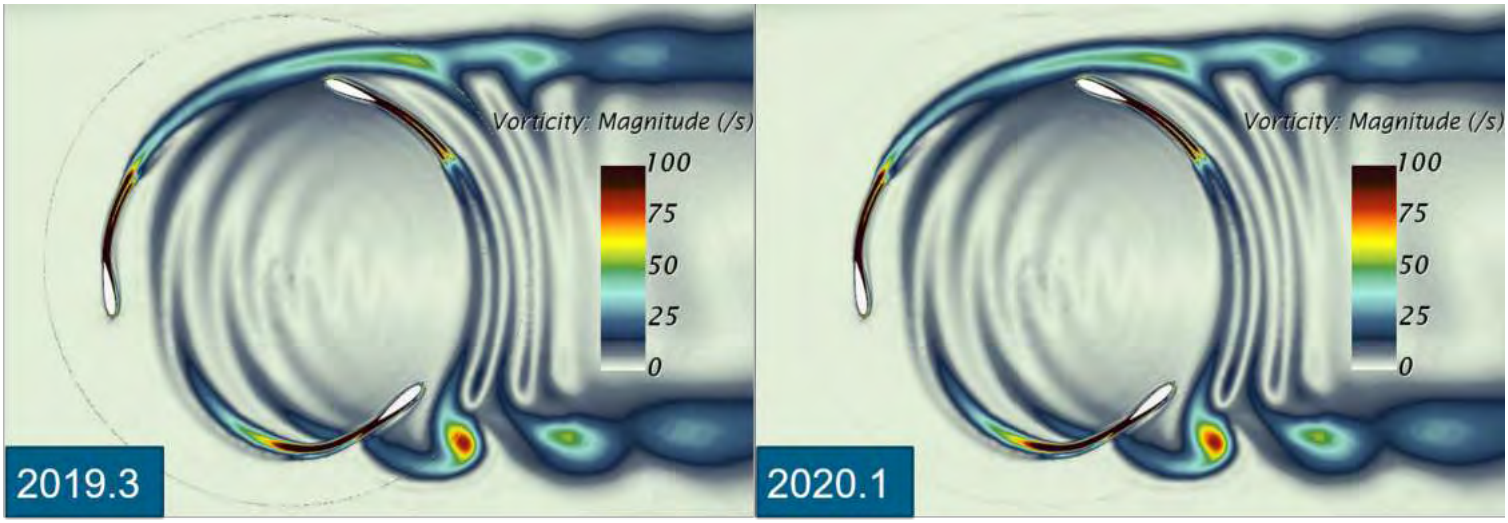
- Note:
  - Prism layer shrinkage in small gaps requires additional user-defined field functions

- **Improved interpolation of Blade Element to volume mesh**
  - Improved accuracy of thrust and torque for time-averaged blade element method
    - Smoother variation of source terms and velocity distribution downstream of disk
    - Reduced sensitivity of source term calculation to blade element grid resolution
    - Previously nearest neighbor interpolation was used
      - Momentum source variation showed spikes
    - Now bi-linear interpolation is used
      - Smooth variation of source term
    - Note: Bi-linear interpolation not available for transient blade element method

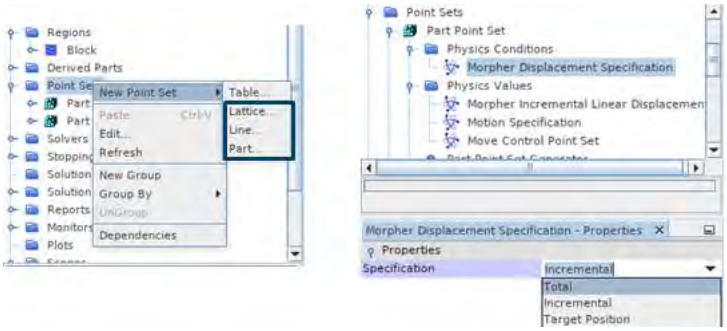


- **Thrust and torque specification for Body Force Propeller Method**
  - Possibility to simulate marine self-propulsion units using sampled velocity plane option
  - Possibility to calculate marine propeller curves
  - Previously you could only specify rotation rate now it is possible to specify a target value of thrust or torque
    - Solver will calculate required rotation rate
- **Improved Overset visualization**
  - Enhances confidence in the overset solution
  - Reduces visual artifacts at the overset interfaces

- Reduced gaps in visualization at overset interface
- Reduced discontinuities in visualizing velocity gradient functions at the overset interface. Example: Vorticity, Q- criterion, Lambda2



- **Improved search algorithm for Volume Data Mappers**
  - Enhanced accuracy for volume data mapping in remeshing scenarios
    - Important on cases with high aspect ratio cells, for example Multi-Mesh Sequencing (MMS) in marine applications
  - Search algorithm now tests for “point in cell”
    - Default for “Solution interpolation” model (remeshing) and Higher-order data mapping
    - Legacy “nearest neighbor” and “higher-order stencils” available by enabling Legacy Method
- **Point sets for additional Morpher control points**
  - Greater flexibility and ease of use in creating morpher control points
    - Example: Protect area around spark-plugs from morphing in in-cylinder combustion simulations
  - Previous table based method was cumbersome
  - Now Point Sets creation is available using the additional methods:
    - Lattice
    - Line
    - Part
  - Control point sets can be moved according to interpolated morpher displacement field



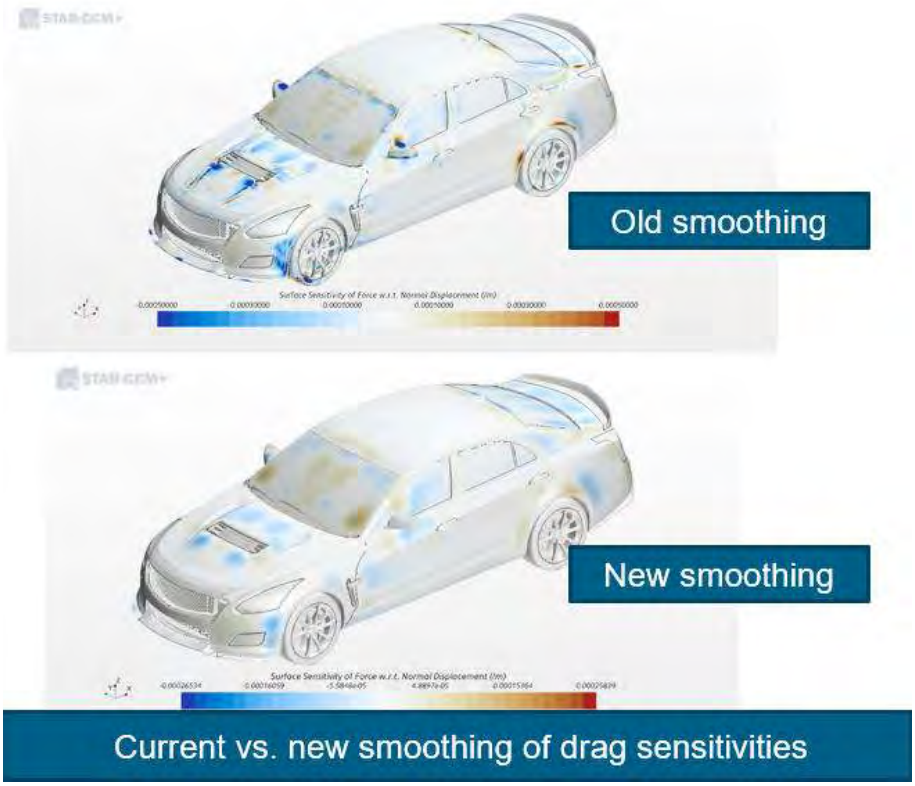
- **Total displacements as a Morpher boundary condition**
  - Reduced complexity in set-up of flexible bodies
    - Enhanced ease of use in specifying total deformations from an external FSI analysis

