SIEMENS

Ingenuity for life

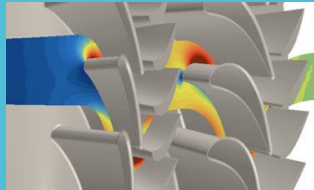Siemens Digital Industries Software

Simcenter STAR-CCM+

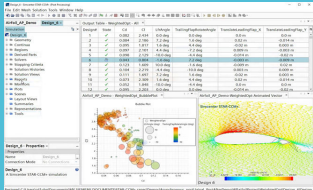## New features and enhancements

Where engineering meets tomorrow.

New Features and Enhancements in Simcenter STAR-CCM+ 2021.1
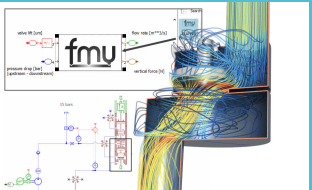

Simcenter STAR-CCM+ Themes

Model the complexity | Explore the possibilities | Go faster | Stay integrated

Where engineering meets tomorrow

Top new features and enhancements for this release are:

- Read-only simulation mode [1]
- NX CAD Client for Linux[1]
- Surrogate models creation in Design Manager
- Inside part field function[1]
- Speedline boundary condition for turbomachinery

- Flamelet combustion with VOF[1]
- Vector Finite Element Excitation Coil
- Electric Circuit Editor[1]
- Sector modeling for the In-cylinder solution
- 3D to 2D averaging, and section flattening, for turbomachinery analysis[1]

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1 Posted on IdeaStorm
  A total of 22 new features and enhancements from IdeaStorm in this version.

Enhancements to Simcenter STAR-CCM+ 2021.1 are presented by category:

Platform

Deployment

- **Newly certified operating systems (OS)**
  - CentOS 7.8, SUSE Linux Enterprise Server (SLES) 12 SP5
- **Newly supported operating systems (OS)**
  - RHEL 7.8
- **Planned operating systems (OS) changes for 2021.2**
  - Adding RHEL 8.2, SLES 15.2, OpenSUSE Leap 15.2, Windows 10 May 2020 Update
  - Retiring CentOS 7.4
- **Advance warning: CentOS 8.x to be retired for 2021.3**
  - This is as a result of the accelerated end of life announcement from the CentOS project with CentOS 8 ending on the 31st of December 2021
- **Newly certified Message Passing Interface (MPI) versions**
  - Linux: Intel MPI 2019.8
- **Retired Message Passing Interface (MPI) versions**
  - Linux: Intel MPI 2019.7
  - Advance warning: Platform MPI will no longer be distributed with Simcenter STAR-CCM+ starting in 2021.3
- **STAR-Cast add-on removal notice**
  - STAR-Cast is retired in this production release
    - The user interface has been removed
    - The casting physics models no longer require a STAR-Cast add-on license
    - The casting material database
      - Is still accessible under Tools
      - Requires a Simcenter STAR-CCM+ Metal Processing Db add-on license

User Experience

- **Read-Only mode for simulation file D2606**
  - Increases return on investment by providing greater flexibility in interacting with simulations

- Quickly check settings without consuming a license feature
- Consult the setup—no changes allowed and no save permitted
  - Ensure consistency of simulation setup by checking settings and comparing simulations
    - Create a new simulation faster by copying from a Read-Only simulation and pasting into a full access one
    - Allows comparison between Read-Only and full access simulation using the compare tool
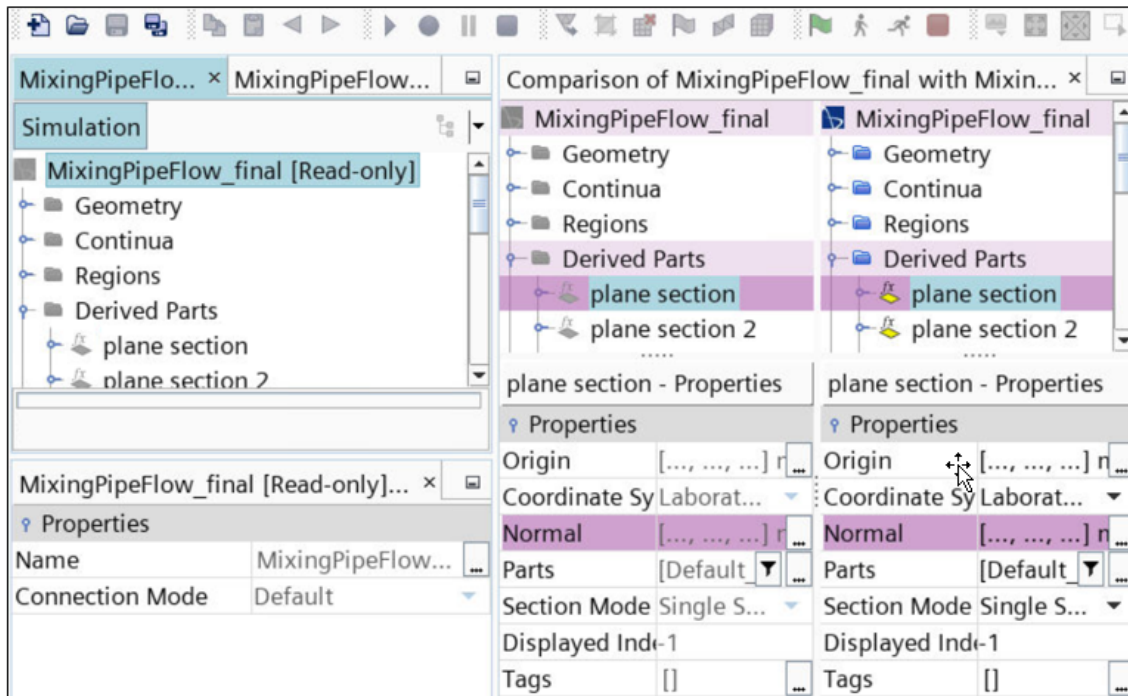
- **Hover tooltip for simulation name and mode**
  - Fewer clicks to identify desired simulation
  - Easy to visually differentiate when multiple files are open
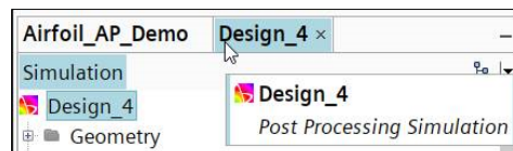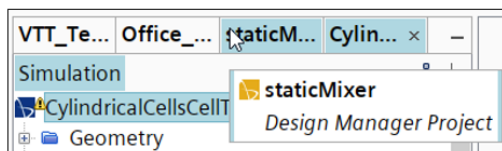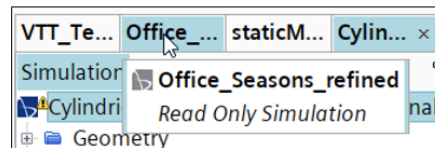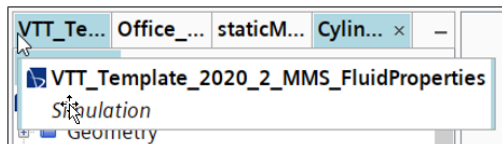
- **Less scrolling with disabled sorting on rename**
  - Sorting occurs when refreshing or in the next session
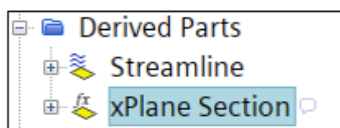
- **Use custom tree as initial tree view for Design Manager**

- ○ Improved productivity with more robust and reproducible workflows
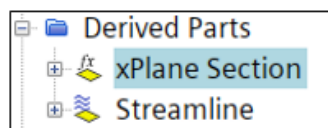- **OpenJDK updated to version 11.0.8**
  - ○ Users should not see any difference from the previous release

CAD Integration

CAD-Clients

- **CAD-Client for NX on Linux** <mark>D4238</mark>
  - ○ Improved integration with NX with CAD-Client support on both Windows and Linux
    - Direct geometry import
    - Bi-directional parameter/expression transfer
  - ○ Facilitate industrial deployment of design space exploration
    - Robustly explore designs using parametrized NX models
    - A Windows system remote access is no longer required
    - Supports NX version 12 to 1926
- **CAD Clients CAE mode feature removal notice**
  - ○ CAE mode (ability to setup a simulation in the CAD package environment) is retired in this release
  - ○ CAD Clients focus solely on
    - Direct geometry transfer
    - Bi-directional CAD information transfer including parameters, expressions, coordinate systems and reference planes
- **CAD Client upgrades**
  - ○ NX 1953 series
    - Windows support only

CAD Exchange

- **CAD Exchange upgrades**
  - ○ NX
    - HOOPS Exchange
      - Up to NX 1926 Series
    - Siemens Adapter
      - Windows - Up to NX 1953 Series
      - Linux - Up to NX 12
  - ○ CATIA
    - HOOPS Exchange
      - Up to V5-6 R2019 (R29)
  - ○ Inventor
    - HOOPS Exchange
      - Up to 2020
  - ○ Creo- Pro/E
    - HOOPS Exchange
      - Pro/E 19 to Creo 7.0
  - ○ ACIS

- HOOPS Exchange
 - Up to 2020
- JT
  - JTOpen reader
   - Up to 10.3

Geometry

3D-CAD

- **Leak detection in extract internal volume**
  - Reliable and easier to use internal volume extraction through automatic leak detection
    - Easily find gaps in the geometry that would lead to extraction failure
      - Leak paths automatically calculated and visualized in scene - interactively select faces/edges to close leaks
    - Possibility to create a sheet body from the internal volume surface after all leaks are closed
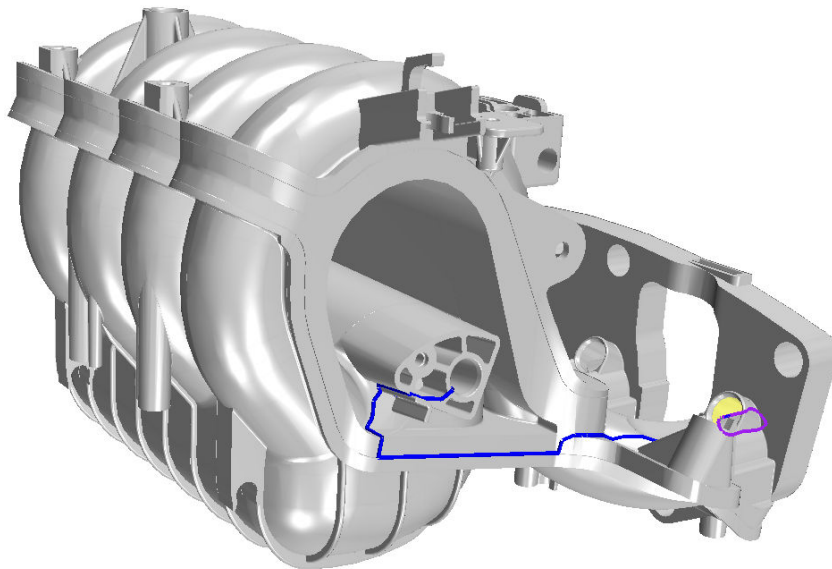
- **Fill surface method in extract internal volume**
  - Robust extract internal volume operation for curved Inlet and Outlet surfaces with new capping method
    - Now curved faces can be capped with the "Fill Surface" method
    - Default option "Prefer Extension" cannot handle the inlet or outlet faces with curved faces
- **Search tool results in table view**
  - Reduced turnaround time for geometry preparation with easier overview of search results
    - Sort results by name, group clashes by body in clusters, and isolate results for easy review
    - Execute operations directly from the table
      - Example: Group clashing bodies in clusters and then easily and quickly unite them
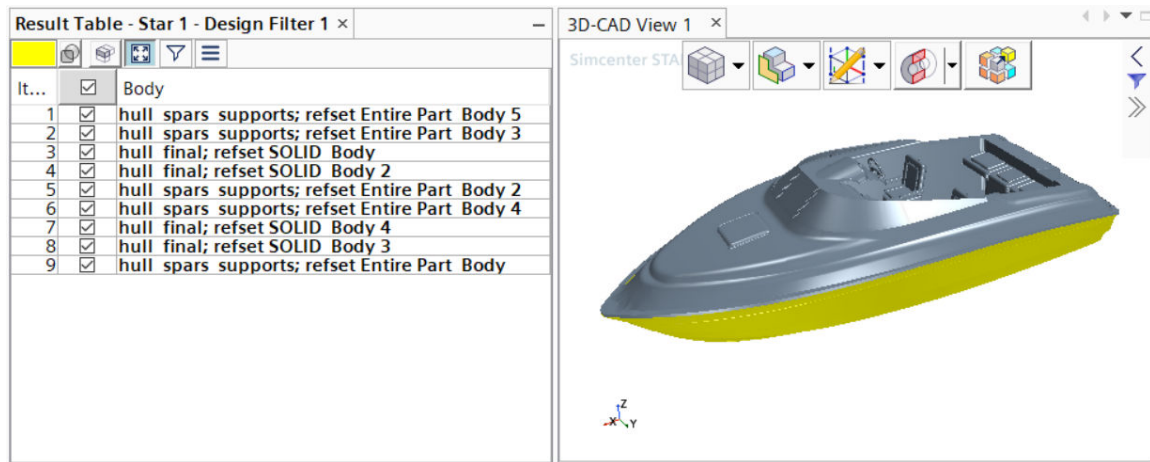
- **Trim guide curves in loft operation**
  - ○ Improves robustness of loft operation by automatically trimming body at intersection between guide curve and end profile
    - ▪ No need to manually ensure that guide curves finish exactly by end profile
- **Multiple profiles in sweep operation**
  - ○ Create more complex geometries through sweeping
    - ▪ Previously, sweep operation supported single profile and single guide curve
    - ▪ Now, you can select more than one guide profile
    - ▪ Applications: Marine propellers, Turbine blades
- **Dynamic sectioning tool from scene**
  - ○ Quicker model interaction through creation of section cut directly from scene
    - ▪ Previously section cut creation involved more mouse-clicks and mouse-miles
    - ▪ Now select any planar or cylindrical face from scene and create a section cut from the right click menu
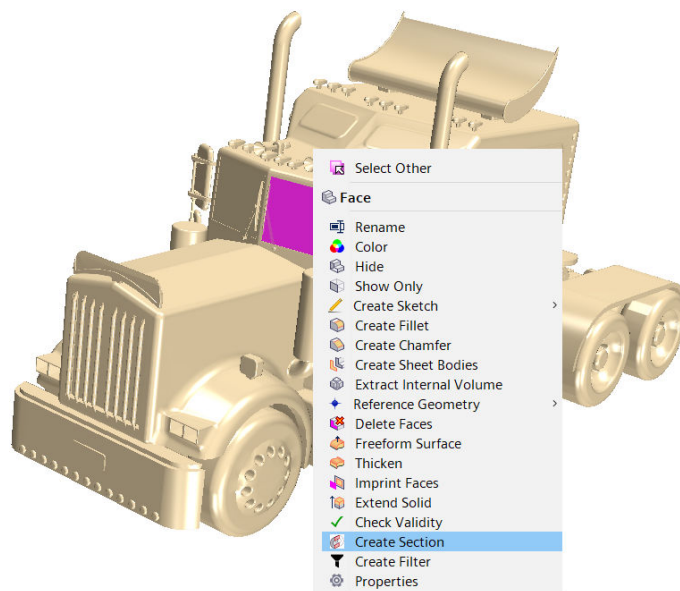

