SIEMENS
Ingenuity for life

Version 2019.2

Siemens PLM Software

Simcenter STAR-CCM+

New features and enhancements

Engineer Innovation

www.siemens.com/mdx

New Features and Enhancements in Simcenter STAR-CCM+ 2019.2

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:

- Multi-Surface free-form deformation[1]
- Import of NX Expressions
- FMU co-simulation[1]
- Simulation Operations[1]

- PISO for Simcenter STAR-CCM+ In-Cylinder
- Combustor-Reactor Networks[1]
- New Adjoint solver[1]
- Screenplay[1]

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[1] Posted on IdeaStorm
  A total of 37 new features and enhancements from IdeaStorm in this version.

Enhancements to Simcenter STAR-CCM+ v2019.2 are presented by category:

Platform

Deployment

- **New certified operating systems (OS)**
  - SUSE Linux Enterprise Server (SLES) 12 SP4
  - Red Hat Enterprise Linux/CentOS 6.10, 7.6
  - Windows 10 October 2018 Update
- **Retired operating systems (OS)**
  - Windows 7 SP1
  - Red Hat Enterprise Linux/CentOS 6.8, 6.9, 7.3
  - openSUSE Leap 42.3
  - SUSE Linux Enterprise Server (SLES) 12 SP3
- **Retiring operating systems in 2019.3 (v14.06)**
  - Windows 10 April 2018 Update
- **New certified Message Passing Interface (MPI)**
  - Microsoft MS MPI 10.0
  - HPE MPI 2.17
- **Retired Message Passing Interface (MPI)**
  - Support for HPE/SGI MPI older than 2.17
  - Support for Open MPI older than 3.1.3
- **Retiring Message Passing Interface in 2019.3 (v14.06)**
 - Support for Microsoft MS MPI older than 10.0

User Experience

- **Set parameters from the command line D1180, D1725**
  - Save time executing a design or physical property variant of a simulation when there is no GUI easily accessible
  - Edit Global Parameter values (Scalar, Vector) by command line input with new option `-param`
    - Supports multiple parameters, and values defined with expressions
    - No support for File parameter yet

```
starccm+ -param inletvel 210.0m/s -param AoA 15 -batch aero.sim
```

```
starccm+ -param MaxWidth "$MinWidth * 2" -mesh,run mySimulation.sim
```

- **Filters: new *Content Of* predicate**
  - More intuitive workflow when setting up simulation templates with filters and query-based selections
    - Spend less time creating a repeatable and automated set-up, increase the flexibility of your simulation templates
  - New *Contents Of* predicate grabs the contents of an object's property, for example: the Output Parts of a Subtract Operation, or the Coordinate System of a report
    - Explicit description of Property name facilitates query creation
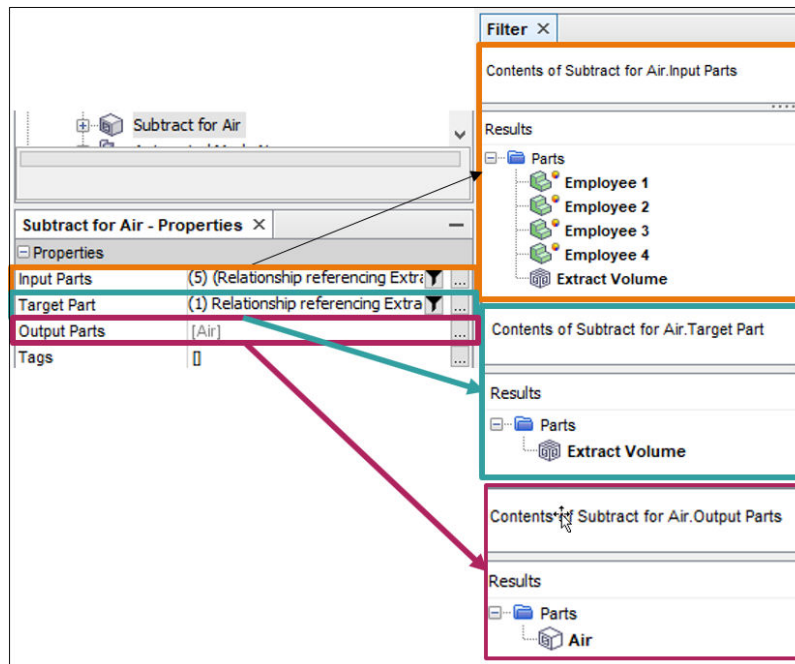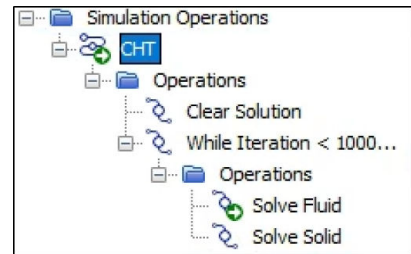

- **Add tags, remove tags**
  - More flexibility during model preparation
    - Reduced manual set-up time required to prepare simulations using Tags
  - Tags context menu option, complementing the existing Set Tag(s) capability with:
    - Add Tag(s): to a single or multiple objects. Appends tag(s) to multiple objects tagged differently.
    - Remove Tag(s)
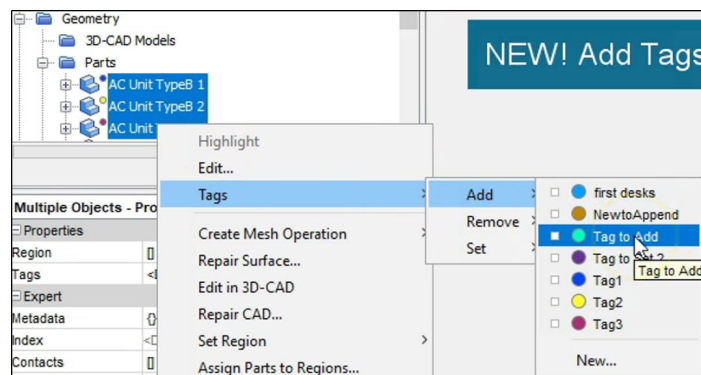
- **Simulation operations <mark>D1074</mark>, <mark>D4789</mark>**
  - ○ Encapsulates simulation intelligence in automatic, persistent, Java-free pipeline
    - ▪ Enhances native automation, removes adoption barrier and maintenance cost of Java for typical simulations
    - ▪ Use for example: on Conjugate Heat Transfer applications with steady-state fluids and unsteady solids, on adjoint applications, on morph and remesh simulations
  - ○ Define an overarching pipeline of the entire simulation allowing sophisticated workflows and simulation scenarios to be easily automated and executed
    - ▪ Provides control operations (Condition, Loop), which trigger based on fulfillment of Expressions, Update Events, Stopping Criteria, and task operations (for example: Mesh, Solve Continua)
  - ○ Simulation Operations allows execution of existing simulation elements, it cannot create new items in the tree or activate new models
- **Alphabetization of physics continuum optional models <mark>D1834</mark>**
  - ○ Faster physics model selection with alphabetical sorting of the Optional Models in the Physics Continuum Model selection panels
- **Implicit selection indicator in Object Selector**
  - ○ Reduce user error setting up models involving manual selection of Composite Parts
  - ○ Child Parts from a selected Composite are now shown as implicitly selected with a light blue indicator, even though they may not have been explicitly selected by the user
    - ▪ Applies only to Part Selection workflows with composites, parts, part surface selections
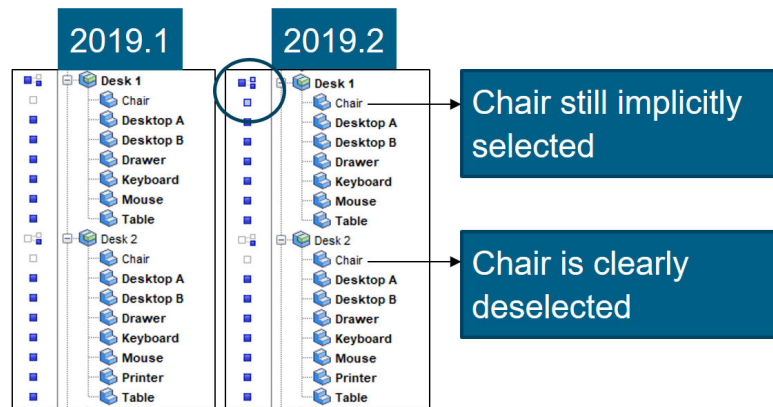
- **Bulk rename <mark>D1868</mark>, <mark>D4747</mark>**
  - ○ Save time organizing the simulation with the availability of a conventional user interaction mode
  - ○ Rename multiple selections at once
    - ▪ Numerical increment appended as suffix
    - ▪ Supports renaming of different object types at once (for example: Reports and Plots)
- **Material pick-lists rendering materials**
  - ○ Faster selection of materials
  - ○ Material picklists using the old-style display were updated to render the material
- **Toolbars for STAR-ICE and E-Cool**
  - ○ Save time starting up the right tool
  - ○ STAR-ICE and E-Cool toolbars are accessible directly from a right-click on the toolbar menu
- **Alerts/Notification persistence**