        - For example, marine hydro-foils, helicopter rotor blades
    - Restructure of 6-DOF morphing boundary conditions for simpler user selection
        - Previously DFBI body was limited to incremental displacements
        - Now morpher total displacements specification available with: DFBI morpher, Morpher with superposed rigid boundary motion
- **DFBI compatibility for anti-periodic interface**
    - Reduced computational effort for simulating transient rotating electric machines employing the DFBI motion model
        - Supports anti-periodic interface condition for Magnetic Vector Potential
        - Allows you to model a periodic sector using DFBI solver with accurate mesh snap-back behavior for anti-periodic interface

Design Exploration

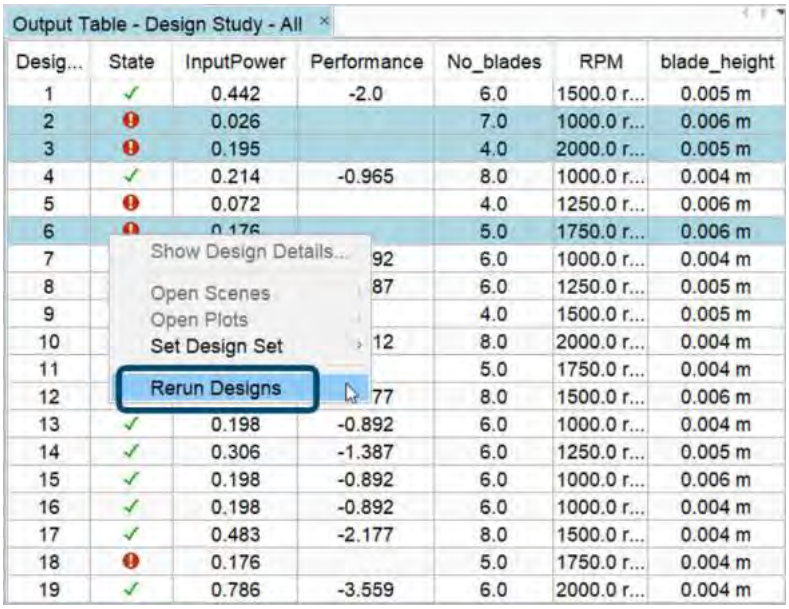
Adjoint

- **Improved smoothing of surface sensitivities**
    - Improves adjoint optimization workflow
        - Better control of sensitivity smoothing
            - Results in faster convergence of the optimization problem
        - Better control over size of geometric features
            - Results in shapes more appropriate for manufacture
    - Filtering noise out of the sensitivity field
        - Removes oscillations of length scale smaller than given radius
    - Automatic transition from moving to non-moving parts



Design Manager

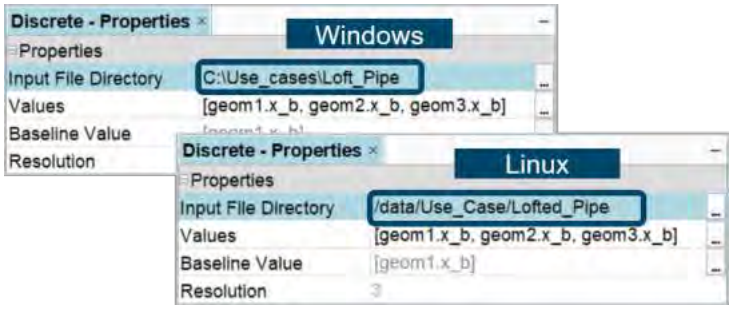
- **Rerun selected designs D4619**
  - Save time and increase product knowledge with greater automation capabilities
    - Automatic rerun of selected designs with automatic results update
      - Helps to manage design runs including failed ones after study execution
    - Accessible from design table, designs sets or plots