- **Split face by edge projection – Repair Tools** D5626
  - ○ Faster method to close gap between bodies without modifying the entire large face through splitting of large face into smaller faces

- **Design Filters**
  - Easily create filters from scene to collect body groups, bodies, faces, and edges
- **Additional Search Criteria – Search Tool**
  - Find bodies that are disconnected and enclosed inside any other body through new category **Void Region**
  - Clean up geometry more easily by finding all tolerant edges through the new predicate **Tolerance** and use Optimize Edges to heal them
    - Vertices can also be found by Tolerance
  - Find unwanted small faces that are not of interest in meshing through new Feature **Sliver Width** and store them in a filter for removal
- **Remove sliver face – Repair Tools**
  - Easily remove unwanted small faces that are not of interest in meshing
  - Automatically identify sliver faces based on tolerance value
  - Remove the sliver faces and heal the geometry
- **Additional features**
  - Optimize Edges feature accepts vertex and vertex filters
  - Option to show/hide sketches in 3D-CAD scene
  - Global option to control frequency of 3D-CAD model data caching
  - Find Similar option supports search for groups of edges
  - Multiple body sew operation allows possible sewable sheet bodies to be converted into solid bodies
  - Airfoil option in Extend Surface for better extension of blade profiles while honoring the shape without distortion
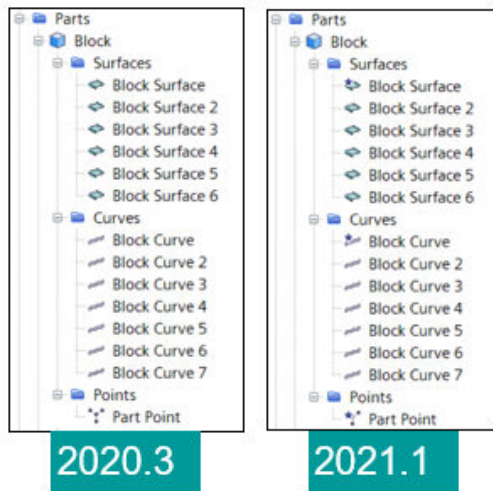
Parts

- **Periodic contact in Conformal mesh between Operations**
  - Achieve a conformal mesh between two mesh operations with periodic contact for tetrahedral meshes
- **Prism layer custom control value node**
  - Reduced number of clicks to change prism layer custom control values through access to most options in the same properties window
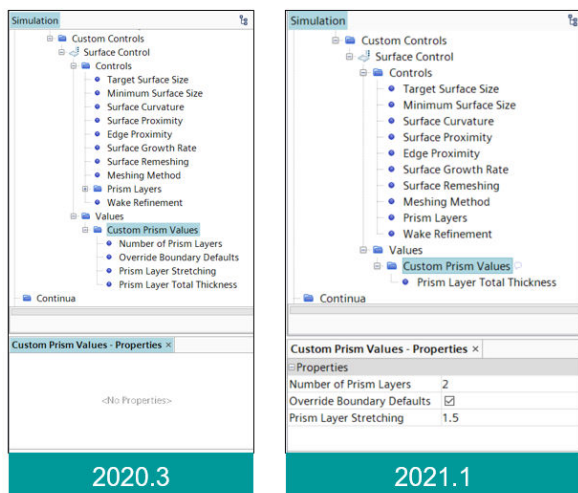
- **Default entity icons in parts**

○ Better differentiation between parts default entity and other entities through dedicated icons for default part surface, curve, and point
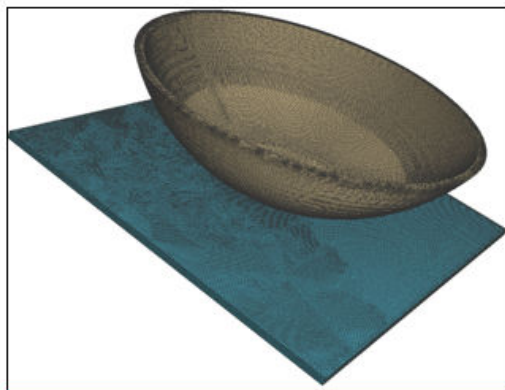

Mesh

Surface Repair

- **Part surface for Fill Polygonal Patch**
  - ○ For improved control, you can now specify the part surface to which the patch filler assigns faces
    - ▪ The patch filler faces can also be assigned to a new part surface
- **Create empty part**
  - ○ Workflow simplified as you can now create an empty part directly from the Organize panel in surface repair

Surface Mesh

- **Faster surface meshing when deploying wake refinements**
  - ○ Impact is case-dependent
    - ▪ Up to 1.2x faster for a vehicle external aerodynamics cases
- **Faster surface wrapping for cases including volume refinement**
  - ○ Up to 1.2x faster
- **Proximity Refinement – Direction Control**
  - ○ Reduced cell count for models with thin plates and small gaps by refining only in gaps
    - ▪ Previously Proximity Refinement searched for proximal faces in both directions, leading to thin parts being refined everywhere
    - ▪ Now search direction can be specified as inside, outside, or both
      - - Specifying "outside" for a thin metal plate makes the mesh refine only from proximity with other parts, avoiding refinement everywhere

2020.3 Surface proximity affects the entire model
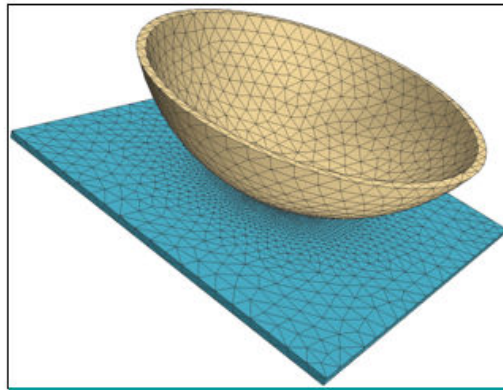
2021.1 Surface proximity affects the mesh around the gap

- **Contact prevention default value update**
  - Avoid unnecessarily long wrap times due to user input error
  - Previously the default value for "Minimum Size" was 1e-7 m, which could lead to over-refinement if not changed
  - Now contact prevention is disabled by default with the value for "Minimum Size" set to 0.0 m
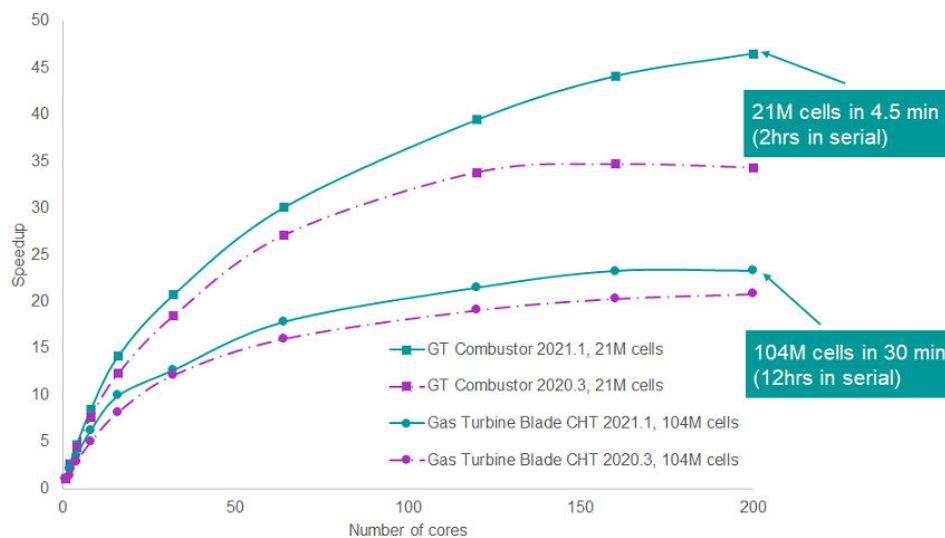
Volume Mesh

- **Inside part field function D740**
  - Improves flexibility in defining physical quantities by identifying volume cells residing within arbitrary shapes including CAD bodies
    - Previously, specifying physical quantity distributions for complex shapes required complicated field functions
    - Now any geometric part can be used to mark cells via the field function **InsidePart**
      - Select one part or a set of parts through customized filters
  - Makes defining of volumetric quantities much easier including heat sources and initialization of phases
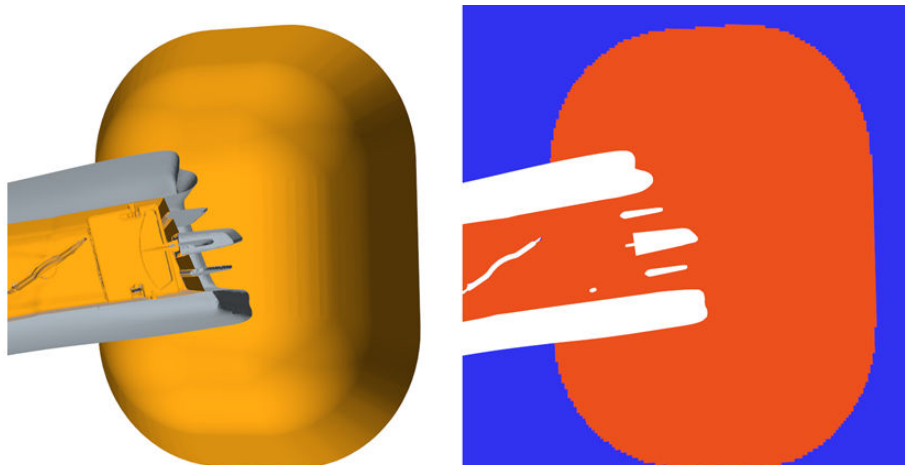
Simplified specification of noise sources for an automotive HVAC duct (red: cells inside the part, blue: cells outside the part)

- **Faster parallel polyhedral meshing**

- Up to 1.35x faster on 200 cores

- **Improved mitigation of unnecessary core mesh refinement with the advancing layer mesher (ALM)**
  - Impact is case-dependent and highest for cases with very low volume growth rates
- **Possibility to turn off local retraction in volume extruder**
  - Saves time during volume extrusion by disabling local retraction for non-complex geometries
    - Local retraction is required for complex geometries but may add significant CPU time
    - New option, *Auto-Retraction*, is off by default
- **Improved retraction in concavities for the prism layer mesher**
  - In 2D meshes there is now less retraction of prism layers at concave boundaries with near core layer aspect ratio (NCLAR) setting active
- **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 2021.3
  - 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 STAR-CCM+ customer support representative for further information

Deprecation of PM_SERIAL_SUBSURFACER environment variable
  - The serial prism subsurfacer environment variable allows the prism subsurfacer to be created in serial rather than in parallel
    - This environment variable has been deprecated starting in Simcenter STAR-CCM+ 2021.1 and is planned to be removed in 2022.1
  - Please contact your Simcenter STAR-CCM+ customer support representative for further information

Change to Volume Extruder Default Behavior
  - Intersection checking has been changed for the volume extruder
  - In Simcenter STAR-CCM+ 2020.2 a robust extrusion for non-planar part surfaces was introduced, allowing for automatic intersection checking and retracting the volume locally if necessary
    - However, depending on the given geometry and mesh density, the intersection checking could be very time consuming

- ○ The default option in current release (Simcenter STAR-CCM+ 2021.1) is not to check for intersections automatically
  - Intersection checking occurs only when the *Auto-Retraction* option is activated

CAE Integration

- **Non-equidistant coordinate cell clustering**
  - ○ Provides greater flexibility when coupling with gPROMS
  - ○ Referring to the figure below:
    - Equidistant clustering (shown on the left) can result in either:
      - Too few larger clusters leading to lower overall fidelity, or
      - Too many smaller clusters leading to increased simulation cost
    - Using non-equidistant clustering (shown on the right) it is possible to create:
      - Many clusters in the region of interest to increase the fidelity
      - Fewer clusters in the far field where a low fidelity is sufficient