- ○ Increased traceability of errors, warnings, notifications
- ○ Messages in the alerts optional mode now persist after the mode is disabled and then re-enabled

CAD Integration

CAD-Clients

- **CAD-Clients rebranding**
  - ○ Updated naming to ensur consistency across Simcenter portfolio
  - ○ All functionalities and GUI stay the same as previous versions
    - Simcenter STAR-CCM+ Client for NX
    - Simcenter STAR-CCM+ Client for CATIA
    - Simcenter STAR-CCM+ Client for Creo
    - Simcenter STAR-CCM+ Client for Inventor
- **NX coordinate systems and reference planes names import** D4744
  - ○ Broaden access and usage of CAD-Clients parameters to extend automation capabilities and application range
  - ○ Transfer of customized names for coordinate systems & reference planes
    - Support for Simcenter STAR-CCM+ Client for NX only
    - Other Simcenter STAR-CCM+ Clients will be supported in the future
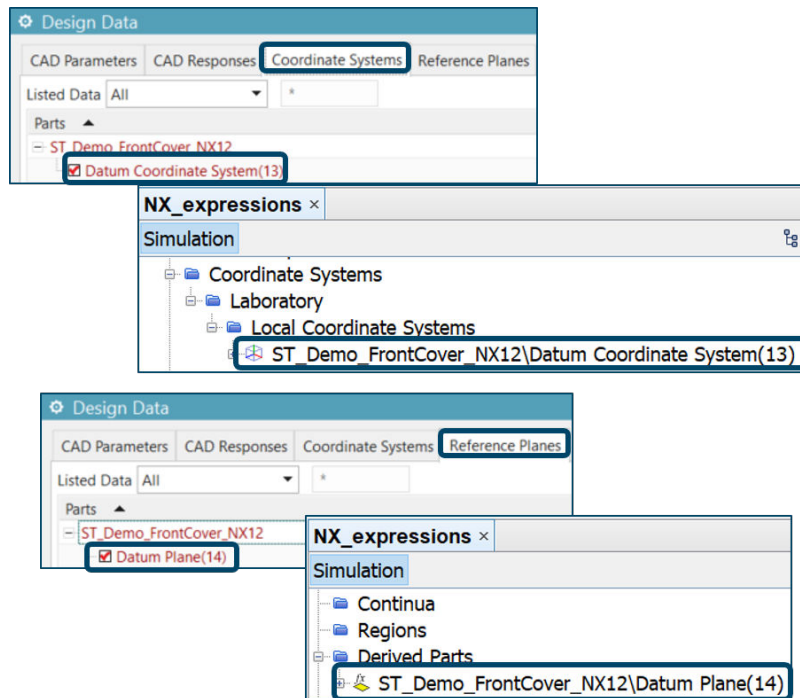

- **CAD-Client parameters in expressions** D4575
  - ○ Broaden access and usage of CAD-Clients parameters to extend automation capabilities and application range
  - ○ CAD-Clients parameters support in expressions to be called in
    - Expression reports
    - 3D-CAD parameters
    - Coordinate parameters
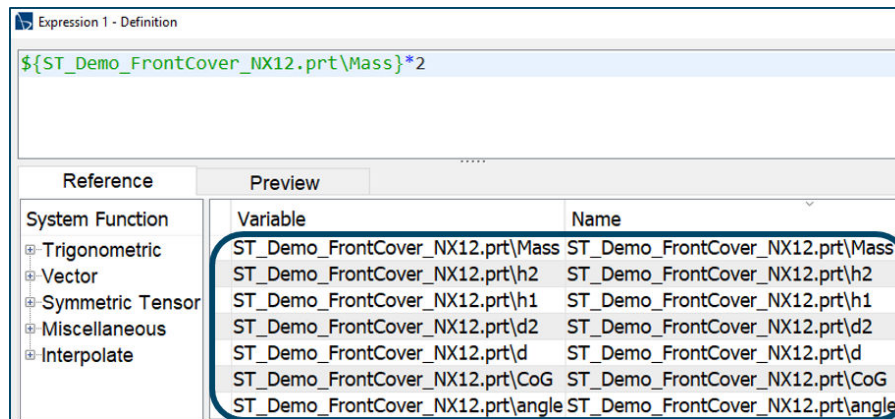
- **NX expressions import**
  - Broaden access and usage of CAD-Clients parameters to extend automation capabilities and application range
  - Transfer of all NX measure expressions under the CAD Response node, including center of gravity, surface area, moment of inertia
  - Shortcuts for expression report creation (to access NX expressions in Design Manager)
  - Support for Simcenter STAR-CCM+ Client for NX only (other Simcenter STAR-CCM+ will be supported in the future)
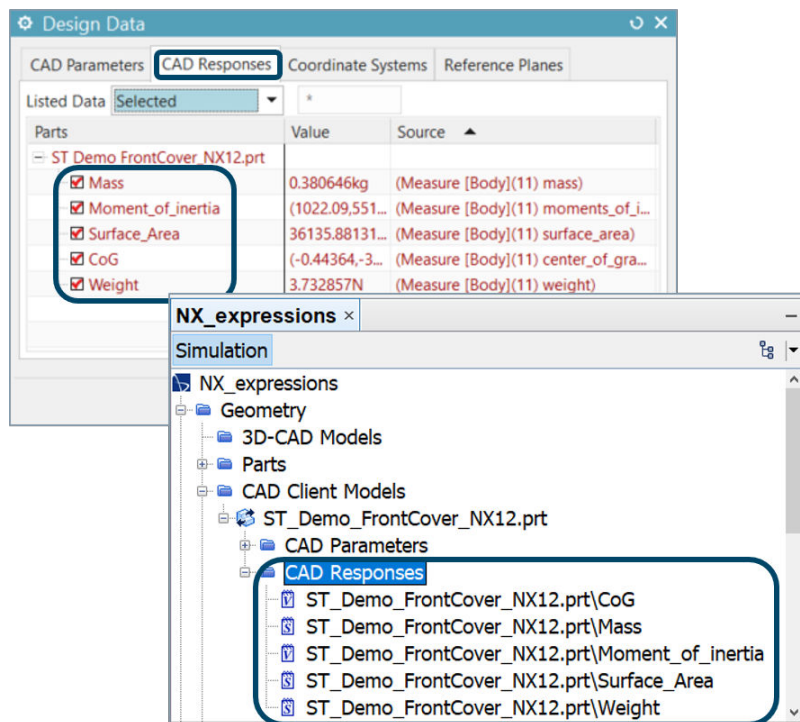
- **CAD-Client version upgrade** D4834
  - Simcenter STAR-CCM+ Client for Creo now supports Creo 5.0
  - All functionally and user interface stay the same as previous versions
- **Renaming support for CAD-Client parameters**
  - Renaming support for both CAD parameters and CAD responses imported using CAD-Clients
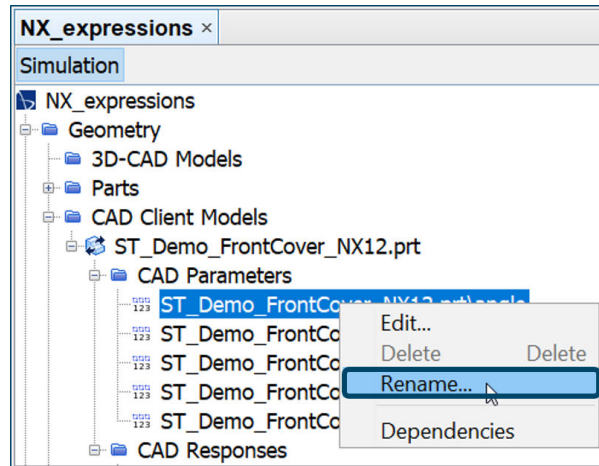
CAD-Exchange