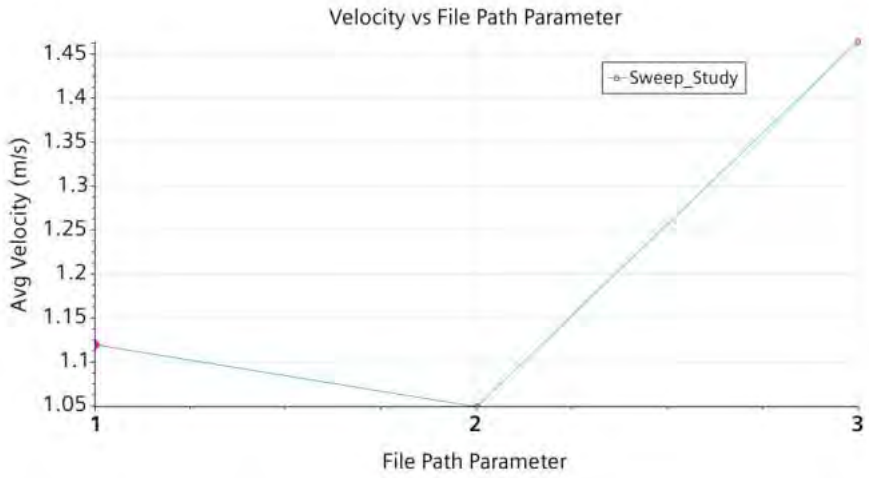
- **Default save of log files**

- Save Log Files property now enabled by default

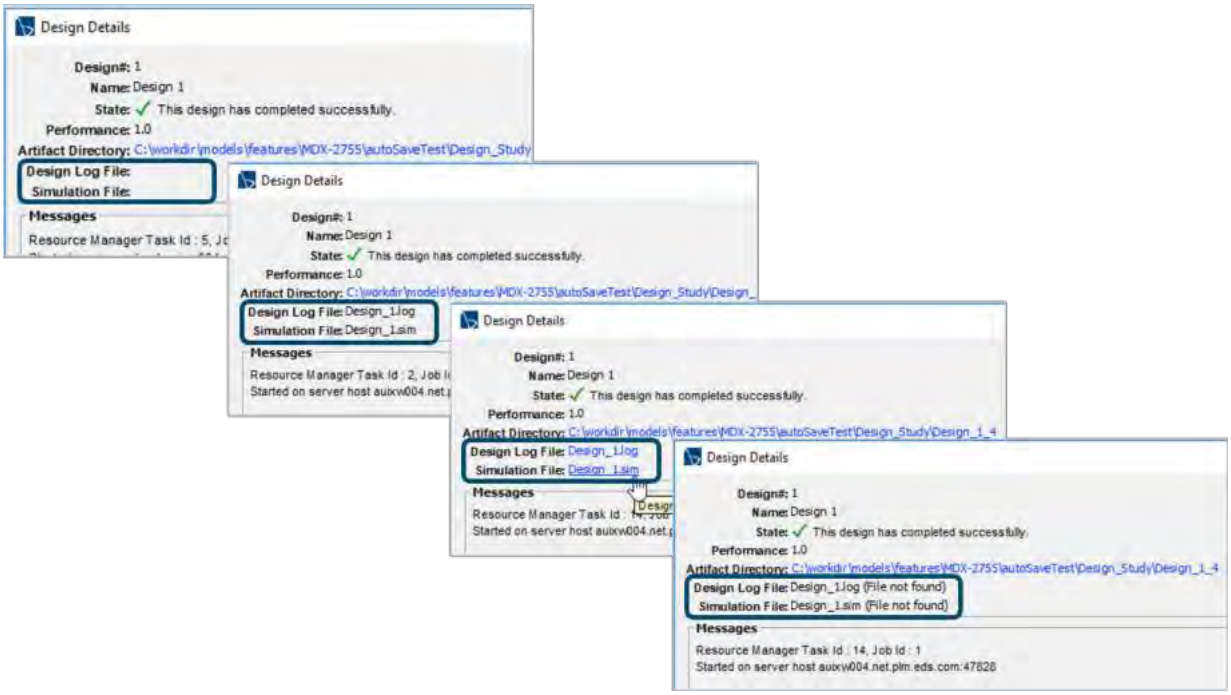
- **Input File Directory: Support of different OS file path**
  - Save time and increase automation
    - Easier set-up of remote studies with no client operating system dependency (support for Windows and Linux file paths)



- **Plotting support for file path parameters**
  - Increase product knowledge by plotting results involving file path parameters
  - Limitation: Integer indices used in plot axis are based on file order in the Values property field



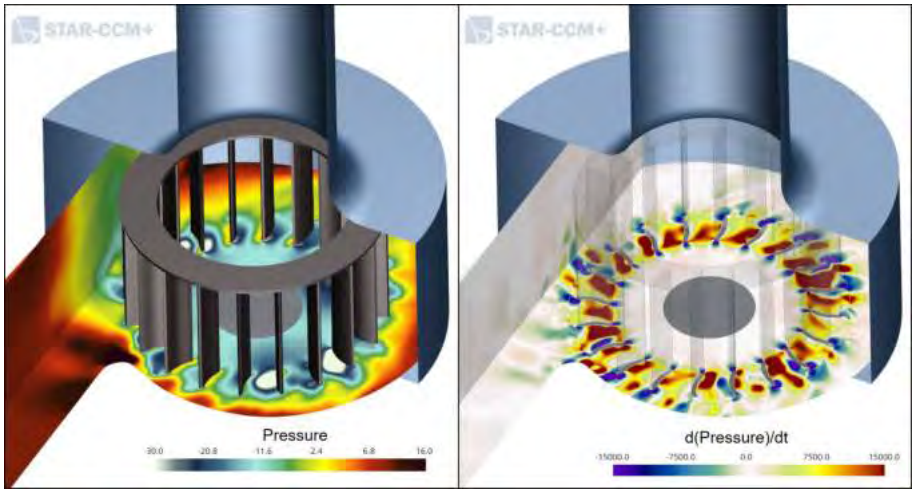
- **Show Design Details improvements**
  - Better tracking of design simulation and log files
    - No file saved, no file name displayed
    - Remote existing file saved, file name displayed
    - Local existing file saved, file name displayed with associated hyperlink
    - Local or Remote but non-existing file saved, file name displayed with “File not found” mention



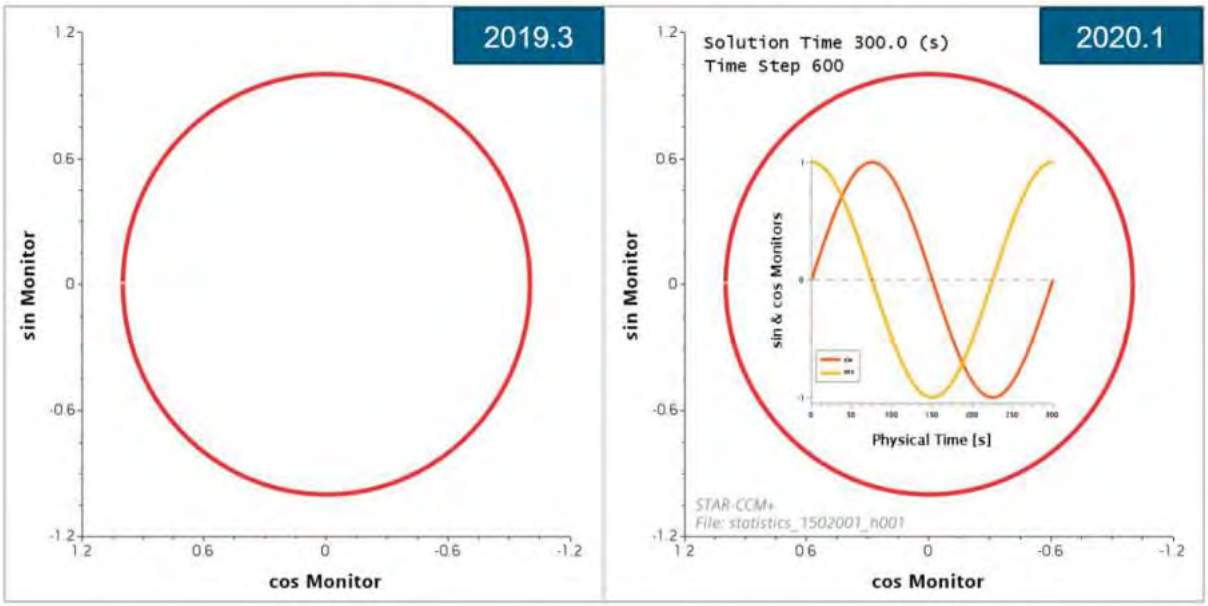
- **Important note: Planned end of HEEDS|post access as part of the Simcenter STAR-CCM+ Intelligent Design Exploration license**
  - Access to HEEDS|Post using the Simcenter STAR-CCM+ Intelligent Design Exploration license has been deprecated starting in Simcenter STAR-CCM+ 2020.1 and is planned to be removed in version 2021.1
    - You are encouraged to utilize the native data analysis tools within Simcenter STAR-CCM+
    - Once this feature is removed, you will still be able to access HEEDS|post from Design Manager with a standalone HEEDS|post license, and through a separate installation, if desired
    - Please contact your Simcenter customer support representative for further information

Data Analysis

- **Field Histories D653, D2204, D2673, D2997**
  - Understand evolving transient phenomena by examining rates of change
  - Make advanced transient data analysis more robust by utilizing in-core methods
  - Field Histories are stored within the .sim file
    - Field Histories store data (in the .sim file) at separate states for specified scalar, vector & tensor functions—for example storing field functions from previous iterations/timesteps
    - Sliding window lets you specify a range
    - Update events can be used to trigger storage
  - Create derivatives and integral expressions with Field Functions utilizing FieldHistories
  - In the illustration below,
    - Pressure contours are shown on the left
    - dp/dt (second order error, backward difference formulation) is shown on the right. This data was created using Field Functions that leverage Field History stored results