2020.3 and earlier
Equidistant clustering

2021.1
Non-equidistant clustering
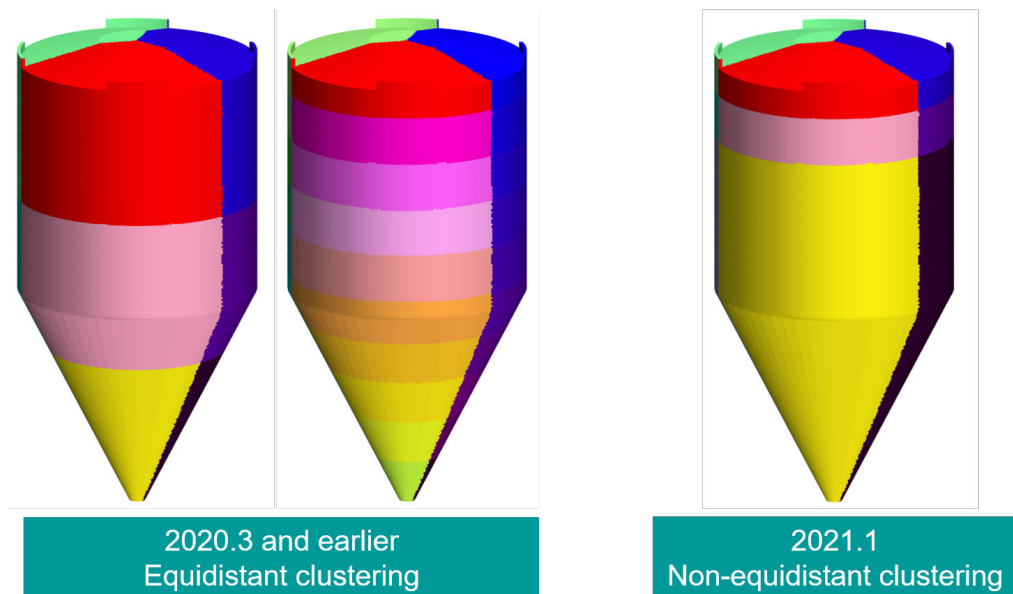
  - ○ The cluster resolution can be controlled along each coordinate system axis
- **Abaqus co-simulation**
  - ○ Version updates:
    - Newly supported: Abaqus 2019
    - Support maintained: Abaqus 2018, Abaqus 2017
    - Retired: Abaqus 2016
  - ○ For the implicit coupling model it is now possible to report the URF applied to the imported displacement when using the adaptive URF method
  - ○ For a zone with exported fields set to pressure only (no wall shear) it is now possible to choose how the pressure is send to Abaqus:
    - New: As pressure (PRESS), without conversion into concentrated forces
    - As concentrated forces (CF)
- **Mesh only export to CGNS files via links no longer forces a solution initialization**
  - ○ Saves time and results in lower memory requirements

- **The same co-simulation FMU can now be imported multiple times**
  - Useful for FMUs which can be instantiated only once per process, such as FMUs from Simcenter Amesim
- **New partner launch method for Simcenter STAR-CCM+ to Simcenter STAR-CCM+ co-simulation**
  - The partner Simcenter STAR-CCM+ simulation can now be launched via Resource Manager
  - Resource Manager handles the partner process internally leading to a more robust management of launched processes

Physics

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

CFD

Flow

- **Speedline boundary condition for turbomachinery**
  - Improved robustness and ease of use for multipoint turbine and compressor simulations with a corrected massflow outlet condition
    - Allows compressor speed lines, from choke to surge, to be generated without the need to change boundary condition types
  - Linear relationship between pressure ratio and exit corrected mass flow along the entire speed line
    - No singularity at choke condition
  - Allows the users to directly set the exit corrected massflow, an important quantity in compressor design
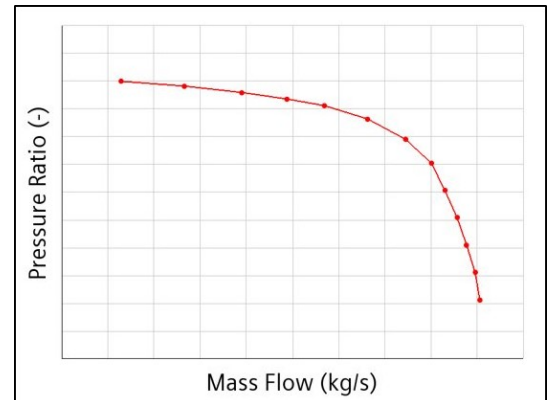
- **Solver robustness: new residual convergence criterion of AMG solvers**
  - Improved stability of steady, coupled flow solver simulations with new residual convergence criterion of AMG solvers
    - Minimizes the need for changing Automatic CFL defaults
    - Reduces the need to resort to Grid Sequencing Initialization (GSI) or Continuity Convergence Acceleration (CCA)
  - Significant speedup with Automatic CFL able to achieve more robust adjustments to the CFL number
    - Faster end-to-end solution especially on simulations that were previously exhibiting stability issues

Density Gradient Magnitude (kg/m^4)
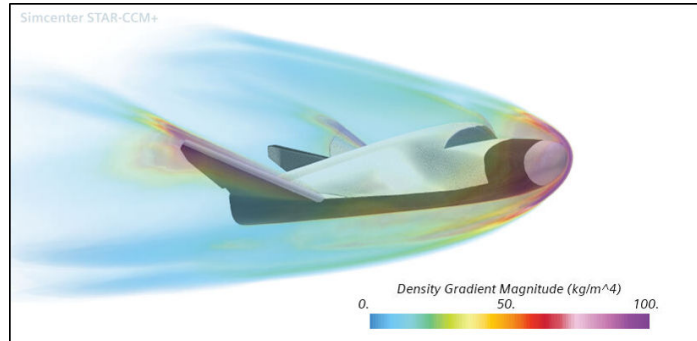
	Time	Speedup
Baseline: Expert Driver	2.3h	1x
Automatic CFL	1.8h	1.2x

- **Material Part Groups: selection priority rules**
  - Facilitates native automation for simulations with large number of parts and materials with a selection priority
    - Object Selection Priority imposes preferred order of material part groups for dynamic part assignments
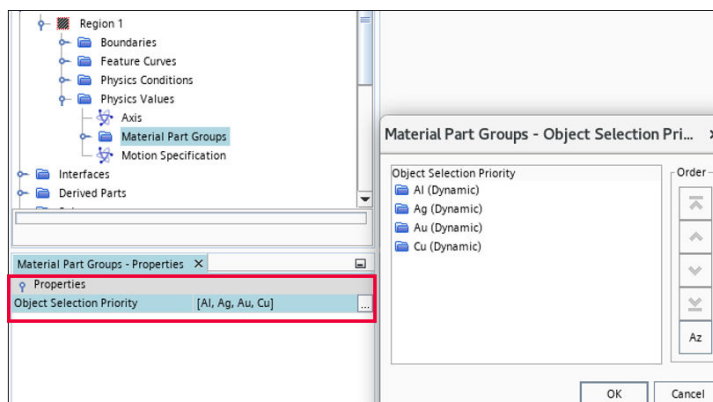
  - Avoids ambiguity and conflicts when using query-based selections with Material Part Groups
    - Manage mutually exclusive dynamic part groups
- **Specific heat specification with table for all equations of state** D2873,D5440,D5528,D459
  - Increased user control and precision when wanting to specify more complex specific heat relationships or relationships over larger temperature ranges
    - Cp(T) option available for all equation of states that already allow polynomial input for specific heat
      - Solid and liquid included
- **Combined species residuals in PISO**
  - Increased computational speed from 1.1x to 2x in a range of industrial in-cylinder simulations by improved treatment for species in the PISO scheme
    - PISO convergence for species and combustion scalars (ECFM, flamelets) based on a combined residual rather than individual component residuals
- **Baffle interface between two phasic porous continua**
  - Enables heat transfer modeling through a baffle interface between two phasic porous media

- **Improved assignment of continua to regions**
  - The pull-down menus for selecting continua for regions have been converted to object selectors

Energy

- **Comprehensive energy model for interfaces involving solid shells**
  - Consolidates energy modeling options and conditions for interfaces with edge/top/bottom boundaries
    - Disables *Internal interface* option when interfaces involve top and bottom boundaries of shell regions (both sides having same continuum)
    - Disables *Mapped interface* option when interfaces involve edge-to-edge connection for solid shells
    - This treatment applies for both coupled and segregated solid shell energy models

Reacting Flows

- **Fast and accurate multiphase combustion D3030**
  - Up to 3x speedup to simulate multiphase combustion by combining Volume of Fluid (VOF) and flamelet methodology
    - Unique capability to model complex free-surface applications with gas-phase flamelet combustion in applications such as Glass Furnaces
    - Combine speed and accuracy of flamelet methodology, for instance Flamelet Generated Manifold (FGM), with VOF
    - Consistent user interaction of the model whether flamelet is in single phase or multiphase
  - Can be combined with model specific adaptive mesh refinements in combustion and VOF
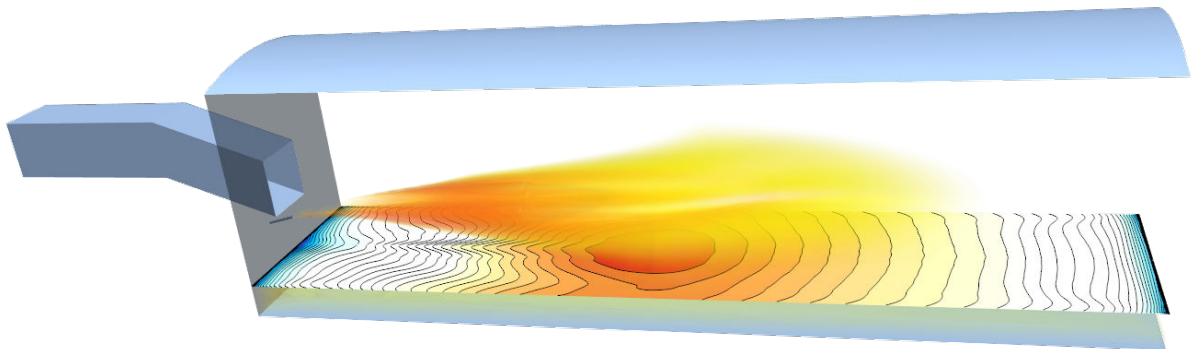
- **Multiple fuel streams in Flamelet Generated Manifold (FGM)**
  - Model multiple fuels in gas phase combustion in a fast and accurate way with enhanced flamelet generated manifold approach
  - Enabling applications in Chemical Process Industry which typically have different fuels such as afterburners and abatement systems
  - Improved usability through *estimate table size* option
- **Retain NOx reactions with Dynamic Mechanism Reduction (DMR)**
  - NOx reactions are now kept when DMR in complex chemistry is turned on, whereas previously the user had to designate N as a *target species* manually
- **Polynomial Cp compatibility in complex chemistry**
  - With complex chemistry it is now possible for the heat capacity (Cp) of the material to be set as a polynomial in temperature
- **Polynomial Density equations of state compatible with complex chemistry**
  - Complex chemistry now supports the use of the Polynomial Density equation of state model
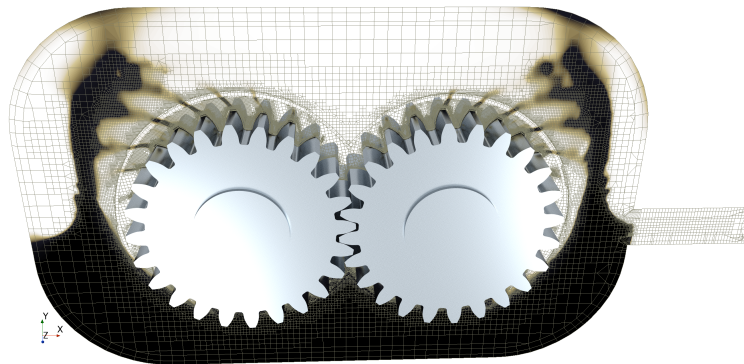
Turbulence

- **Improved computational efficiency of the Gamma-ReTheta transition model**
  - Reduced turnaround time for transition modeling through solver optimization
  - Up to 1.2x speedup improvement observed, without loss of accuracy
  - Background modification, no user interaction required

Multiphase Flow

Mixture Multiphase (MMP)

- **Adaptive Mesh Refinement (AMR) compatibility with Mixture Multiphase (MMP)**
  - Efficient simulation of industrial multiphase flows
    - Application enablement through reduced computational cost with refinements only where needed
    - Improved ability to capture flow features of interest with user defined, field function based, Adaptive Mesh Refinement (AMR)
      - Coarse mesh for homogeneous mixture regions elsewhere
      - No need for extensive regions of fine mesh
    - Gradient based approach can be used to refine free surfaces captured with the Large Scale Interfaces (LSI) model
      - Model based refinement not yet available for free surfaces with MMP

  - Cuts down overall meshing setup time for industrial multiphase flow simulations
    - No need to determine length scales a-priori

Eulerian Multiphase (EMP)