- **CAD Import upgrade**
  - Updated version support for CAD import
    - Solid Edge (Up to 2019)
    - Parasolid (Up to v31)
    - JT (Up to v10.2)
    - SolidWorks (Up to 2019)
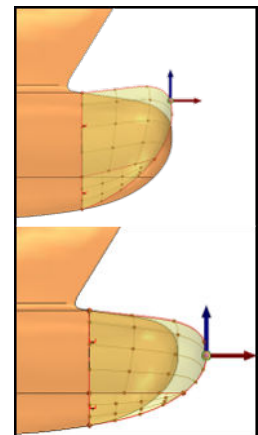   - Autodesk Inventor (Up to 2019)

Geometry

3D-CAD

- **Multi-Surface Freeform modeling D3792**
  - Greater flexibility when manipulating a complicated 3D surface
  - Easily parametrize surface with design parameters
  - Interactively push or pull points lying on a multi-surface patch
    - Can be used on both faces of a solid body or surface body
    - Use on mesh-ready CAD
    - Available for all CAD types, created in or imported to 3D-CAD
- **Multi-profile sweep D2119**
  - Reduce the number of clicks for creating sophisticated swept geometries
  - No need to create a sketch for each profile to be swept
  - Profile sketches can now contain any number of profiles with the following constraints
    - Each profile must be closed
    - No profile is allowed to intersect or touch another profile
    - Each profile may lie completely within no more than one other profile
- **Interactive Sections D5172**
  - Fewer mouse clicks, and less tree scrolling, to visualize the assembly
   - Work on the half or quarter model

- Enable easy picking of face or body that are hidden inside a assembly
  - Provides an interactive section that can be swept through the model to visualize internal details
  - New icon "Section View" is added to the Visibility Toolbar
   - Use Section View to turn view sectioning on or off
- **Fill Holes** D5031
  - Reduce the number of clicks and features in the tree by finding and filling all holes for sheet bodies
  - Fill holes is a new CAD Repair option that can be used on single or multiple faces
 - User can exclude holes from the filling operation by selecting hole edge
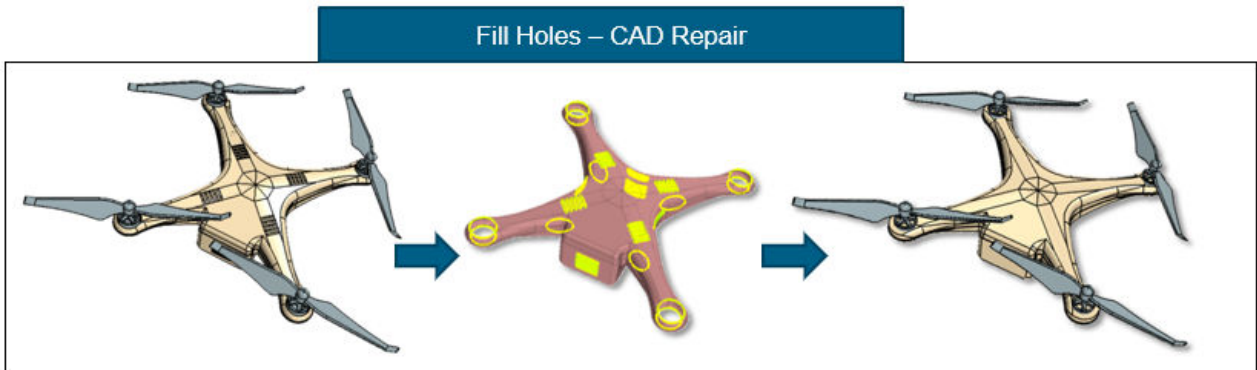
- **Split face by UV point**
  - Increase accuracy and robustness while fixing errors locally for invalid faces
  - Face split is a new CAD Repair option
    - Split any face into smaller faces by defining split point on UV grid
    - Without this option user must delete the entire invalid face
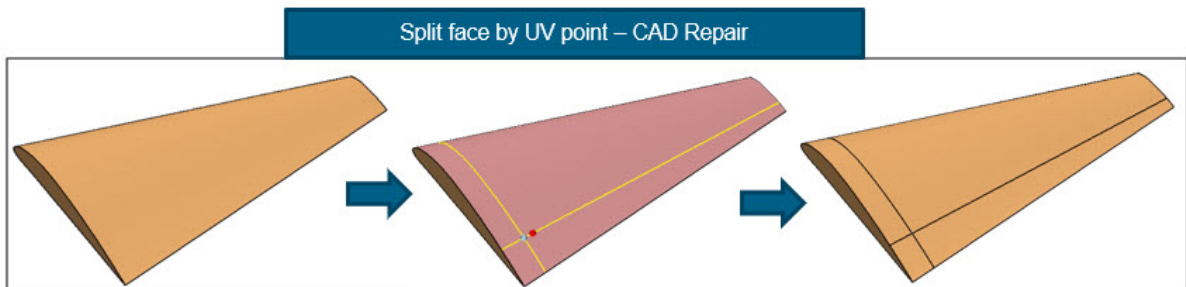
- **Merge Faces**
  - Remove unwanted faces to support the following scenarios
    - Repair invalid faces
    - Remove small faces which may affect mesh
    - Reduce number of faces for freeform deformation
  - Merge Faces is a new CAD Repair option
    - Remove redundant faces, edges, and vertices from selected bodies
   - Limitation: Cannot handle conical shapes
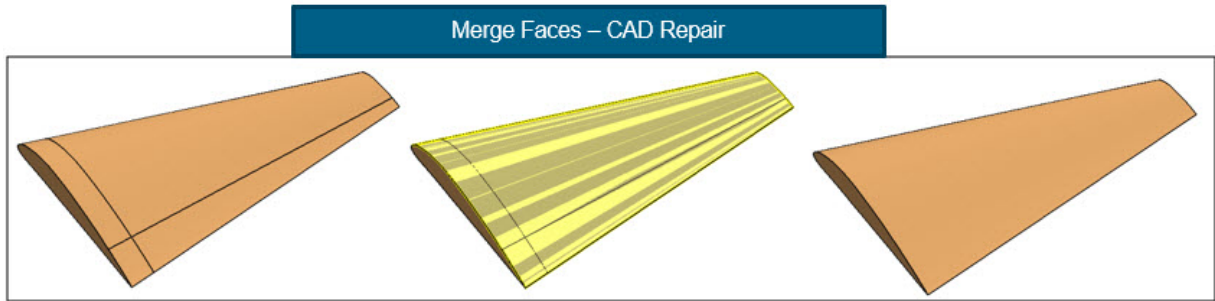
Parts