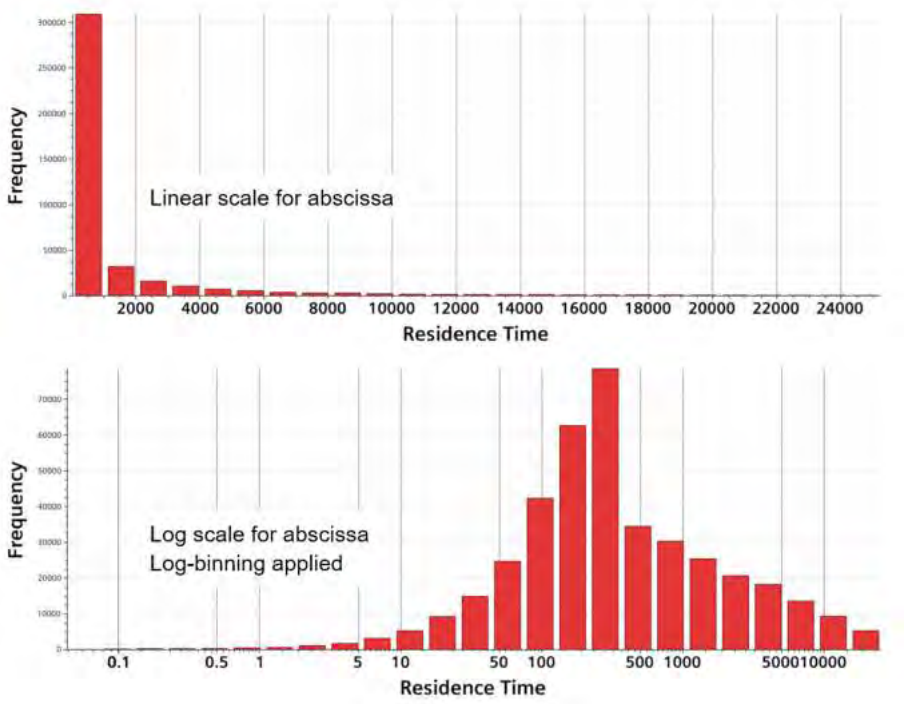


- **Plot Annotations D1783, D1968, D5135**
  - Increase effective communication of information by adding Annotations to plots
    - Add layers of information to broaden context
    - Add Solution Time to a Monitor vs Monitor plot
  - Save time creating annotated plots intuitively using the familiar Scene Annotation workflow
  - Create a plot annotation by dragging directly...
    - ...into the Plot window, or
    - ...onto the Plot node in the Simulation tree
  - Most annotation types are supported except for Scene Grid or 3D image annotations
  - In the illustration below
    - A monitor vs monitor plot (on the left) suffers the shortcoming of not presenting the solution Time or Time Step
    - The same plot (on the right) uses several annotations to provide additional layers of information

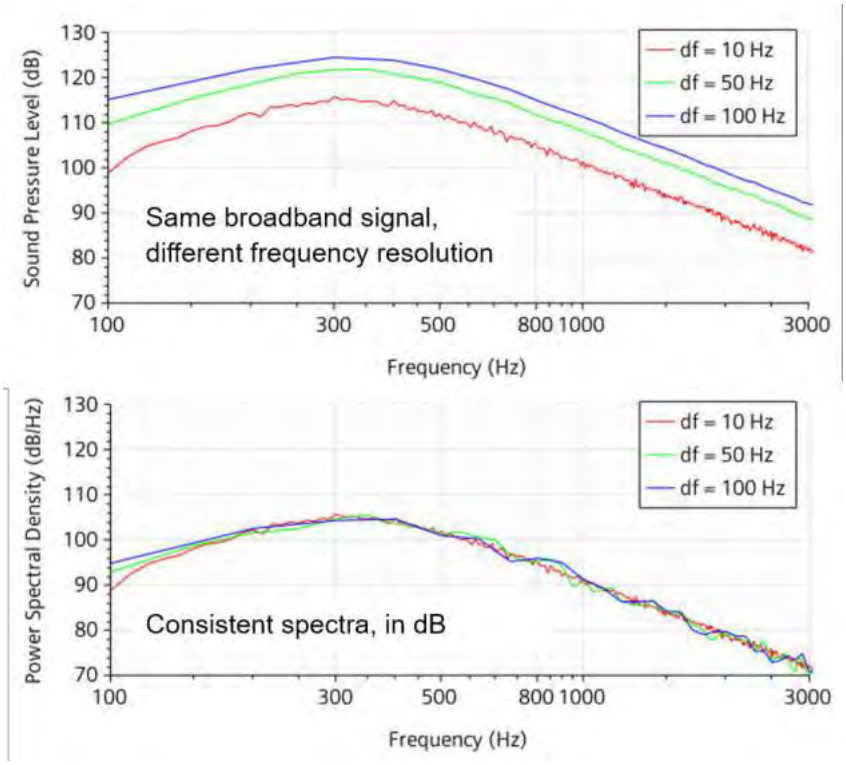


- **Log-spaced histogram bins D3683**
  - Faster interpretation of information in histogram plots resulting from improved presentation
  - Log binning can be applied to the plot abscissa