- **Mixture turbulence modeling**
  - Improved robustness by reducing degrees of freedom
    - Previously EMP only had the option of solving turbulence separately for each phase
    - Users now have the option to solve turbulence for the mixture or on a per-phase basis
    - Comparable accuracy for suitable cases
      - Particularly benefits bubbly flows where turbulence is mainly a function of the continuous liquid phase and phasic turbulence is unnecessary
      - Less suitable for droplets and particulate flows
  - Reduced time to solution by solving fewer transport equations
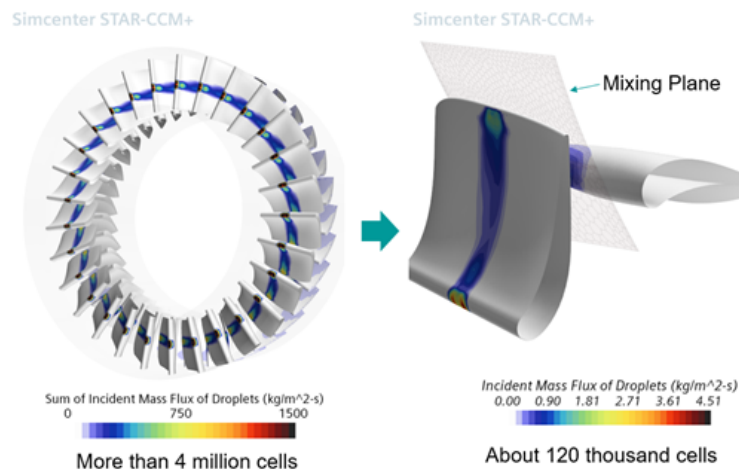   - Typically saves at least 2 equations per additional phase

- Test cases show 1.1-1.2x speed-up
- **High Resolution Interface Capture (HRIC) scheme for EMP-LSI**
    - Improved accuracy for free surface flows where interface is known to be sharp everywhere
        - Achieved by applying HRIC throughout the domain
        - Mirrors Volume Of Fluid (VOF) approach within EMP framework
        - Presented as new option alongside existing ADaptive Interface Sharpening (ADIS)
        - Not suited to cases where fluid interface is physically not sharp everywhere
    - More tolerant of under-resolution of problems
        - ADIS applies HRIC only in identified interface regions
            - Assumes diffuse interfaces physical
            - Often in reality caused by under-resolution
        - HRIC aims to sharpen everywhere
            - Less physical approach but more tolerant of under-resolution
            - Free surfaces are better maintained as sharp features
- **Wall boiling: Unal model for bubble departure diameter**
    - Improved accuracy for low pressure boiling applications while providing comparable accuracy to existing models for higher pressure applications
    - Three options now available for bubble departure diameter
        - Unal
        - Tolubinsky
        - Kocomostafagullari
- **S-Gamma population balance model performance**
    - Reduced run times with the S-Gamma population balance model
        - Particularly benefits the Discrete Quadrature S-Gamma model
            - Test cases show up to 1.34x speed up
            - Benefit increases with number of quadature points
        - Pre-Integrated approach also demonstrates small performance improvement

Solution Method	Time per Iteration 2021.1	Time per Iteration 2020.3	Speed-Up
Pre-Integrated	27.73 s	29.37 s	1.06x
DQ4	32.98 s	37.80 s	1.15x
DQ12	54.57 s	73.22 s	1.34x

Lagrangian Multiphase (LMP)

- **Transmit mode for Lagrangian particles at mixing plane interface D3121**
    - Reduced computational cost in simulation of droplet/particle ingestion in turbomachinery
        - Up to 100x speedup depending on the number of blades and the complexity of geometry
    - Typical applications include
        - Water droplet ingestion by turbine engines, ice accumulation on blades
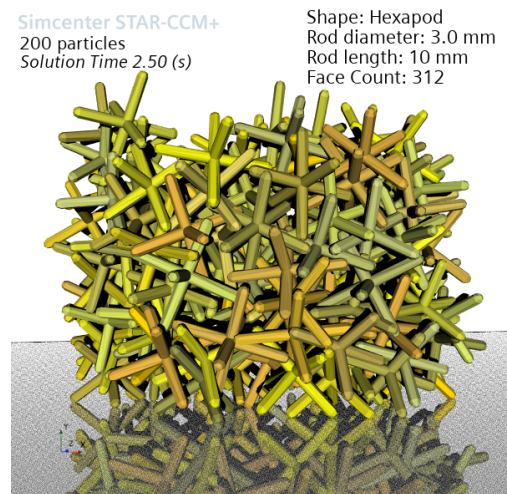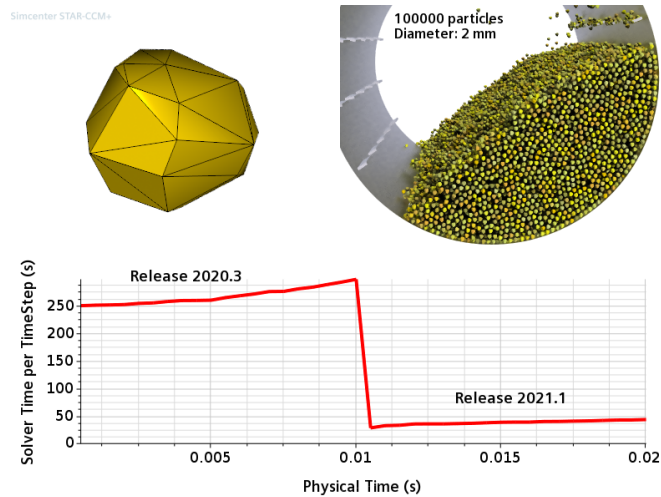   - Sand ingestion by helicopter engines

Sum of Incident Mass Flux of Droplets (kg/m^2-s)
0   750   1500
More than 4 million cells

Incident Mass Flux of Droplets (kg/m^2-s)
0.00   0.90   1.81   2.71   3.61   4.51
About 120 thousand cells

- **LMP drag coefficients exposed as field functions**
  - ○ Improved understanding of simulation results with new field functions for Lagrangian drag coefficients
  - ○ Ease of use improvement when setting user-defined drag force
- **VOF-Lagrangian impingement field functions availability adjusted**
  - ○ Improved ease of use by accounting for model dependencies when presenting the choices for field functions
  - ○ Field functions VOF-Lagrangian Momentum Source of Phase Interaction, VOF-Lagrangian Continuity Source of Phase Interaction, and VOF-Lagrangian Energy Source of Phase Interaction are now available only when Two-way Coupling model is active

Discrete Element Method (DEM)

- **Concave polyhedral particles** D3485
  - ○ Expands application coverage in capturing the effect of particle shape by supporting concave shapes in the Polyhedral Particle model
  - ○ Typical applications
    - ▪ Packing of catalyst particles in fixed bed reactor
    - ▪ Handling and packing of manufactured parts
    - ▪ Processing food particles
- **Optimized contacts for non-spherical DEM particles**
  - ○ Robustness and speed improvements for simulations with non-spherical particles through algorithm upgrade
    - ▪ Up to 10x speed improvement
    - ▪ Speedup depends on particle material properties, surface mesh, selected models
    - ▪ Relevant for Polyhedral, Cylindrical, and Capsule particle models

Simcenter STAR-CCM+
200 particles
Solution Time 2.50 (s)

Shape: Hexapod
Rod diameter: 3.0 mm
Rod length: 10 mm
Face Count: 312

Computational Rheology

- **Curing (Chemorheology) solver**
  - Gain insight into product end quality in curing and thermosetting processes such as tire vulcanization
    - Many polymers, rubbers, and plastics require a curing step in manufacture to harden the product
    - Chemorheology solver allows prediction of the *degree of cure* and the *apparent curing viscosity*
    - Can be used in a coupled manner with the flow, or more commonly as a separate step after filling by freezing the flow
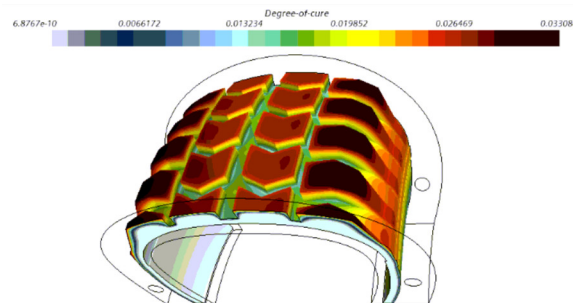
Computational Solid Mechanics

- **New workflow for Fluid-Structure Interaction (FSI)**
  - Easier, more consistent, workflow for FSI simulation
    - Workflow completely revised to ensure consistent setups
  - The FSI model is no longer required in the solid physics continuum
  - Coupling specifications have been moved from the interface to the interface boundary in the solid and fluid region
    - The FSI Coupling Specification at the interface boundary in the solid region may be set to either:
      - Uncoupled - no fluid loads are applied

- Fluid Load - fluid pressure and wall shear are applied as a traction load
  - The FSI Coupling Specification at the interface boundary in the fluid region is a read-only property and is controlled through the motion assigned to the coupled solid region
  - Solution stabilization methods must be enabled under the Fluid-Structure Coupling solver
    - The new default is to use no solution stabilization method
    - For 2-way coupled setups it is highly recommended to enable the Boundary Interface Added Mass method
    - In previous releases the Boundary Interface Added Mass method was always enabled
    - Only one solution stabilization method may be used at a time. Combining two solution stabilization methods is no longer supported
  - The workflow enforces:
    - Consistency of references frames
      - Fluid and solid must use the same reference frame
    - Consistency of interface deformation
      - The mesh on both sides of the interface must move and deform in the same way
      - No sliding or any other form of relative motion is allowed
      - Not all motion models can be combined with each another
  - The following coupling scenarios are supported
    - 2-way coupling
    - 1-way coupling fluid to structure
    - New: 1-way coupling structure to fluid
  - Please refer to the user guide for a detailed description of all changes
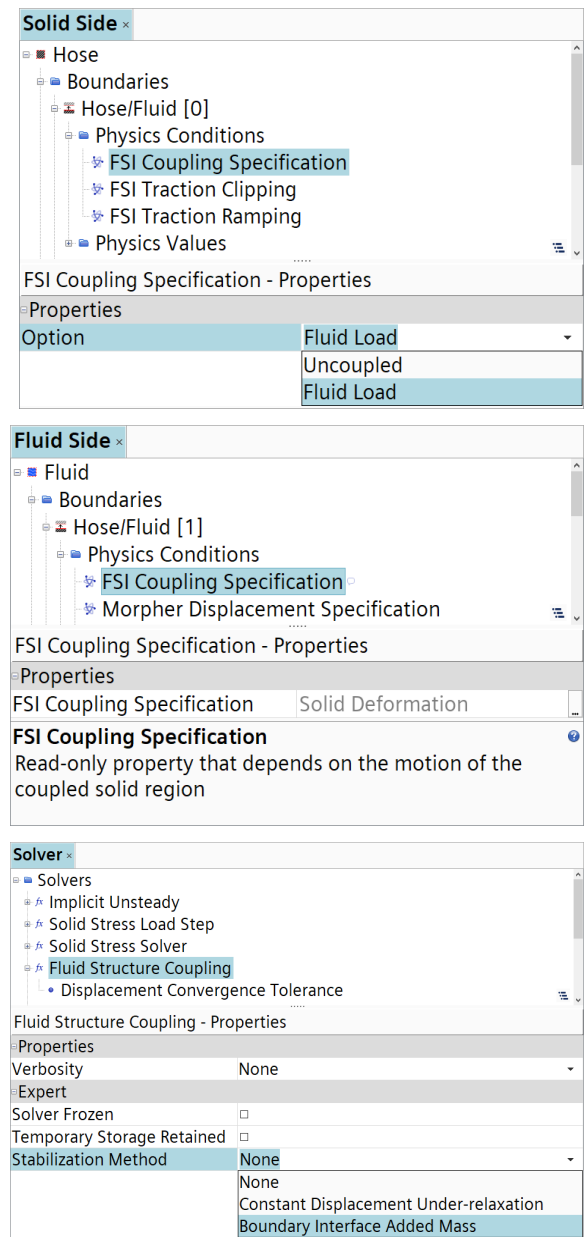
Electromagnetics and Electrochemistry

Electromagnetics

- **Finite Element (FE) Excitation Coil model: Vector method**
  - Improved usability of 3D simulations with new vector method option for FE Excitation Coil model