- **Link Mesh Operation and Output Part Names** D4200
    - Easily identify output parts from a specific mesh operation
    - New option "Link Output Part Name" is added
        - By default, this option is off
    - Renaming either operation or output part updates the other
    - Renaming is disabled on the output parts associated with the operation
    - Linear and circular pattern is not supported
    - A new right click option added for operation and output parts
        - Select Mesh Operation(s)
        - Select Output Part(s)
- **Performance improvement for Linear & Circular Pattern**
    - Improved the performance for executing the operation
    - Creation of Linear & Circular pattern algorithm is optimized for better performance
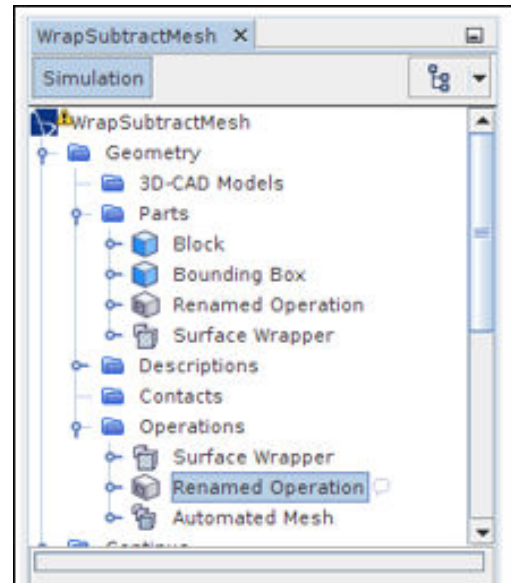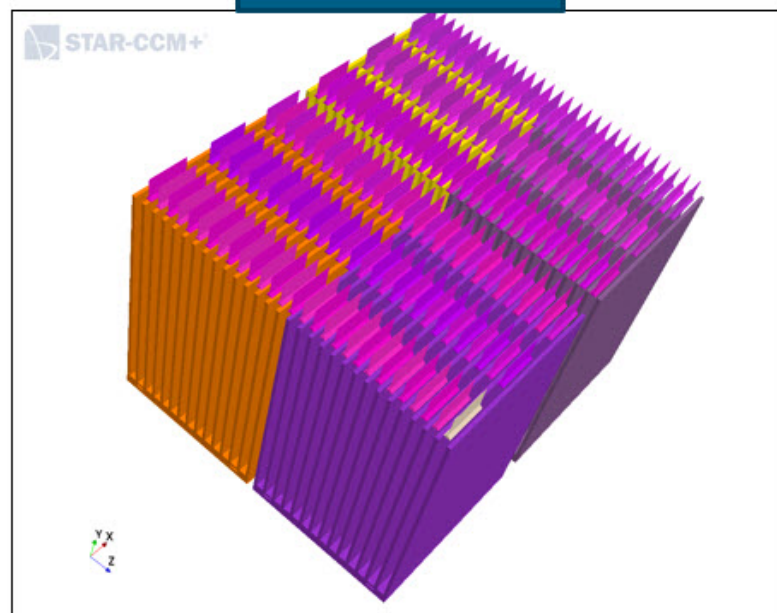
- **Surface Offset operation robustness**
 - Improves overall robustness of the surface offset operation
  - Both the quality and execution time is improved
  - Improved the surface quality by eliminating self intersection
  - Improved method for smoothing the boundaries of the patches

| 2019.1 | 2019.2 |

Offset	2019.1	2019.2
Pierced Faces	15	0
• 1.25x faster		
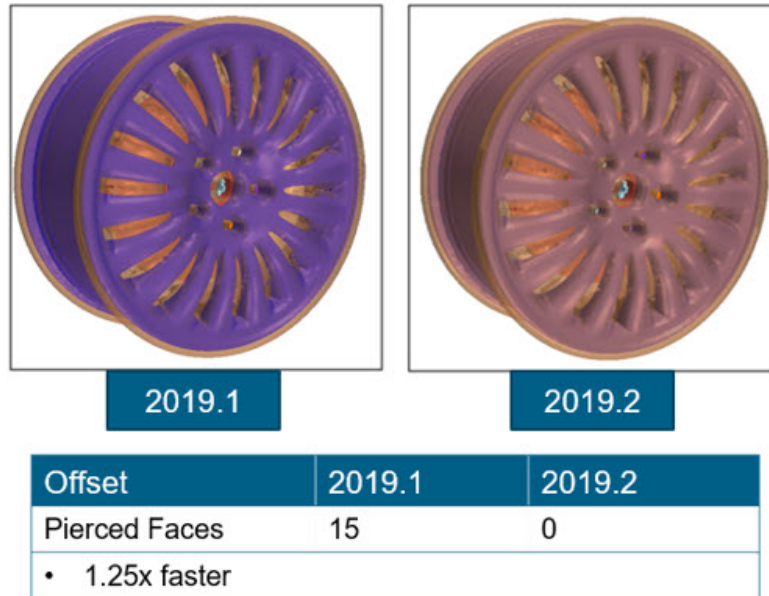
- **Sheet support for subtract operations**
  - More easily incorporate sheet bodies into models
    - Ability to subtract "sheet" parts in the discrete Boolean subtract operations
  - Automatically mark baffle as sheets that are not closed or are non-manifold
  - The output of subtract operation can be used directly in subsequent meshing operations