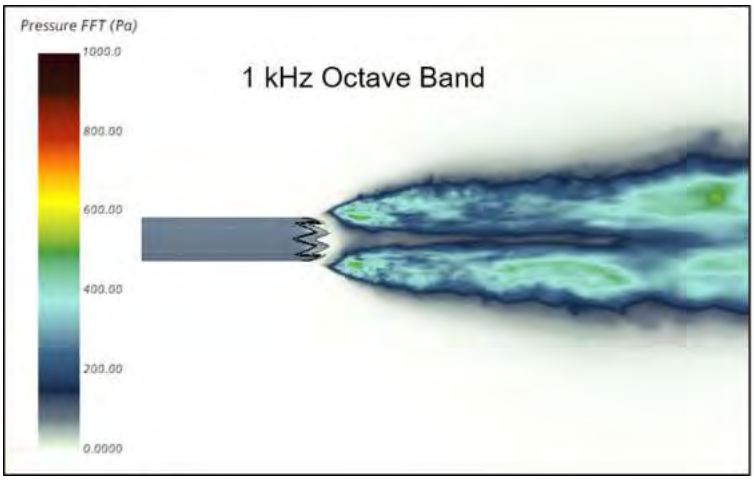
- Bins will have equal width

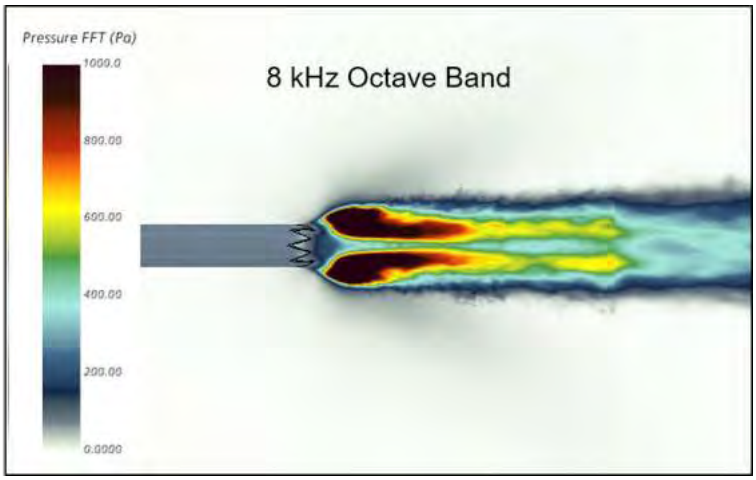


- **Plotting Power Spectral Density as db/Hz D3683**
  - Power Spectral Density (PSD) plots provide consistent spectra for broadband signals, regardless of frequency resolution
    - Enables comparing simulation and experimental results with different frequency resolution
  - PSD is insensitive to frequency resolution, as opposed to Sound Pressure Level
    - PSD was previously only available in Pa^2/Hz
    - Acoustic results are more common in dB
    - PSD is now also available as dB/Hz



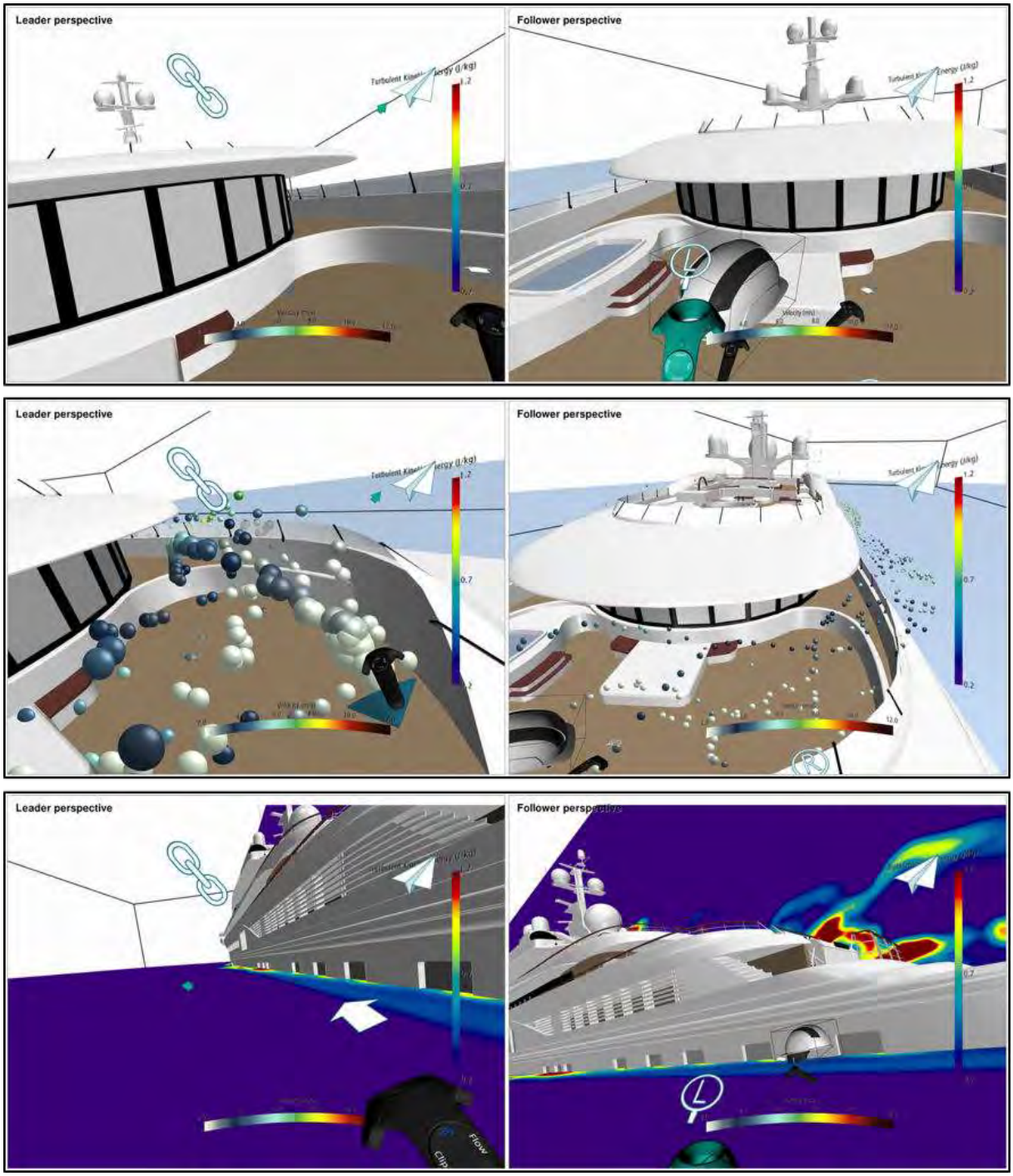
- **Frequency bands for Surface & Line Data Set Functions**
  - Engineering insights for transient analysis
  - Useful to, for example, detect location of high pressure fluctuations, often related to sound generation
  - Previously only available as a field function, with the productivity drawback of being recalculated for each change in visualization
  - Calculates surface and line FFT's
    - Displays results over bands rather than single frequencies
    - The field function approach recalculates the FFT each time the display frequency is changed
    - Data Set Functions retain FFT's, leading to large cost savings when viewing many frequencies





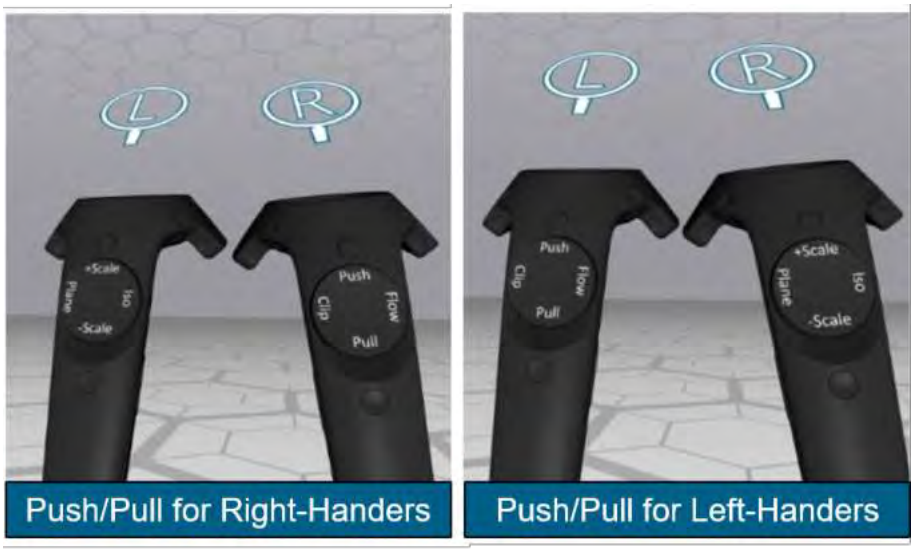
- **Collaborative Simcenter STAR-CCM+ Virtual Reality D5299**
  - Overcome isolation common in immersive environments with multiple user interaction
  - Save time when performing
    - Design reviews to confirm correct BOM content