- Specify coil current direction simply via a point and an arrow
- Useful for simulations of electric machines requiring a 3D approach, for instance due to magnet segmentation or skewness
  - Expanded application coverage with setup of closed coils (uninterrupted loops)
    - Useful for modeling Axial Flux Machines
  - Reduced cell count for coil geometries which can make use of periodicity conditions
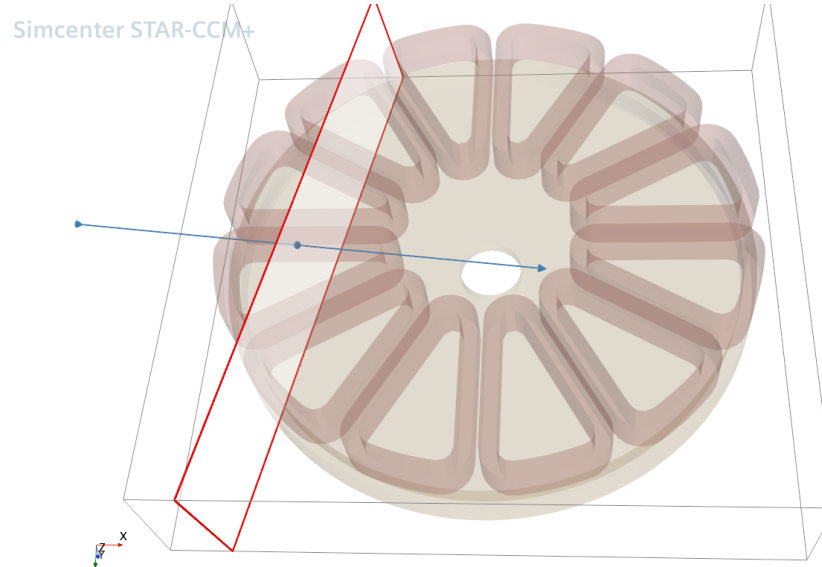
- **Electric circuit editor D4103**
  - Simplifies setup of electric circuits thanks to graphical editor
    - Set up circuits with an easy-to-use, intuitive, point-and-click tool
    - Easily inspect and interpret existing circuits for a clear and immediate overview
    - Includes library of common circuit element symbols (resistors, capacitors, voltage, current sources)
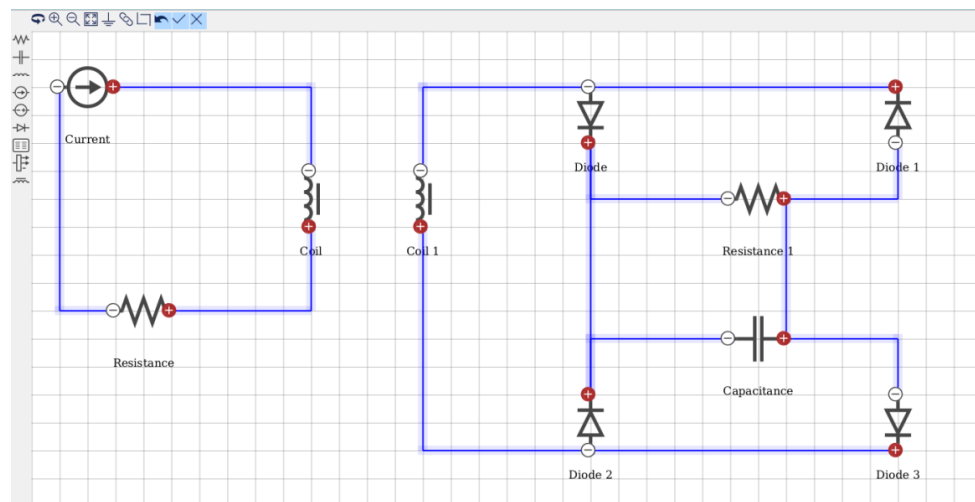
- **Speedup of Finite Element (FE) computations in frequency domain**
  - Improved turnaround time (up to 9x speedup) and decreased memory footprint (up to 5x less) of frequency domain simulations with FE thanks to new Iterative Solver
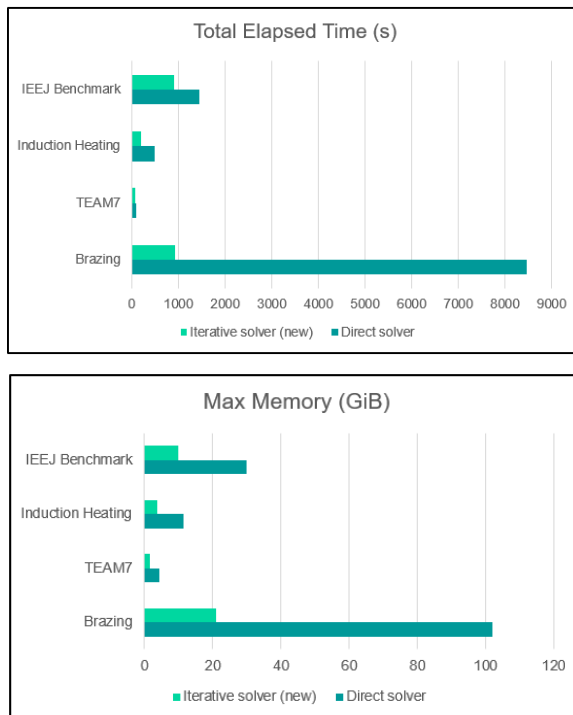
- **Finite Element (FE) Excitation Coil model in frequency domain**
  - Simplified setup of induction coils in frequency domain
    - The FE Excitation coil model is now compatible with the Harmonic Balance FE Magnetic Vector Potential model
    - Pre-computing and mapping of coils' current no longer required
- **Finite Element Excitation Coil model: compatibility with Finite Element Solid Energy model**
  - Combining the two models potentially improves accuracy of predicted temperature distributions
- **Improved accuracy and robustness of nonlinear anisotropic permeability material model**

Electrochemistry

- **Secondary Gradient Limiter for improved stability for Electrodynamic Potential Solver**
  - Substantial improvement in the stability of the electrodynamic potential solver through novel numerical treatments
    - Spend less time optimizing for stiff mesh requirements
    - Automated detection of cells that require this approach
    - Can be combined with *Electric Potential Presolve* for improved initialization leading to more stability
  - Improved ease of use with a single switch for all continua
    - Consistent secondary gradient treatment across any continua using the solver
    - Allows explicit choice between accuracy and stability
- **New initialization: Electrodynamic Potential Presolve**
  - Improved usability and stability for electrodynamic potential solver through automated initialization method
    - New initialization method for electric potential, similar approach to Grid-Sequencing in coupled solver
    - No longer necessary to tune expert solver setting for initialization
    - Linear ramps on other solvers can now be removed
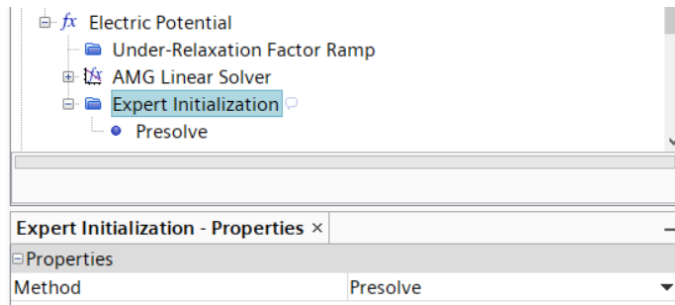
Aeroacoustics

- **Usability enhancements for the acoustic wave model**
  - Faster set-up for aeroacoustics simulations with better defaults
    - *Acoustic Damping Option* and *Noise Source Weighting Option* now always enabled and the options are no longer in the user interface
    - No reduction in functionality
  - Improved ease-of-use through clearer input options
    - Explicit User Defined Noise Source—previously hidden in the Noise Source Weighting Coefficient
- **Efficiency enhancement for acoustic wave model substepping**
  - Higher efficiency through improved default solver settings
  - New defaults make more efficient use of solver processes, which can save up to half the number of acoustic iterations

Motion, Mesh Adaption, and Mapping

- **Automatic Remeshing Solver D2286**
  - Improved ease of use for morph and remesh scenarios through automatic remeshing
    - Avoids negative volume cells through pre-morphing, triggering remesh when needed
    - Eliminates Java macros for export, re-import of deformed surfaces, and remesh
    - Applications: Rigidly deforming boundaries requiring remeshing such as in-cylinder combustion, ice-accretion, electrochemical machining
      - Dynamic Fluid Body Interaction (DFBI) and fluid-structure interaction (FSI) not supported
    - Selected via **Physics Continuum > Models > Remeshing**
      - User-defined definition of remeshing criteria by a Trigger (for example, Time-Step or Update Event)
      - Clear Solution: Mesh reset restores the initial mesh
- **Faster Adaptive Mesh Refinement (AMR) in cases with interfaces**
  - Previously all the interfaces were reset during adaption
    - Solver elapsed time increased due to interface intersection time
  - Now interfaces are reset during adaption only if cells at the interface are refined/coarsened
    - Supported interfaces: imprinted, mapped, explicit mapped contact, and connect average
  - Speedup is case dependent

Adjoint topology optimization of a brake cooling duct

Yellow region: AMR active
Pink: Interfaces where AMR active
Blue: Interfaces without AMR

Total Solver Elapsed Time
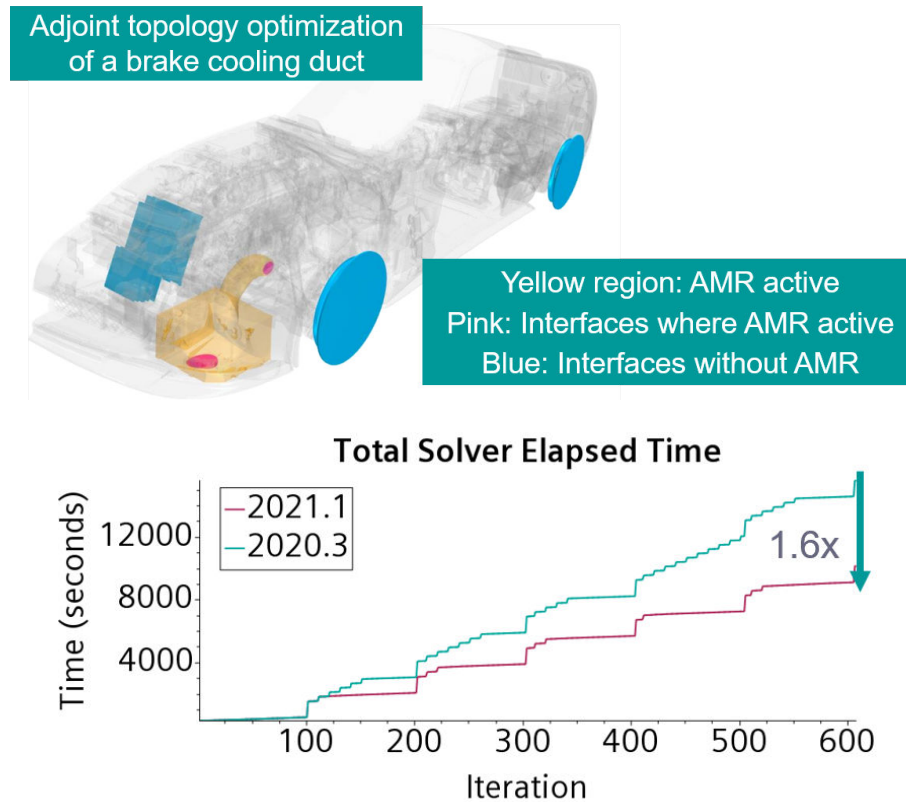
- **Prism Layer Shrinkage for Fluid Structure Interaction**
  - Accurately and efficiently resolve flow in small gaps between contacting walls through shrinking the prism layers
    - "Prism layer shrinkage", a feature in overset meshes, is now available for fluid/solid interface (mapped contact interface)
      - *Mapped contact interfaces* can trigger and allow prism layers to shrink
    - Applications: Opening/closing of flexible valves
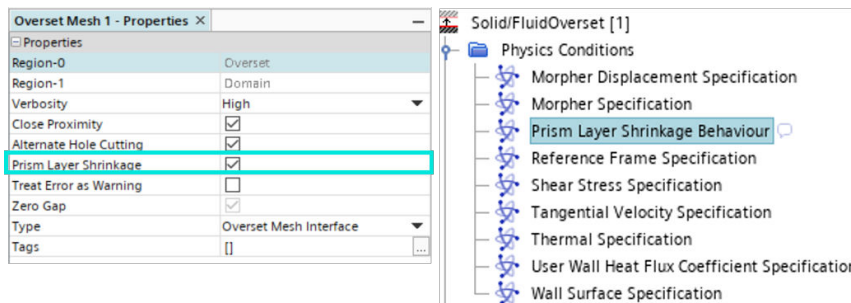
- **Robust handling of prism layers with jumps in number of layers when using overset "Prism layer shrinkage" or "Rigid prism layer" morphing option**
  - The field function **Prism Layer Shrinkage Status** is replaced with **Prism Layer Level**
- **Second order accurate grid velocity can now be selected for second order time-accurate rigid body motion cases**
  - Available for superposing motion, user-defined vertex, and morpher motion

Design Exploration

Adjoint

- **Adjoint support for passive scalar** <mark>D4404</mark>
  - Extends adjoint capabilities by facilitating optimization with respect to a passive scalar transport quantity
  - Enables the tracking of flow that starts from one inlet and branches out in several directions
    - Can be used as a reversed passive scalar with a cost function of the passive scalar surface integral
  - The adjoint passive scalar can run independently of the adjoint flow model
    - Segregated primal allowed
- **Adjoint automatic differentiation of field function source terms**
  - Improved usability and reduced user error by automatic differentiation of field function source terms
    - In the past, the user had to provide the source term differentiation

Design Manager

- **Surrogate Models**
  - Leverage and exploit your accumulated knowledge by predicting thousands of variants using existing databases of simulated results
  - Surrogate models approximate new designs' responses by fitting mathematical models to a database of simulated results
    - Least squares linear or quadratic models for local approximations
    - Kriging and Radial Basis Function models for entire design spaces
  - Inputs usually come from DOE studies, but any existing database of results can also be leveraged
    - Model outputs are predicted new variants
  - Increase robustness and reliability of high performing designs
    - Predict thousands of variants around best designs
    - Assess local parameters' sensitivity using distributions
    - Analyze probability of failure using the Probability Distribution Plot

Probability Distribution Plot

Velocity Uniformity MA:
Mean = 0.875052
Variance = 7.04175e-05
Std. Dev. = 0.00839152
Bin Width = 0.00204818

- Reliability_3
- Uniformity constraint (min 0.87)

Velocity Uniformity MA
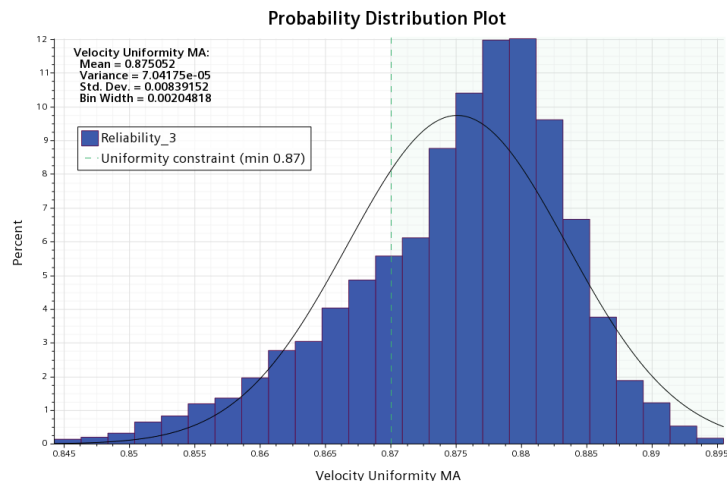
  - Save time during 0D/1D coupling (Simcenter Amesim, Simcenter Flomaster, ...)
    - Quickly characterize 3D components with a fast integrated model interrogation