Subtract Operation - Support sheets

Part Surface → Baffle
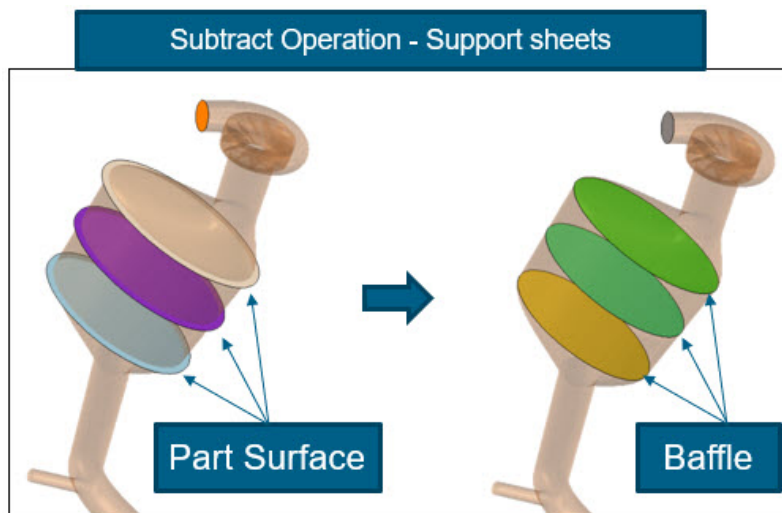
- **Motion-based transform control**
  - Introducing motion-based transform operation in mesh pipeline
  - The transform operation can take Translation and Rotation motion as input
  - Coupling this feature with simulation operation allows easy setup of morph and remesh applications
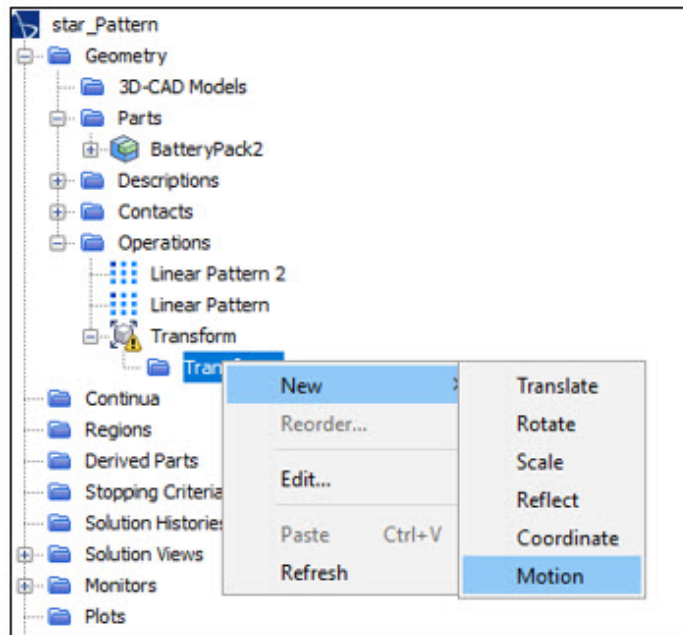
- **Parts - New Icons**
  - ○ Easily understand if you are in Parts or Operations sub-tree
  - ○ Easily distinguish parts created by operations
  - ○ New icons for mesh operation output parts
  - ○ Previously, operations and output parts shared the same icons
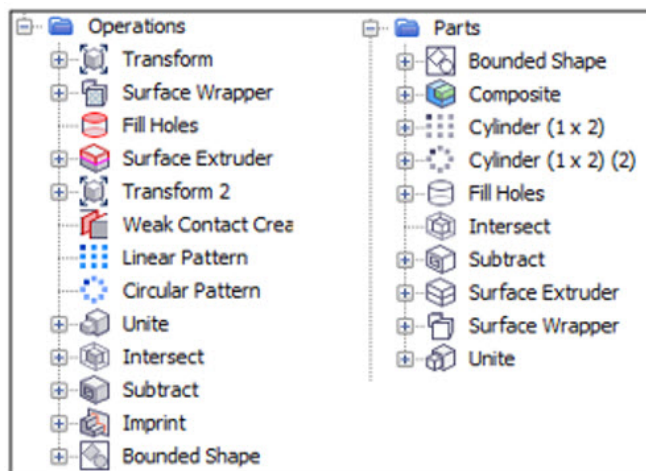
Mesh

Surface Wrapper

- **Improved Gap Closure**
  - ○ Improve overall robustness and reliability of the surface wrapper output
  - ○ Notable Gap Closure algorithm Enhancements
    - ▪ Close any holes/gaps smaller than the size specified
    - ▪ More accurate/consistent placement of gap closure faces

○ Added a new option "Use Enhanced Size-based Method"

Volume Mesh

- **Specify volume distribution in Directed Mesh through cell size** D3261
  ○ Easier specification of directed meshing in, for example, pipes and after-treatment systems
  ○ More straightforward design exploration—preserve cell size regardless of pipe length
  ○ Specify cell size instead of number of layers to define volume distribution
    ▪ New property "Size Specification" – "Size" for Directed Mesh
    ▪ Specify "Base Size", "Target Size", "Growth Rate" and "Spacing"
- **Improved sector meshing - Rotational sweep coarsening**
  ○ Improved sector mesh quality for applications such as in-cylinder combustion engines and cylindrical burners
    ▪ Reduced aspect ratio and less sharp angles close to rotational axis
  ○ New option "Rotational sweep coarsening" for directed mesh rotational sweeps
    ▪ Enables coarsening close to the rotational axis
    ▪ Define aspect ratio or manually specify any number of transitions through transition distances and merge ratios.

Without rotational sweep coarsening

With rotational sweep coarsening
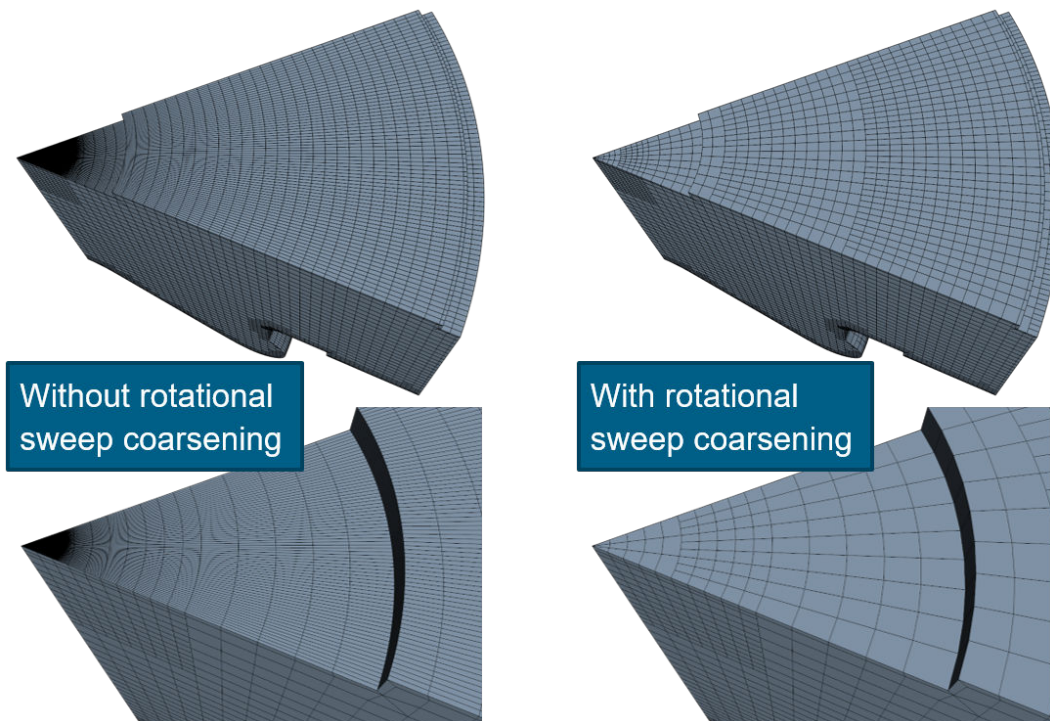
- **Improved parallel performance for Trimmed Cell Mesher**
  ○ Faster volume mesh generation with Trimmed Cell Mesher in parallel when using Per-Part Meshing mode
    ▪ Greatest effect when surface mesh pre-generated and loaded from file
  ○ Decreased memory usage on master node for cases where surface remeshing is already performed
  ○ Parallellization of the Trimmed Cell Mesher is extended
    ▪ The surface handling part of the Trimmed Cell Mesher operation is now parallelized
    ▪ Note: Only active when Per-Part Meshing Property is activated