        - Assessment of meshing operations
        - Critical reviews of simulation results
    - VR clients connect to Simcenter STAR-CCM+ server
        - Avatars show location of other users
    - The current VR state is synchronized
        - Particles emitters, plane sections, and iso-values can be created, modified and/or deleted in collaboration or on an individual basis
    - In the series of images below, the leader perspective is shown on the left and the follower perspective is shown on the right
        - The top pair shows basic navigation in an immersive environment
        - Next, we see two different perspectives on massless particles (which are being introduced by the leader on the left)
        - Last we see how each collaborator can view results on cutting planes from very different locations



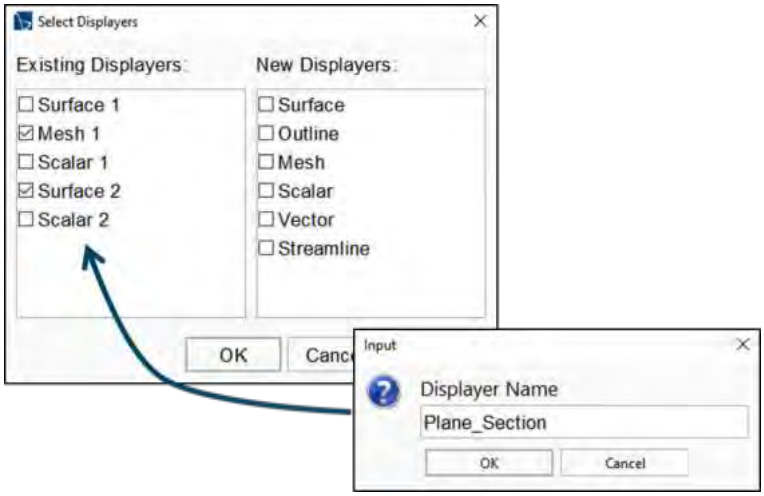
- **Expanded hardware support for Simcenter STAR-CCM+ Virtual Reality**
  - Customers now have a wider range of options when it comes to rapidly evolving VR headset technology
  - Windows Mixed Reality headsets are cheaper compared to HTC & Oculus
  - Certified (QA tested internally)
    - HP Windows Mixed Reality
  - Supported (known to work)
    - Oculus Rift* (contact your dedicated support engineer, some additional configuration may be needed), Varjo VR-2
  - Unsupported (expected to work)

        - All Windows Mixed Reality devices
        - Oculus Rift S* (contact your dedicated support engineer, some additional configuration may be needed)
- **Improvements for Simcenter STAR-CCM+ Virtual Reality**
    - Immersive experience works best when acknowledging left/right handedness
        - Hand controller menus can now be swapped

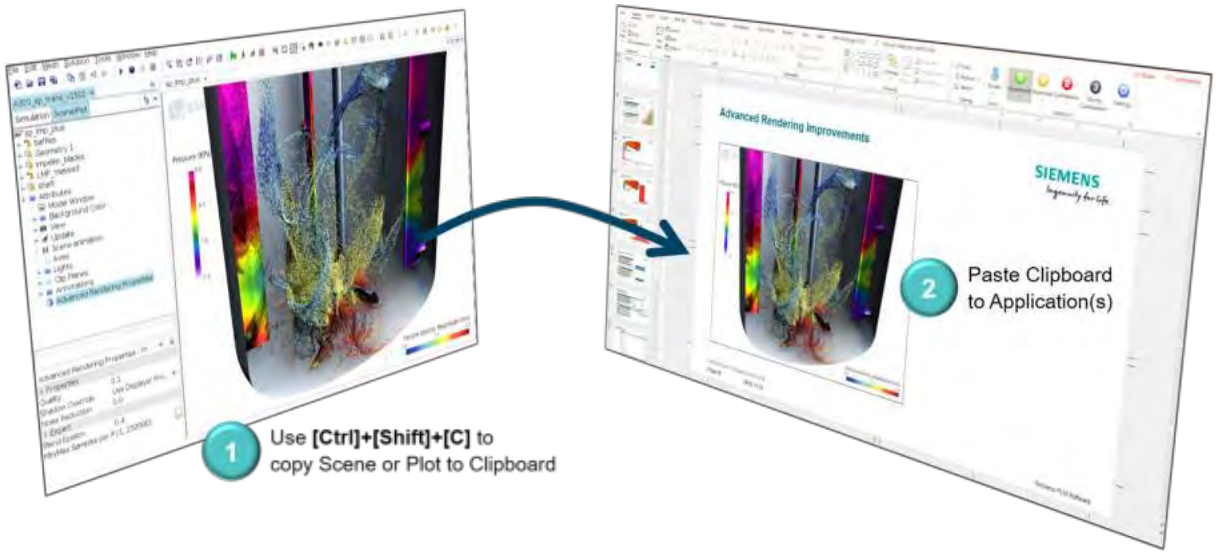


    - View can now be preserved on scene load
        - Use the stored view in the .sce or .sim file, OR
        - Use the current view in the STAR-CCM+ client
        - View Reset in VR also uses the preserved View
    - Simcenter STAR-CCM+ Virtual Reality stays responsive during long load times
        - Feedback provided to show progress on connecting, downloading, updating,...

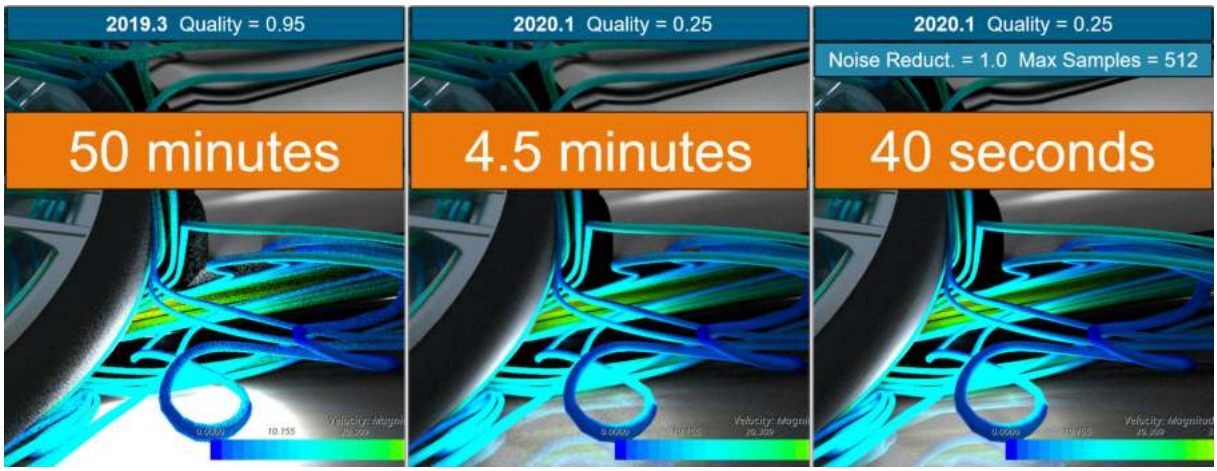
- **Improved Scene Usability D389, D1922**
    - Compose scenes faster, in a more intuitive and robust way, using a new dialog for drag'n'drop
    - Generate scene content with less effort using new defaults for Geometry, Outline & Mesh Displayers
    - Save time when modifying scenes with a simplified tree
        - A new dialog is presented to create Displayers
        - Drag'n'drop objects from the main tree into any scene, or
        - Select an object within a scene to bring up the dialog
        - Add/remove objects to/from existing displayers
        - Rename newly created displayers on-the-fly