- ▪ Automatic FMU export for a greater information exchange
- ○ Accuracy of surrogate models can be assessed using
  - ▪ R² (coefficient of determination) for least square method
    - - Can be visualized using the Surrogate Fit plot
  - ▪ Cross Validation residuals for all models (the lower the better)
    - - Can be visualized using the Actual vs Residual plot

Actual vs Residual Plot
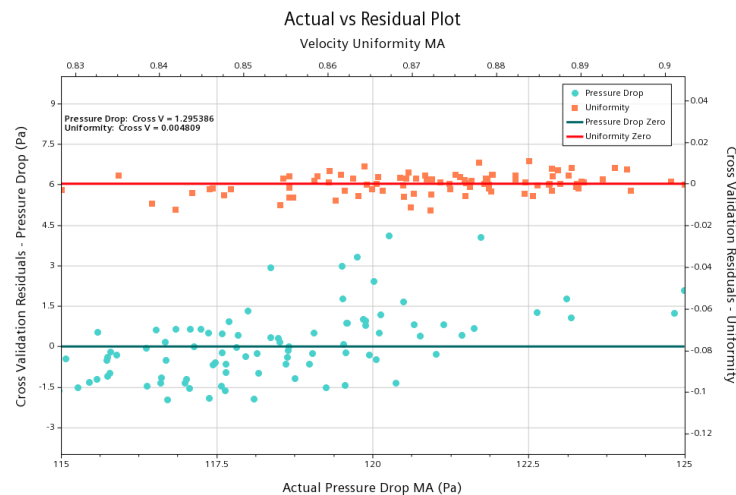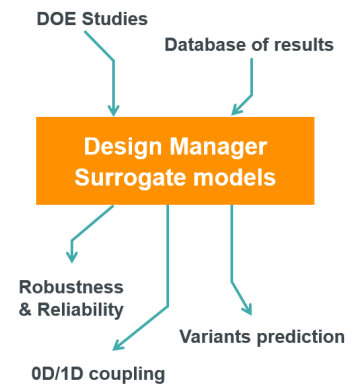
- ▪ Prediction Error Sum of Squares (PRESS) for Kriging and RBF
  - - Corresponds to a leave-one-out cross validation

- **Update design metrics**
  - ○ Leverage existing data to predict results for new study scenarios
    - ▪ Allow changes of any study objective or constraint
    - ▪ Automatically update design metrics values and plots accordingly
  - ○ Provide flexibility to adjust study scenario based on
    - ▪ Results obtained (relax constraint for example)
    - ▪ Project requirements evolution
- **Pie Charts**
  - ○ Immediately grasp design study health to save time and resources by clearly visualizing design state and study convergence
    - ▪ Running, error, successful, feasible, unfeasible
  - ○ Take action while running to avoid wasting resources
    - ▪ Immediately free up hardware and license resources from a review of your study progress indicators
  - ○ Automatic chart creation occurs at start of study
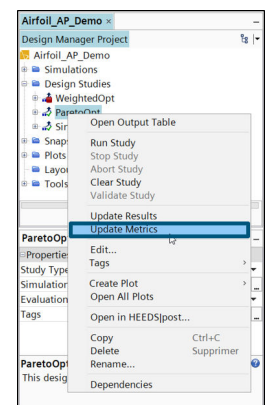
Pie Chart_Pitot Optimization
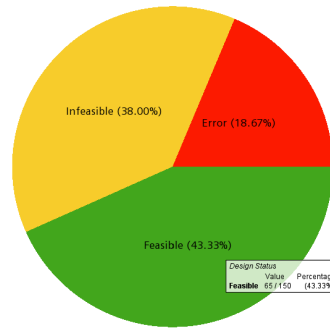
- **Import external data** D4537
  - ○ Leverage and compare results from various sources
    - ▪ Import and plot data from
      - - Different Design Manager studies or projects
      - - Experimental studies
      - - Any other simulation tool
- **Local scratch space support for pre-allocation mode**
  - ○ Increase flexibility of cluster deployment by enabling the use of local workspaces
- **Direct Design Table access** D5094
  - ○ Faster access to study data by double clicking on study node
- **Clear plot selection**
  - ○ Removing any highlights in plots when clicking on an empty area
- **Design queue state**
  - ○ Quickly identify the queue state and resource type used for each design using both tooltip and design details dialog

- **HEEDS|post access from Design Manager change notice**

- ○ HEEDS|post packaging with the Simcenter STAR-CCM+ Intelligent Design Exploration license is discontinued in this release
- ○ HEEDS|post is still accessible from the Design Manager interface with:
  - ▪ A standalone HEEDS|post license (one license checked out per session)
  - ▪ A separate HEEDS|post installation2nd level list item

Data Analysis

- • **Simplified Weighted Average Report D4366**
  - ○ Increased robustness when applying arbitrary weighting factors in averaging reports
    - ▪ Specify user defined weighting function using a simpler workflow compared to previous releases

2020.3   2021.1
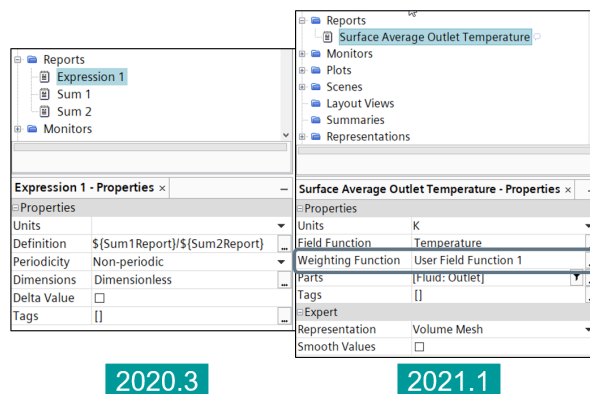
- ○ Creation of sum and expression reports is no longer required
  - ▪ New option to specify arbitrary Field Function as Weighting Function
  - ▪ Currently applies to Surface Average and Volume Average reports
- • **Plotting enhancements**
  - ○ Easily find inputs for a given data series in the simulation tree
    - ▪ New right click option for data series inputs in the tree
      - - Avoids tedious scrolling in simulation tree to find and edit appropriate inputs
    - ▪ Ability to multi-select and multi-edit the input objects
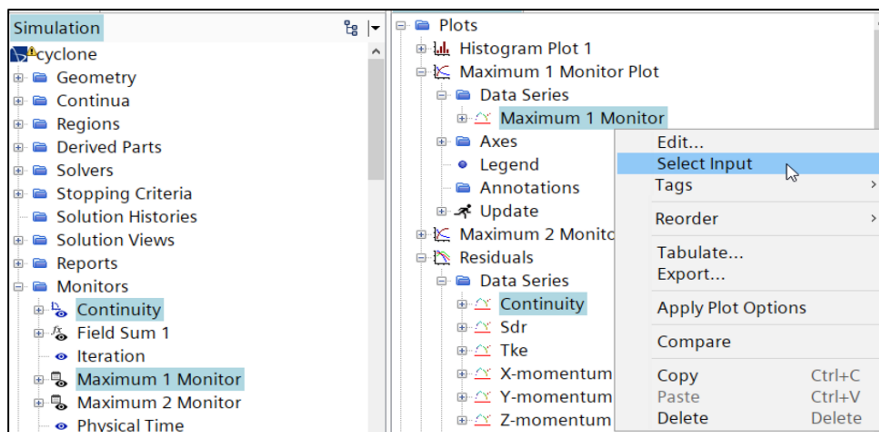
- ○ Improve readability of Histogram Plots
  - ▪ Overcomes limitation of obscured bars for better visual comprehension
  - ▪ Now possible to change the transparency of bars
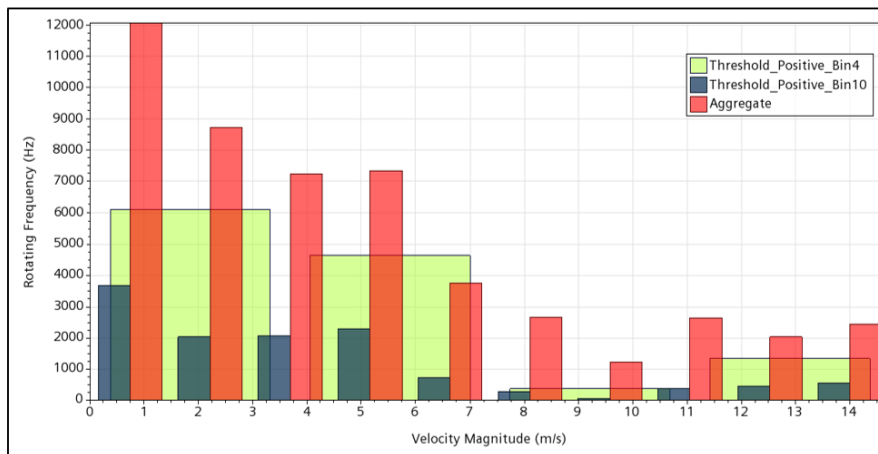
- **Expression support: Colorbar Range in Displayers D4906**
  - Provides greater flexibility by defining colorbar range using expressions
    - Quickly/consistently synchronize ranges between displayers/scenes using global parameters
    - Normalize displayer range for ease of comparison
    - Pre-define Min/Max ramp rate for transient simulations

  - Overcome previous constraints of using constant values
    - Specify Min/Max value using expressions in different units
    - Currently applicable in scalar, vector and streamline displayer types
- **Circumferentially averaged solution visualization D3418**
  - Easily visualize 2D average of a 3D solution for turbomachinery to better understand overall machine performance
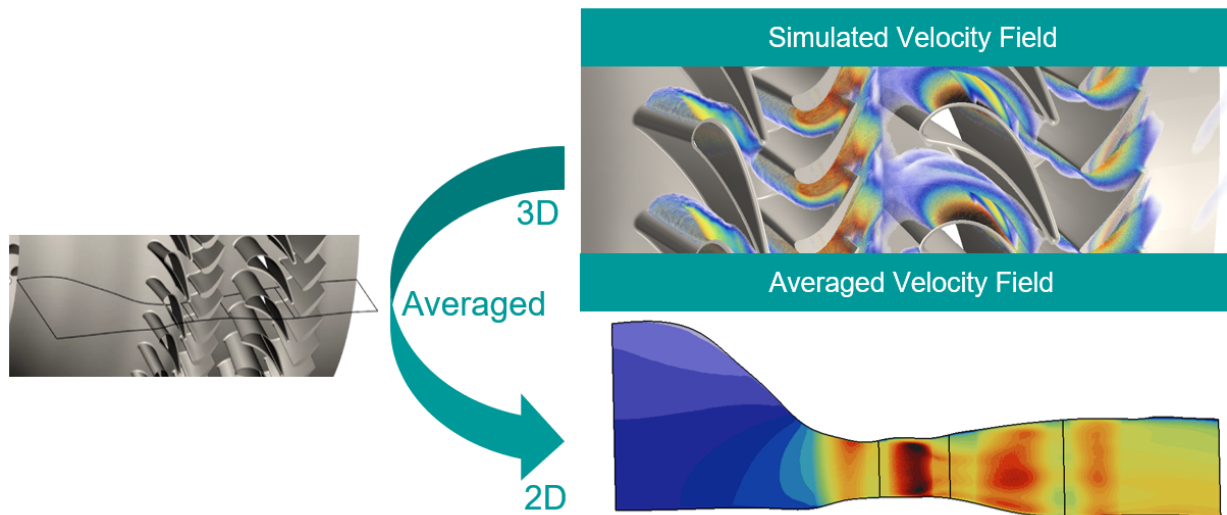
- Visualize key flow field characteristics influencing performance
- Readily identify issues in the flow-path
- Relate simulation to earlier lower-order design methods

- **Flattened view of a rotational geometry solution D3418**
  - Clearly and consistently compare different candidate designs by projecting complex blade-to-blade solution to a flattened 2D view
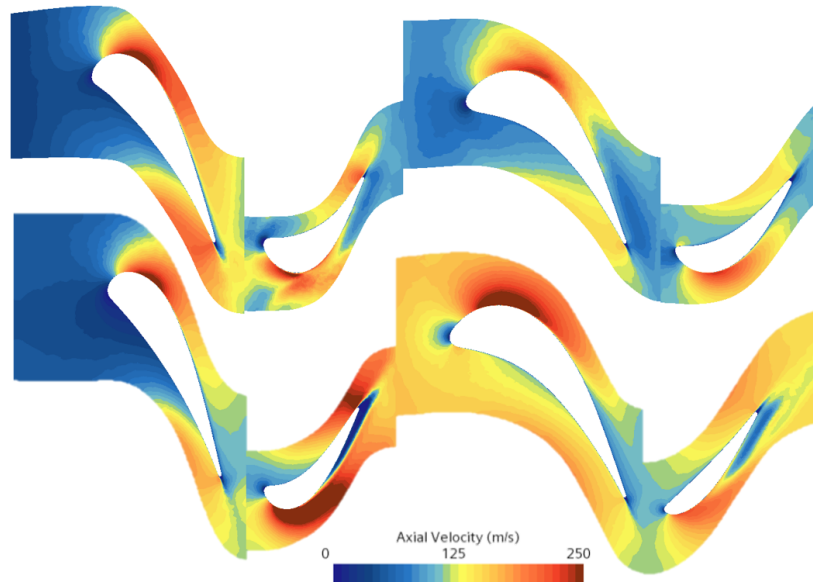