Trim volume meshing of heat exchanger from existing surface mesh, 8M cells
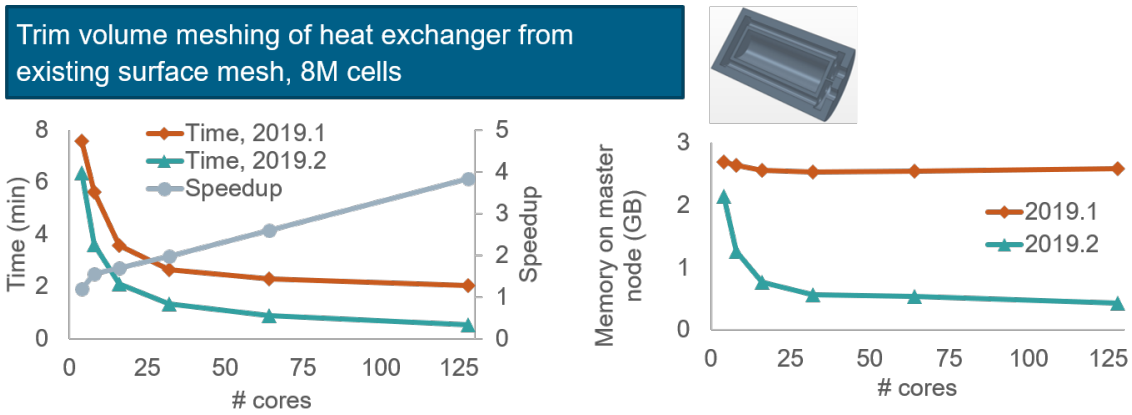
CAE Integration

- **Functional Mock-up Interface (FMI), Functional Mock-up Unit FMU D3547**
  - Makes it possible to combine the speed of 1D models with the accuracy of 3D models
    - Any Co-Simulation FMU compliant with the standard 1.0 & 2.0 can be run within Simcenter STAR-CCM+
  - For more information on the FMI standard, refer to: https://fmi-standard.org/
  - Some FMUs may require access to specific libraries during run time (e.g. Co-Simulation FMUs exported from Simcenter Amesim). If that is the case, Simcenter STAR-CCM+ needs to be launched with the -ldlibpath option pointing to the required library.
    - For more information on the -ldlibpath option, refer to the user guide section: Client-Server Setup > Command-Line Reference "Server Options"

Physics

CFD
Multiphase Flow
Computational Rheology
Computational Solid Mechanics
Electromagnetics and Electrochemistry
Aeroacoustics
Motion, DFBI, Overset, and Mapping

CFD

Flow

- **Stopping criteria relative to activation of Physics Continua**
  - Improves workflow for single sim multi-timescale simulations
    - Allows the user to easily setup relative stopping criteria while using the activate/deactivate workflow
  - This feature allows refresh sampling from the start of the continua activation as opposed to the start of the simulation for:
    - Relative, asymptotic and standard deviation stopping criteria
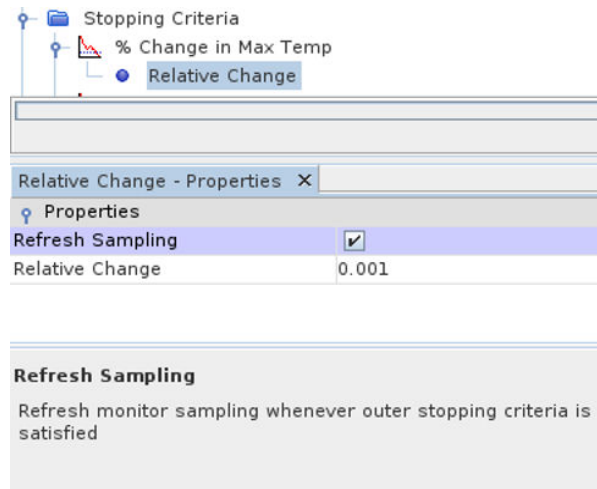
- **Table option for specific heat input for ideal gas D2873**
  - Improves workflow and allows user to easily port data from external material libraries
    - No need to fit tables into polynomial data
  - The Table (T) option for specific heat input was added for ideal gas
- **Import of Teamcenter Integrated Material Management (IMM) database libraries**
  - Ensure consistency of material properties between Simcenter STAR-CCM+ and Teamcenter
  - Teamcenter IMM exports Simcenter STAR-CCM+ material library file formats
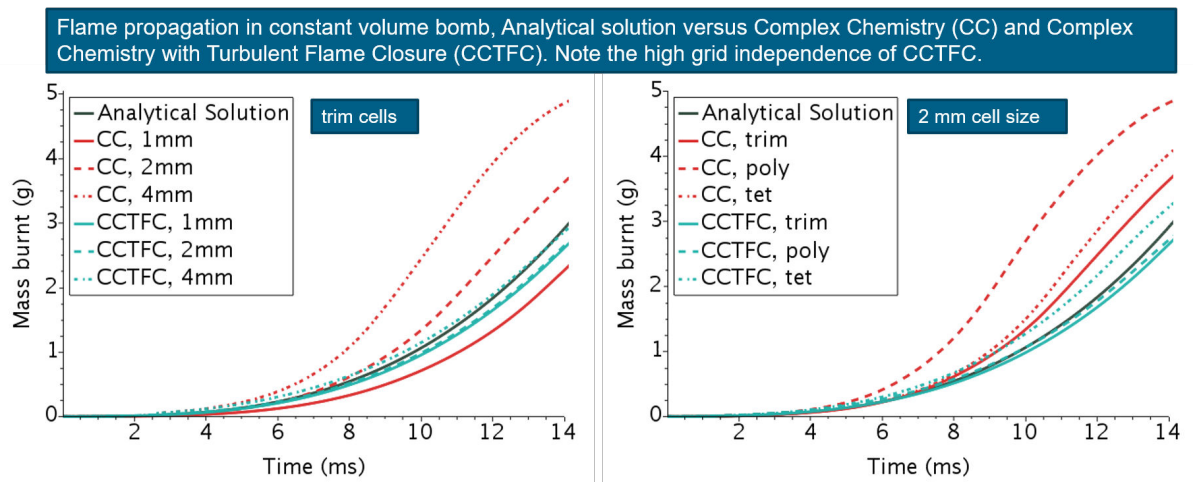   - IMM uses MatML standard format
    - Translator ensures compatibility with Simcenter STAR-CCM+ material database format
- **Min/max absolute pressure reference values**
  - Improves usability for hypersonic cases where Absolute Total Pressure may exceed the previously hardcoded limit
  - Min and Max Absolute Pressure is exposed to the user under reference value manager
    - User may change the default values for cases that require user specification
- **Atmospheric Boundary Conditions D2590**
  - Improves physical realism by accurately modelling atmospheric boundary flows
  - Improves workflow with standard field functions created that describe velocity, pressure, temperature and turbulence profiles for a fully developed atmospheric boundary layer
  - Compatible with standard k-epsilon turbulence model
- **Invalid Cell Boundary Type**
  - Enables robust solver execution in cases where there are invalid/low quality cells present
  - A new boundary type for faces surrounding removed cells is introduced which replaces the existing symmetry condition
  - For existing cases the remove invalid cells operation must be re-applied to apply new condition
    - The invalid cell boundary type is automatically selected
- **Monitor Explicit Relaxation based on Correction Control**
  - Added Active Explicit Relaxation property in coupled flow
    - Presents the actual value of explicit relaxation that the Expert Driver is running with as opposed to the initial value set by the user under Explicit Relaxation