- **Quick Scene/Plot copy-paste [CTRL]+[Shift]+[C]** D2010
  - Easily create hardcopy, pasting directly to your clipboard to improve your productivity when generating presentations and reports

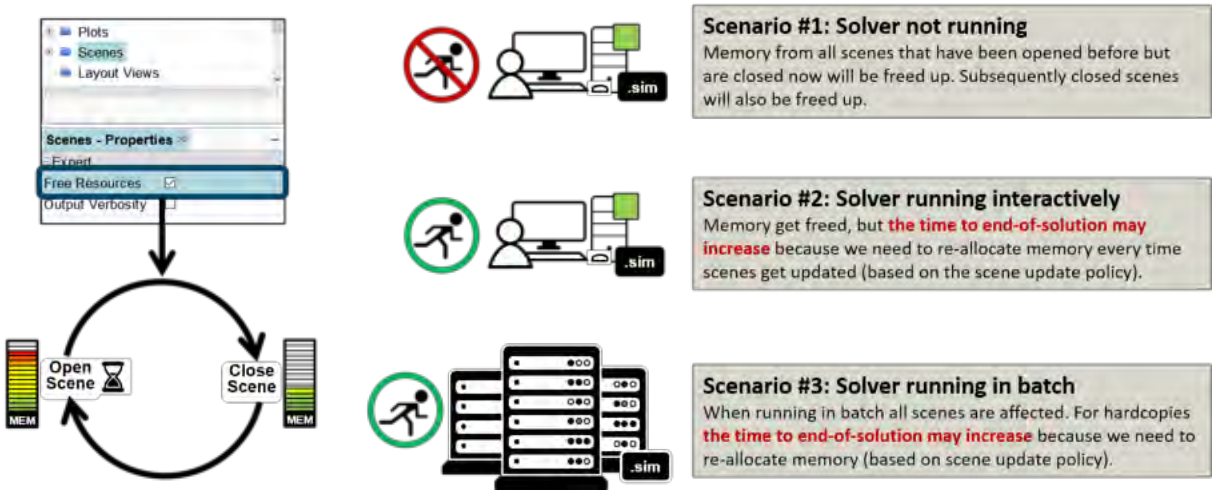


- **Advanced Rendering Improvements**
  - Significant performance improvements dramatically reduce the time to create scenes when emissive and metallic materials are used together



- Improvements & fixes
  - Scenes with emissive lights render much faster
  - No more speckles in finished images
  - Noise Reduction works with true pixel variance
  - Emissive light brightness & reflection corrected
  - Simple materials no longer extremely bright
- Changes in behavior
  - Scenes may render longer with current defaults and/or stored settings
  - Emissive lights cannot be partially transparent
  - Emissive lights will always occlude each other and the environment when lighting advanced materials
  - Scenes with very bright spots will appear differently
  - Re-Render happens when increasing max samples

- **Free Rendering Resources when closing a Scene D3609**
  - Leverage hardware capabilities/limitations against large model data analysis requirements
  - Deliver end-user workflow flexibility by exposing user-definable resource trade-offs
  - Render-side memory can now be released when a scene is closed
  - Free Resources applies to all Scenes



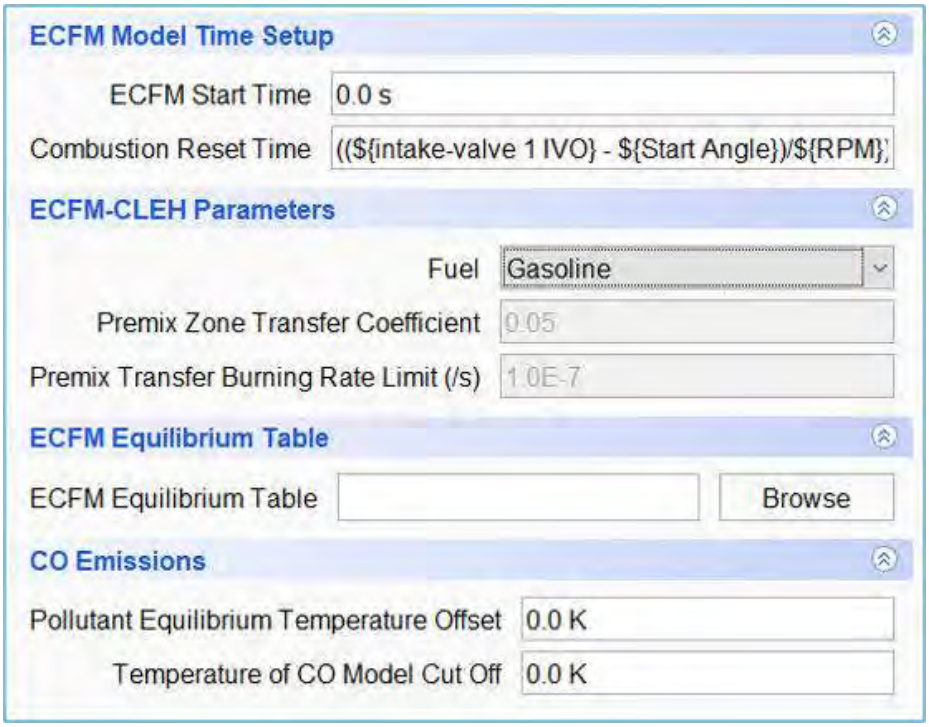
Application Specific Tools

Simcenter STAR-CCM+ In-Cylinder Solution
Electronics Cooling

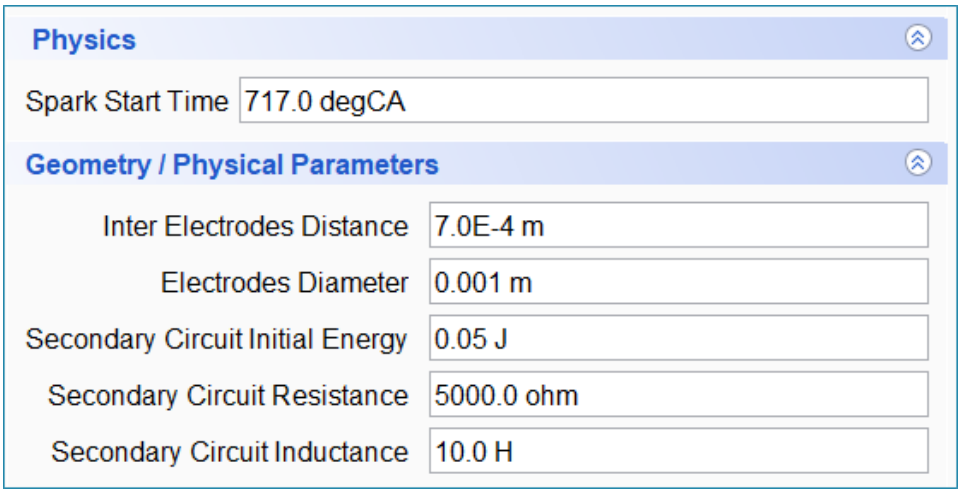
Simcenter STAR-CCM+ In-Cylinder Solution