  - More meaningful comparison between candidate designs
    - Retain angles so that vectors relative to the blade orientation are preserved
    - Relate lengths so that blade shape and size are preserved

- **Updated scene defaults**
  - Increase productivity compared to previous releases with better scene defaults
  - Fewer modifications to get to an effective scene
    - Better visual comprehension of results
      - New default colormap is *blue-yellow-red*
      - Solid white background

- Updated Axis triad colors
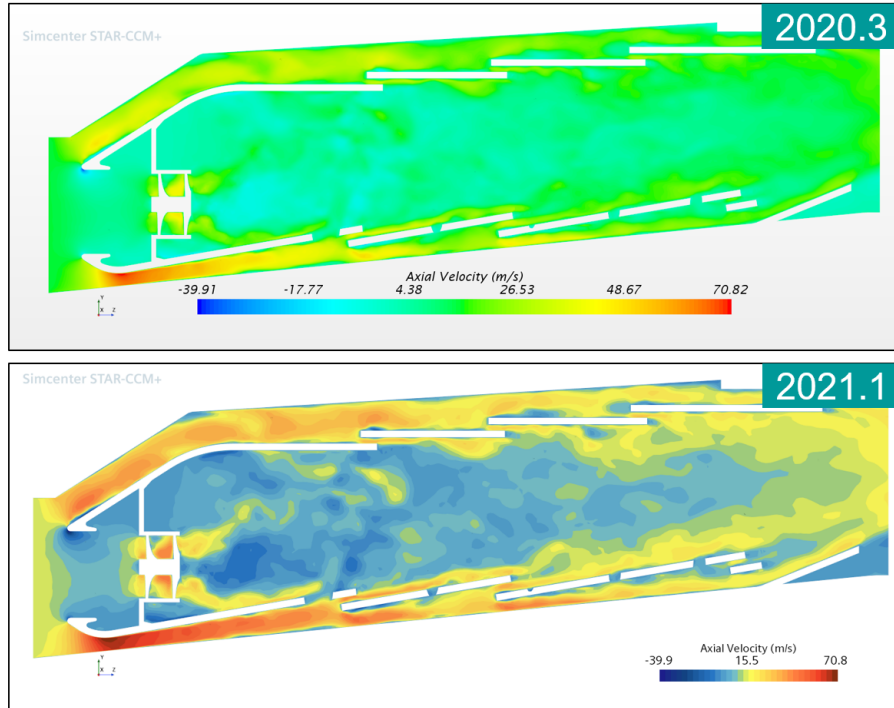
- Easier interpretation and less visual clutter for colorbar
  - Number of labels set to 3
  - Format set to 3 significant digits
  - New width, height, and position placement
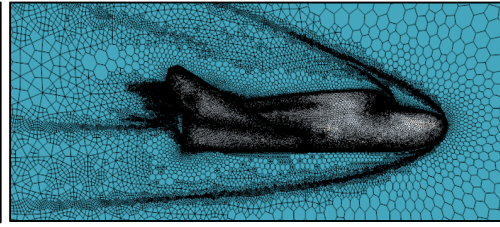 - Colorbar font set to *plain*
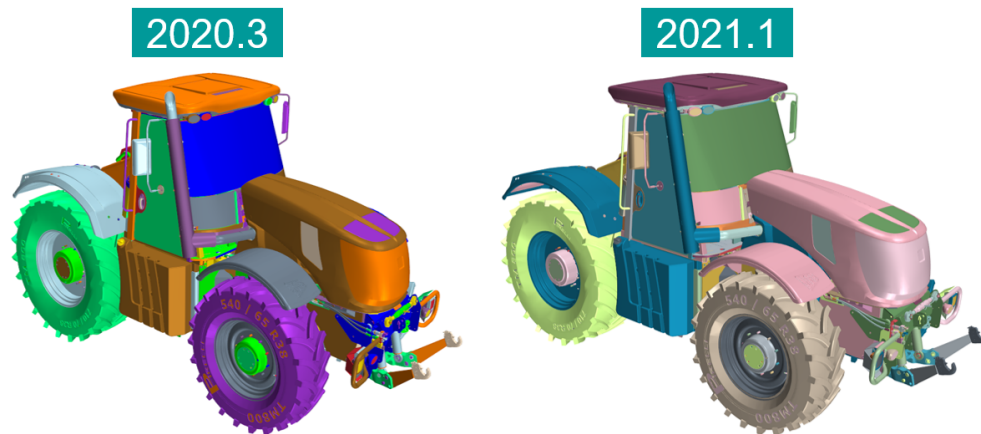
- New palette colors automatically applied for:
  - Color by boundary type
  - Color by regions type
  - Distinguish inputs/region mode
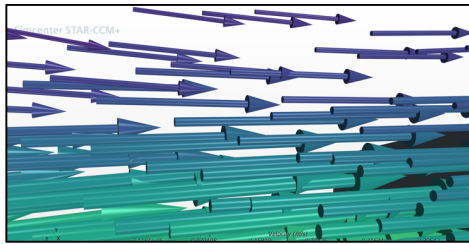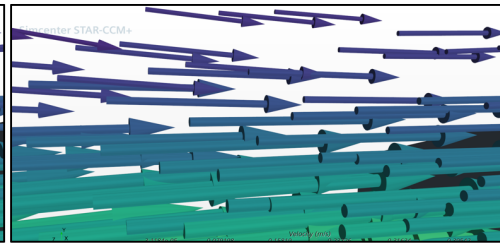 - Consistent with other Siemens Portfolio tools
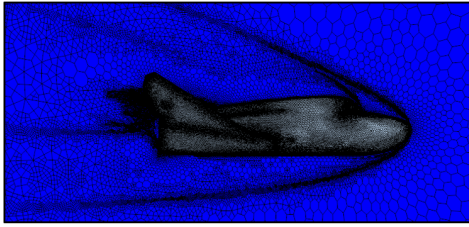
- Enhanced surface lighting avoids visual distortion
  - Per-pixel lighting becomes new default
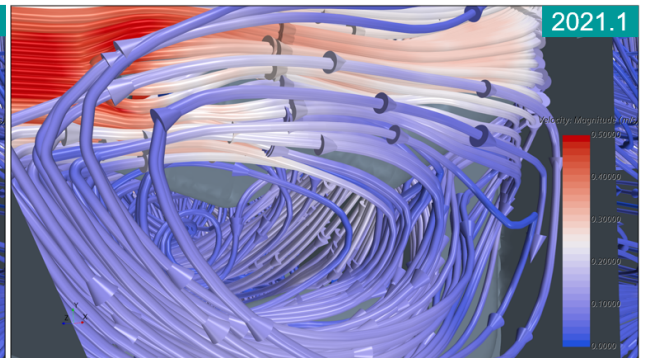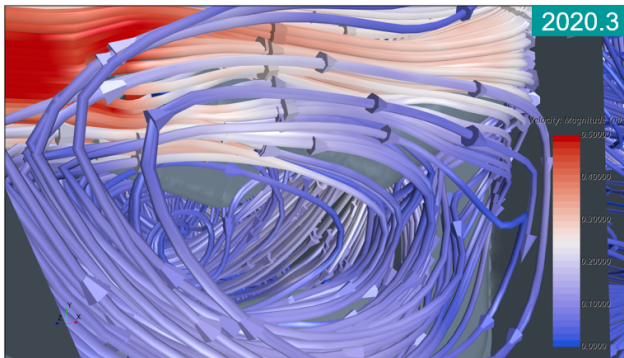 - Diffuse lighting in data displayers (geometry, vector, and streamline) improves visual effectiveness


- **Improved appearance for Streamlines**
  - Achieve better visual comprehension of results with improved streamline rendering
    - Streamlines now use less memory resulting in smoother animations
    - The *Tubes* mode for streamline displayers is now the default


- **MP4 export for animations**
  - Maintain high movie quality at significantly reduced file size compared to previous releases with support for MP4 export
    - Share movie files more efficiently
    - Enhanced compression output delivering smaller size while maintaining quality
    - Bar chart below illustrates significant reduction in Screenplay animation export file size in 2021.1
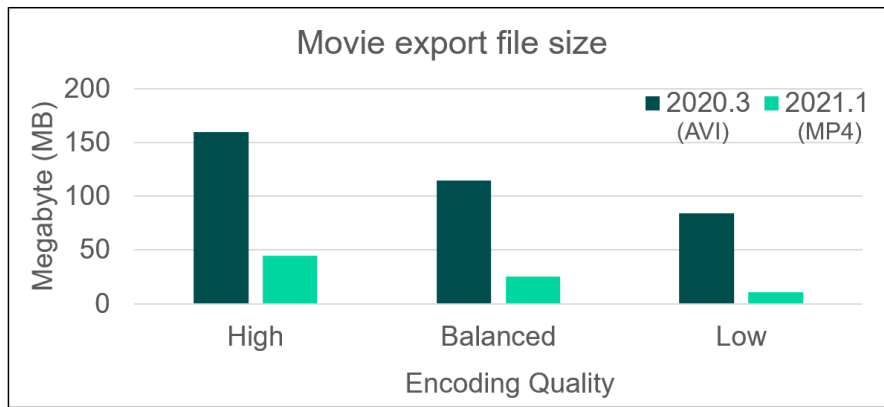
-
  - Macros from previous releases auto export in new format
- **Multi-GPU support for rendering**
  - Faster rendering for simultaneous users on multi-GPU rendering resources
    - Increased performance benefit with increasing number of simultaneous users
    - Addressed first GPU only limitation of previous versions
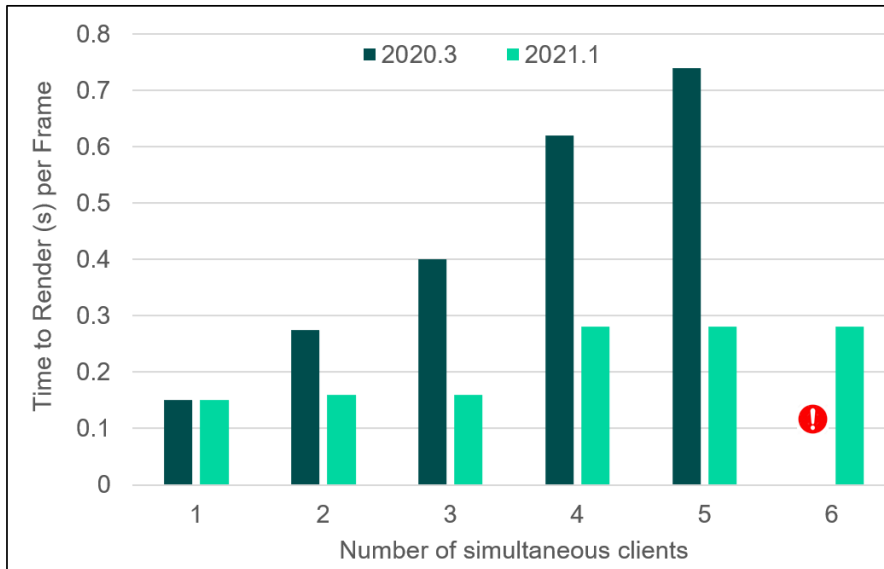