Energy

- **S2S View Factor Calculation – Reciprocity speedup**
  - Upto 8X speed up on reciprocity calculation
    - Total speedup of up to 3x seen in vehicle thermal management and gas turbine blade cooling cases when used with Advanced Ray Tracing combined (ray tracing + reciprocity)
  - Further improvements in ray tracing efficiency (applicable to both default based and advanced ray tracing) with reduced MPI communication
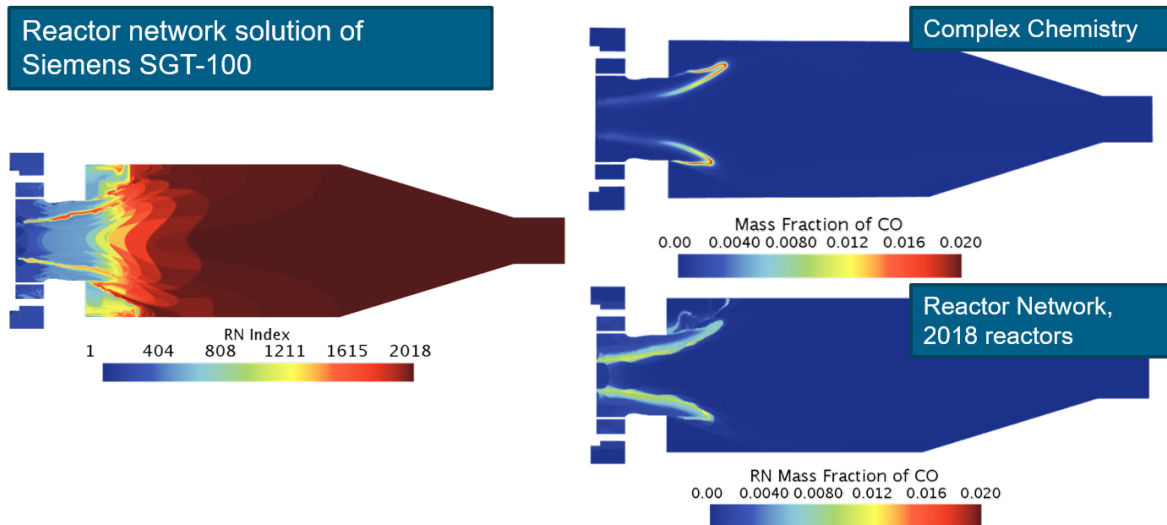
Reacting Flows

- **Complex chemistry + Turbulent Flame Closure (CC-TFC)**
  - Accurately capture ignition/extinction, slowly forming species *and* flame position for partially premixed or premixed combustion
  - Novel model combining
    - Complex chemistry for accurate species, emissions, ignition, extinction
    - Turbulent Flame Closure for accurate flame location
  - For quick flame propagation or combustion in mixtures with no chemical mechanism available, combine with relax to equilibrium
  - Access through selecting Complex Chemistry as Reacting Species Model and Turbulent Flame Closure as Turbulence Chemistry Interaction model

Flame propagation in constant volume bomb, Analytical solution versus Complex Chemistry (CC) and Complex Chemistry with Turbulent Flame Closure (CCTFC). Note the high grid independence of CCTFC.

- **Combustor Reactor Networks D3212**
  - Allows quick assessment of emissions in gas turbines or burners
    - Post-process flow solution from quick flame propagation model to predict emissions – less need to run full complex chemistry
  - Create a reactor network from a detailed steady CFD simulation with just a few clicks
    - Use any chemical mechanism
    - Run and post-process directly in Simcenter STAR-CCM+
  - New Model "Reactor Network"
    - Constant Pressure and Perfectly Stirred Reactor supported
    - User defined target number of reactors
    - Right click, "Run Reactor Network"
    - New field functions for post processing of reactor network scalars