- **ECFM-CLEH combustion model setup**
  - The ECFM-CLEH combustion model can now be selected in the “Model Selection” panel as an alternative to the ECFM-3Z model
    - ECFM-CLEH caters for all modes of combustion and can be used for both gasoline and diesel engine simulations

- In the ECFM-CLEH panel, default model parameters are provided for gasoline and diesel, with an option for user-specified model parameters
  - Full support for diesel combustion systems is coming in a later release
- The ECFM-CLEH model requires the use of an Equilibrium Table
  - A set of basic tables is available through the Global Technical Access Center (GTAC) under Simcenter STAR-CCM+ > Full Products > 2020.1 > Related Files and Documentation > In-Cylinder



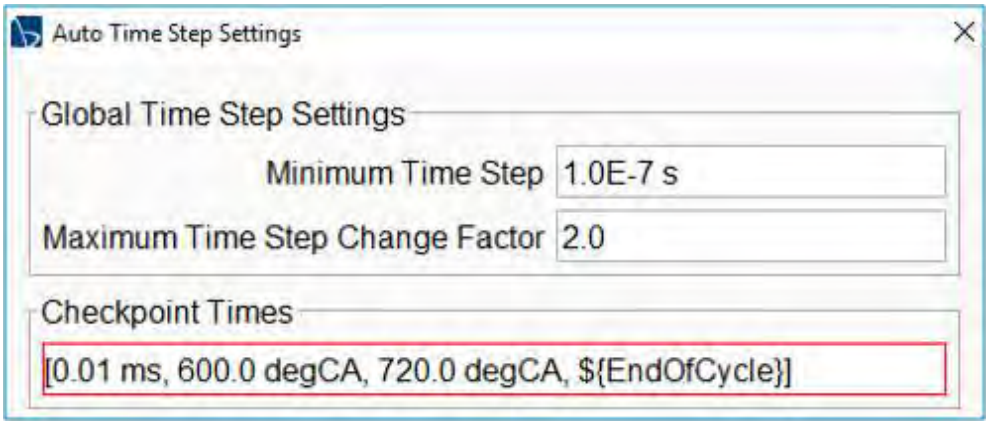
- **ISSIM spark-ignition model setup**
  - The Imposed Stretch Spark-Ignition Model (ISSIM) can now be selected in the “Model Selection” panel as an alternative to the FI model
    - ISSIM caters for a better description of the physics associated with ignition and initial flame kernel development than the more basic FI ignition model
  - ISSIM model parameters are edited via the “ISSIM” node under the “Models” folder in the In-Cylinder tree
  - The details of the secondary electric circuit are edited via the “Ignitor” setup panel



- **NORA NOx emissions**

- The Nitrogen Oxide Relaxation Approach (NORA) can now be selected in the "Model Selection" panel when either ECFM combustion model is activated, allowing prediction of NOx emissions (NO, NO_2 and N_2O)
- NORA model parameters are edited via the "NORA" node under the "Models" folder in the In-Cylinder tree
- A NORA table must be specified in the NORA model panel. This table is provided in the set of basic tables available through the Global Technical Access Center (GTAC) under Simcenter STAR-CCM+ > Full products > 2020.1 > Related Files and Documentation > In-Cylinder

- **CO emissions**
  - CO emissions can be predicted with ECFM-3Z and ECFM-CLEH models
    - ECFM-3Z caters for CO without additional modeling, while for ECFM-CLEH, a separate CO emission model is activated automatically in the “Model Selection” panel
  - Plots of the crank-angle resolved evolution of CO are provided in parts-per-million (PPM) by mass and by mole
- **Set specific checkpoint times**
  - Specific points in time can now be reached exactly when using automatic time-stepping
    - Ensures that, for example, each cycle in a multi-cycle run starts and ends in the same cyclic point in time, and that critical mid-cycle points for design exploration are always the same
  - A list of checkpoint times are entered in the “Auto Time Step Settings” panel
    - Each element of the list is given in a physical time unit (such as ms or degCA) or as an expression that evaluates to time



Electronics Cooling

- **Editing of library parts**
  - It is now possible to edit, and delete, parts stored in the QuickPart library

User Guide

- **New Tutorials**
  - Foundation Tutorials
    - Usability: Working with Layout Views
  - Compressible Flow
    - Adaptive Mesh Refinement: Hypersonic Flow
  - Heat Transfer and Radiation
    - Surface Photon Monte Carlo Radiation: Headlamp
  - Multiphase Flow
    - VOF: Tank Sloshing with Adaptive Meshing
  - Aeroacoustics
    - Acoustic Suppression Zone Modeling: Direct Noise Simulation
  - Electromagnetism
    - Airgap Remeshing: Electronic Speedometer
  - Electrochemistry
    - Proton Exchange Membrane Fuel Cell
- **Modified Tutorials**
  - Basic 3D-CAD: Adding Blades as a Pattern of Bodies – Changed direction of the fan blade (and in subsequent tutorials following on from this one)
  - 3D-CAD Defeature and Repair using the European Truck – Added extra section for removing small studs
  - Transonic Flow: RAE2822 Airfoil – Applied consistent definition for angle of attack
  - Harmonic Balance: Single Stage Periodic Flow – Reduced number of modes (reducing runtime)
  - Marine Resistance Prediction: KCS Hull with a Rudder – Additional stopping criteria (reducing runtime)
  - Body Force Propeller Method: Marine Self-Propulsion – Simplified procedure and additional stopping criteria (reducing runtime)
  - Trajectory Motion: Paint Dipping of a Chassis on a Fixed Skid – Now uses Adaptive Mesh Refinement (AMR) for resolving the mesh around the overset interface
  - Surface Chemistry: Methane on Platinum Oxidation – Now uses the CVODE solver instead of DARS-CFD
  - Simcenter Amesim Co-Simulation: 1D Coupling – Updated to use Amesim v2019.1
  - Co-Simulation API: Spindle Valve – Now uses a 1/8th sector and runs for a shorter time (reducing runtime)
  - Advanced Rendering: Ray Tracing – Added extra section for emissive materials
  - Gasoline Engine: ECFM-3Z Combustion – Updated to use new model selection UI

  In addition to these changes, all tutorials that use the coupled flow solver were updated to use the new controls.
- **New Cases in the Verification Suite**
  - Radiation – Surface Photon Monte Carlo Modeling of Solar Loads Focusing through a Lens
  - Electromagnetism – TEAM Problem 20: 3D Static Force Problem

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