⊘ Renderer crashes due to oversubscription of graphics hardware

  - Leverage all available GPU resources
    - Default auto-assignment of next GPU to each new user
   - New command line option to custom assign specific GPU
- **Interactive quantitative analysis in Virtual Reality** <mark>D5199</mark>
  - Perform quantitative analysis directly in Virtual Reality
    - Interactively analyze data through annotations
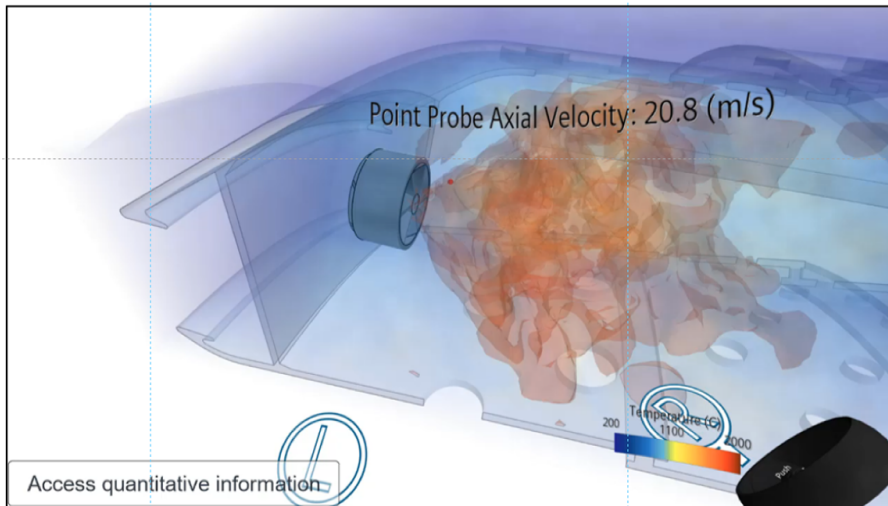
- Support available for four derived parts
  - Point probe, Line probe, Plane section, Presentation Grid
- Intuitive and precise editing of existing derived parts
  - Delete, Copy, Clone, Splat
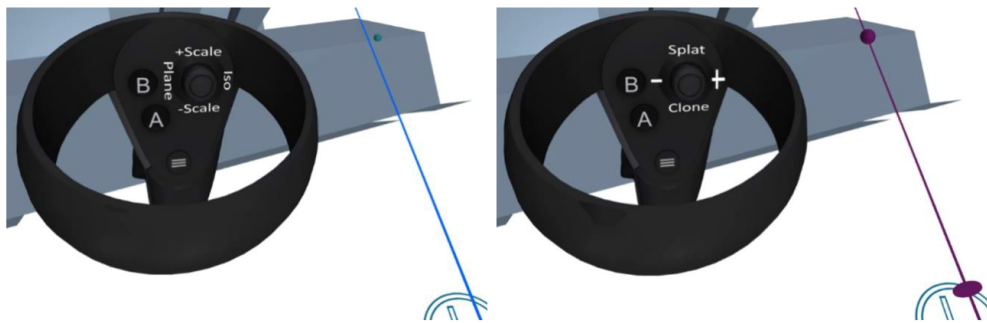
- Scene scale limits to reduce user confusion or discomfort
- **Improvements to scene rendering and hardcopy**
  - Improved scene rendering throughput on Linux systems
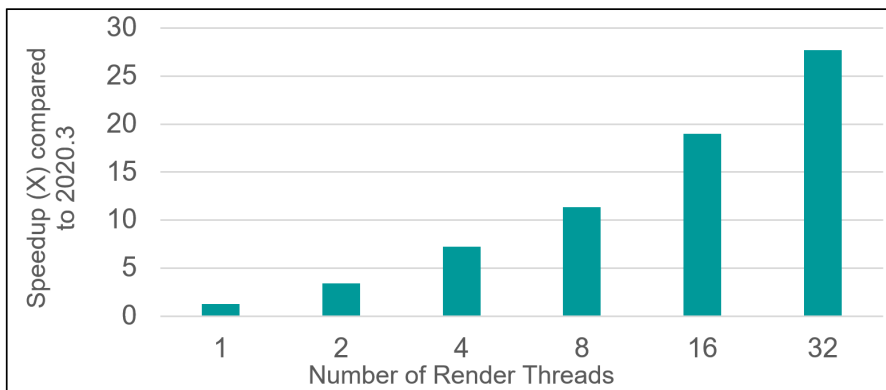
- Bar chart above illustrates performance gain for rendering a scene with 13M triangles
- Performance gain increases with increasing number of render threads
- Faster export of scene hardcopies with Magnification Factor > 1
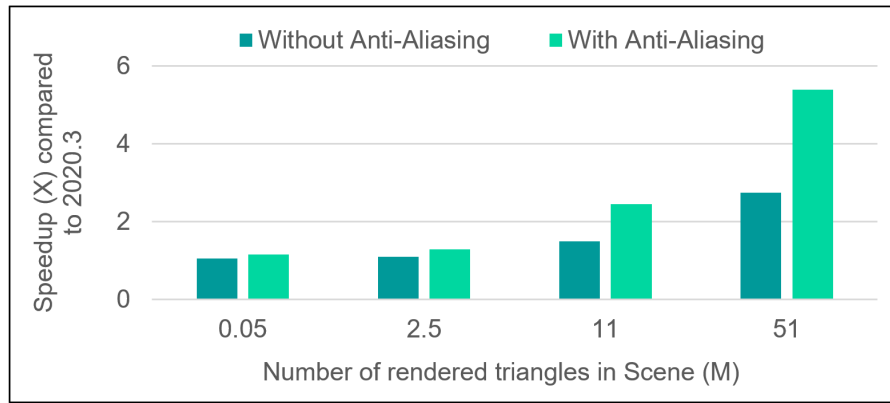
- ○ Performance gain:
    - Is greater when anti-aliasing is used
   - Increases with increasing triangle count in a scene

Application Specific Tools

Simcenter STAR-CCM In-cylinder Solution
Electronics Cooling

Simcenter STAR-CCM In-cylinder Solution

- **Axisymmetric sector modeling**
    - ○ Save significant time for closed-loop simulations by running a sector model
        - Various options for spline import of head/liner/piston profiles
        - Select 3+ symmetric sectors
        - Fast and stable mesh with radial cell coarsening
        - Initialize swirl in the cylinder
        - Optional selection of Diesel formulation for Angelberger wall treatment
- **GruMo-UniMORE heat transfer model**
    - ○ Improved accuracy of thermal heat flux for CHT simulations without ad hoc scaling
        - Developed via research partnership with the University of Modena, previously released and proven in STAR-CD
        - Simple setup via the In-cylinder Solution workflow with a single selection
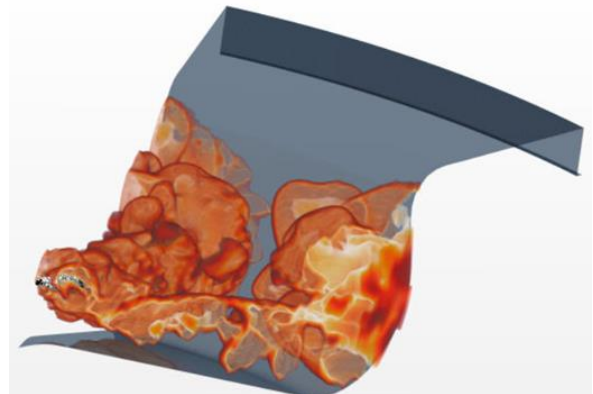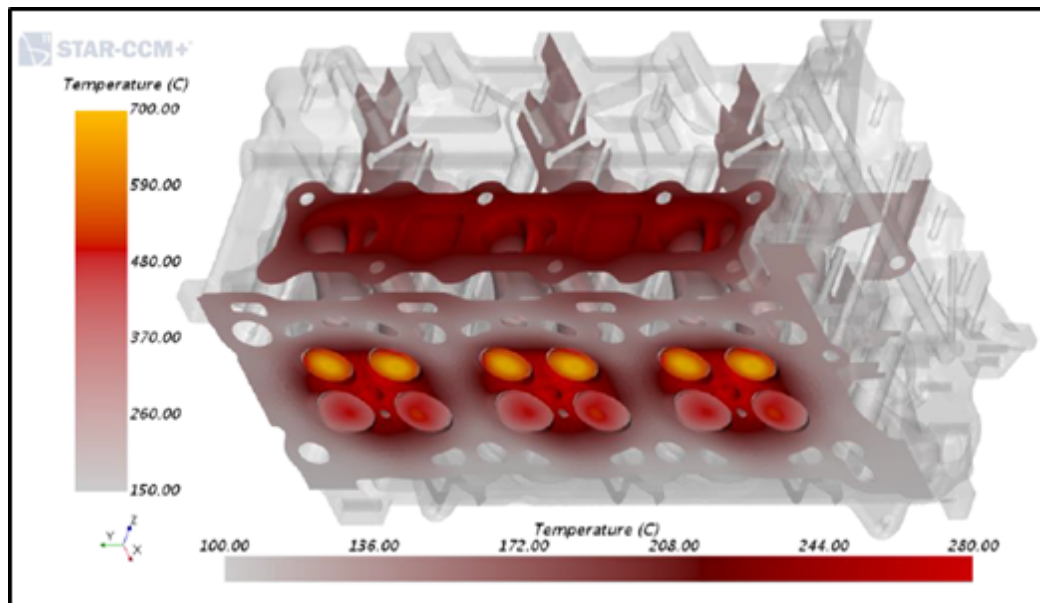
- **Multi-edit of QuickPart surfaces** <mark>D5631</mark>
 - Greatly reduce setup time and costly input errors for repetitive actions by editing multiple QuickPart surfaces simultaneously
  - Notable time/effort savings in setting up thermal boundary conditions when applying XYZ tables
- **Ignitor persistence when changing combustion models**
  - Eliminates the need to setup an ignitor after changing combustion models (for example, from ECFM-3Z to ECFM-CLEH)
    - Ignitor definition persists and is not deleted
- **Modified auto-timestep algorithm**
  - Set up more robust simulations with flexible time step control
    - The time step control input has been simplified, allowing flexible input of the time unit for the fixed step size (s or degCA)
    - A table vs. time and automatic control can now be combined; whichever is smallest at any given point in the cycle is applied
- **Set initial conditions as single-point, constant values**
  - Reduce complexity when setting initial pressure/temperature conditions without the need to generate a simple lookup table
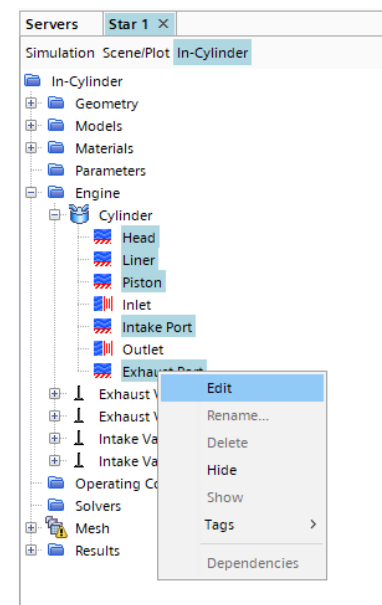
Electronics Cooling

- **Multiple scenes**
  - Improved flexibility in viewing simulation results with the ability to create multiple scenes
    - Allows visualization of different simulation elements without having to remove existing ones
    - Provides consistency with main simulation tree as you are no longer constrained to a single scene
  - Overall functionality remains the same. You can create and add multiple displayers in each scene
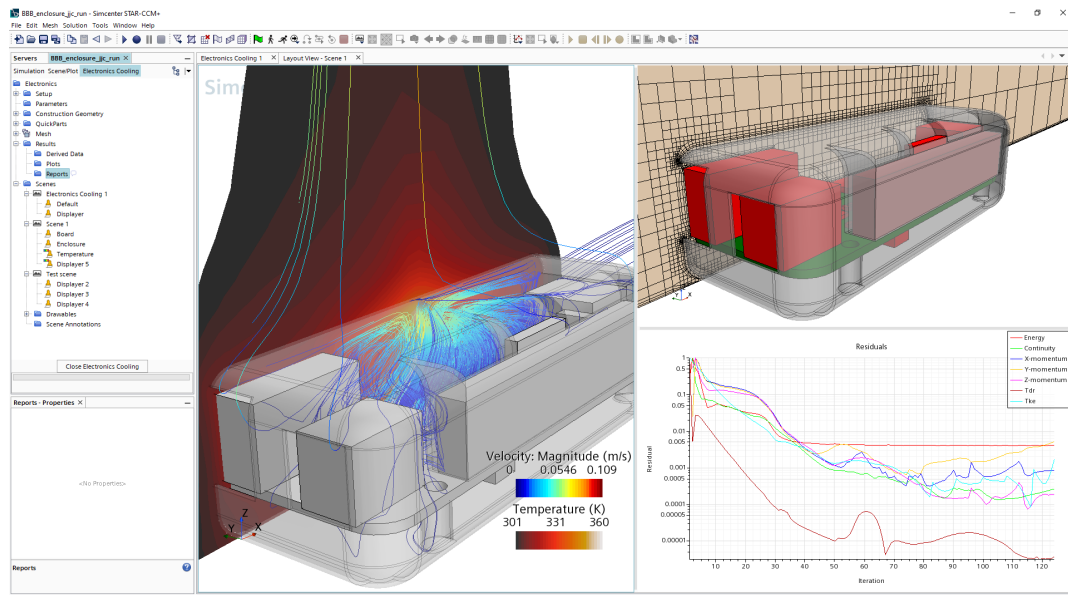
- **Change to default color of generic Quick Parts to differentiate between solids and fluids**

User Guide

- **New Tutorials**
  - Heat Transfer and Radiation
    - Simulation Operations: Transient-transient Multi-Timescale Conjugate Heat Transfer
  - Design Exploration (renamed from Design Manager)
    - Surrogates: Reliability of an Industrial Exhaust System
    - Surrogate FMU: Flapper Valve Representation within Simcenter Amesim
  - Simcenter STAR-CCM+ In-Cylinder
    - Diesel Engine: Closed-Cycle Sector Model
- Modified Tutorials
  - Adjoint Topology Optimization: Channel Flow with Minimized Pressure Drop – minor update to procedure; moved into the Design Exploration category
  - Acoustic Wave Modeling: Noise from a Cylinder – updated due to user interface (UI) changes
  - gPROMS File Export: Spray Dryer – updated to reflect revised setup procedure
  - Cylindrical Particles in a Rotating Drum – revised setup for improved performance
  - Solid Oxide Fuel Cell – added pre-solve for Electric Potential
  - The following tutorials were updated to use Abaqus 2019:
    - Abaqus File-Based Coupling: Exhaust Manifold
    - Abaqus Co-Simulation: Thermal Coupling
    - Abaqus Co-Simulation: Mechanical Coupling
  - The following tutorials required a time model for the external continuum due to workflow changes:
    - Simcenter STAR-CCM+ to Simcenter STAR-CCM+ Coupling: Heat Transfer in a Chimney
    - Simcenter Nastran Co-Simulation: Disc Valve
    - FMU Co-Simulation: Temperature Controller
    - Co-Simulation API: Spindle Valve

- ○ The electronics cooling tutorials were updated to use the latest UI for post-processing:
  - ▪ Electronics Cooling Toolset: Natural Convection JEDEC
  - ▪ Electronics Cooling Toolset: Graphics Card Cooling
- ○ Fluid-structure interaction tutorials were updated to reflect the latest procedure (using the Partitioned Coupled Solver):
  - ▪ Fluid-Structure Interaction: Vibrating Pipe
  - ▪ FSI with Prescribed Solid Motion: Flapping Wing
  - ▪ Conjugate Heat Transfer and Thermal Stress: Exhaust Manifold
- ○ Gasoline Engine: Charge Motion – now includes liquid film modeling
- ○ Battery Simulation Module: Cell Thermal Analysis – updated to use parts-based meshing
- ○ Cylindrical Cells: Cell Thermal Analysis – updated to use parts-based meshing
- ○ The category, **Design Manager**, has been renamed to **Design Exploration**.

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