Reactor network solution of
Siemens SGT-100

Complex Chemistry

Mass Fraction of CO
0.00   0.0040 0.0080 0.012 0.016 0.020

RN Index
1   404   808   1211   1615   2018

Reactor Network,
2018 reactors

RN Mass Fraction of CO
0.00   0.0040 0.0080 0.012 0.016 0.020

- **Surface reactions in Phasic Porous Media**
  - Improved catalyst simulations including thermal inertia of solid phase and its effect on chemical rates
    - Correct residence time due to physical instead of superficial velocity
  - Possibility to calculate detailed surface chemistry at the surface of any solid phase in phasic porous media
    - Using robust complex chemistry ODE solver
    - Can be combined with gas phase chemistry
- **Storage of flamelet table outside .sim file**
  - Less disk space usage for flamelet combustion cases where the same table is re-used for multiple runs
    - Combustion table not included in sim file
  - Faster load and save of .sim file, faster autosave
  - New option "Save Table in .sim file". When unchecked, table is stored outside sim file
  - Limitations:
    - Auxiliary files not yet supported by Design Manager – manual upload of table file required
- **Relax to Chemical Equilibrium**
  - Efficient calculation of combustion in single- and multi-stream systems, for example exhaust gas abatement and incinerators
    - No need for a chemical mechanism, only thermodynamic data required
    - Can be used with any number of streams
  - New approximation option "Relaxation to Chemical Equilibrium" for Complex Chemistry CVODE solver
    - Thermodynamic data used to calculate equilibrium in-situ
      - Define burn rate (rate of relaxation to local equilibrium composition) through Chemistry Time Constant and Flow Time Constant
      - No reaction rates are needed
  - Identical to the approximation option "Equilibrium Time Scale" for Complex Chemistry DARS-CFD solver
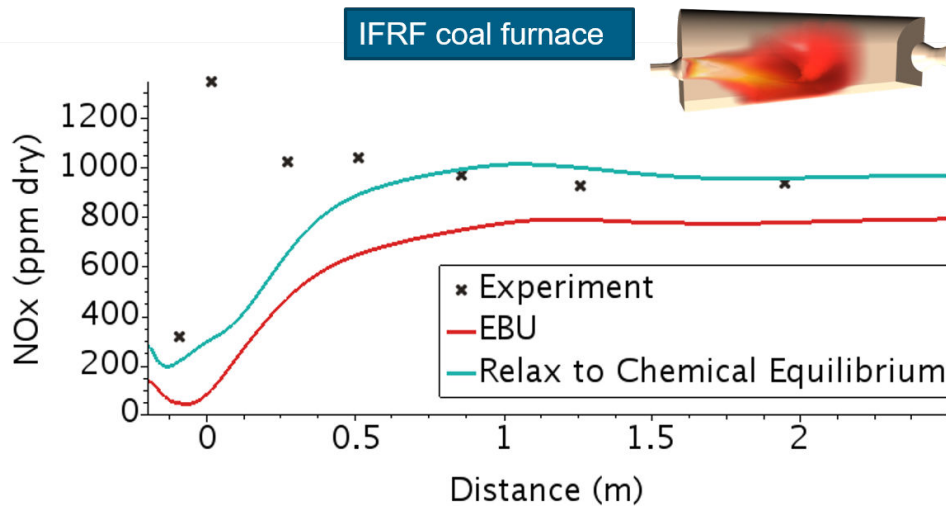
- **OH added as a default Clustering variable for Complex Chemistry**
  - More easily attain higher accuracy when using the Clustering Chemistry Acceleration technique
  - Improved accuracy when using default settings in, for example, premixed combustion close to the wall, where temperature and equivalence ratio are constant
- **Default user coding temperature source term**
  - Accurate energy balance when User-Defined Species Reaction Sources are applied
    - New option "Internal Reaction Energy Source" to automatically calculate energy source term from user defined species source terms
    - On by default

Turbulence

- **Boundary distance model redesign**
  - Improves flexibility for different physics models which require wall or boundary distance calculations
  - Some GUI changes required to reflect software architectural changes
    - Boundary distance options moved from Solver node to Physics Continua, affecting for example Wall Distance and VOF
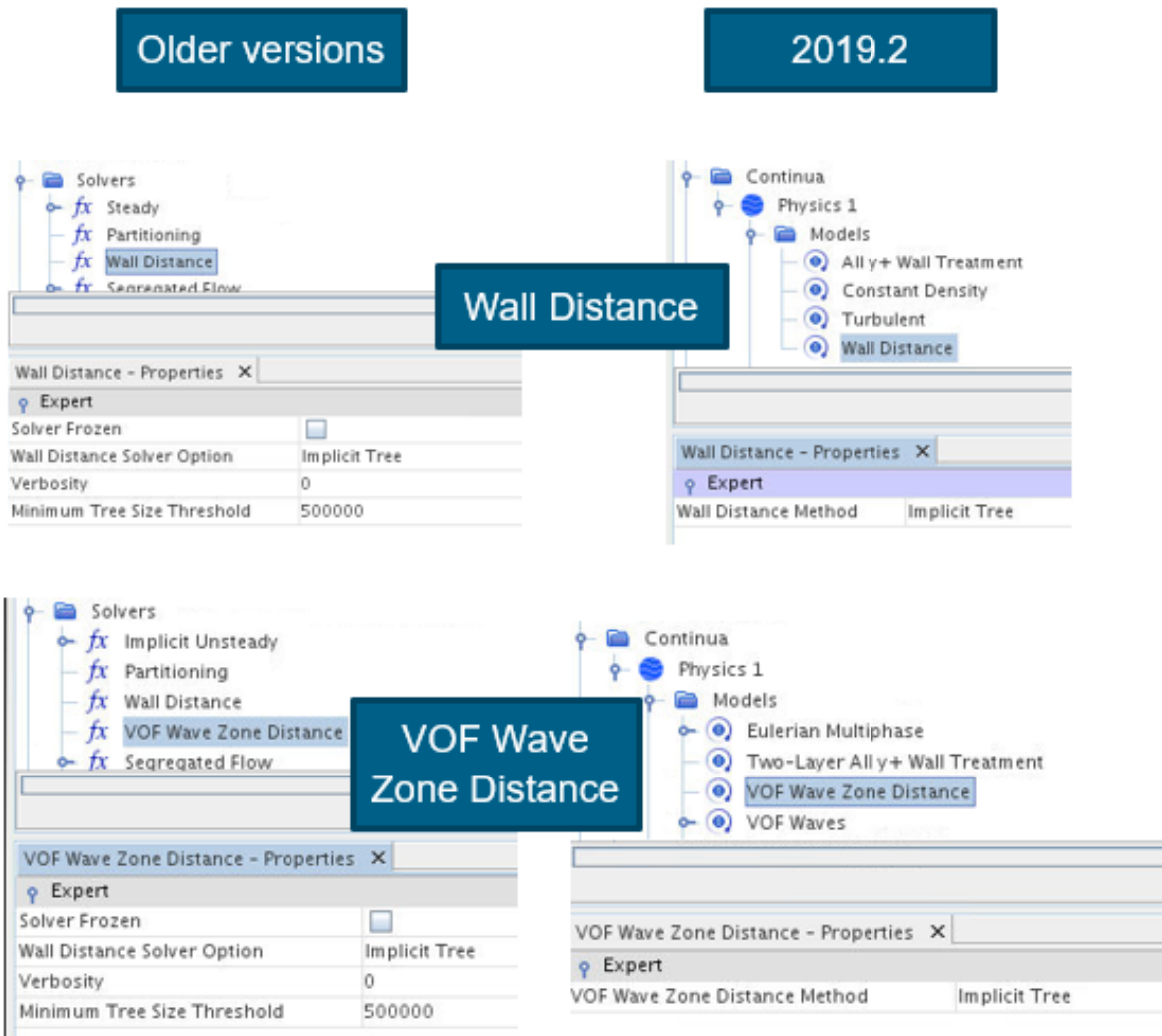
Multiphase Flow

Volume of Fluid (VOF)

- **Adaptive Time-Step for VOF free surfaces D4203**
  - Reduces time to solution for free surface simulations using VOF
    - Allows a larger time-step to be run than is possible using either a constant time-step or the previous CFL based time-step-control
  - The former Time-Step Control model is renamed the Adaptive Time-Step model
    - The former options appear as *Time-Step Providers* together with a new method, Free Surface CFL Condition
    - Multiple *Time-Step Providers* can be used together
      - Minimum time-step size from all *Time-Step Providers* is used subject to minimum limits applied
  - Free Surface CFL Condition method adds free surface specific adaptive time-step controls
    - Limits CFL number normal to the free surface
    - Sets the time-step size based only on the region of the free surface
    - Avoids setting small time-step unnecessarily - max. CFL number may be away from free surface

○ Applications include marine vessels, casting, tank sloshing, and vehicle water management
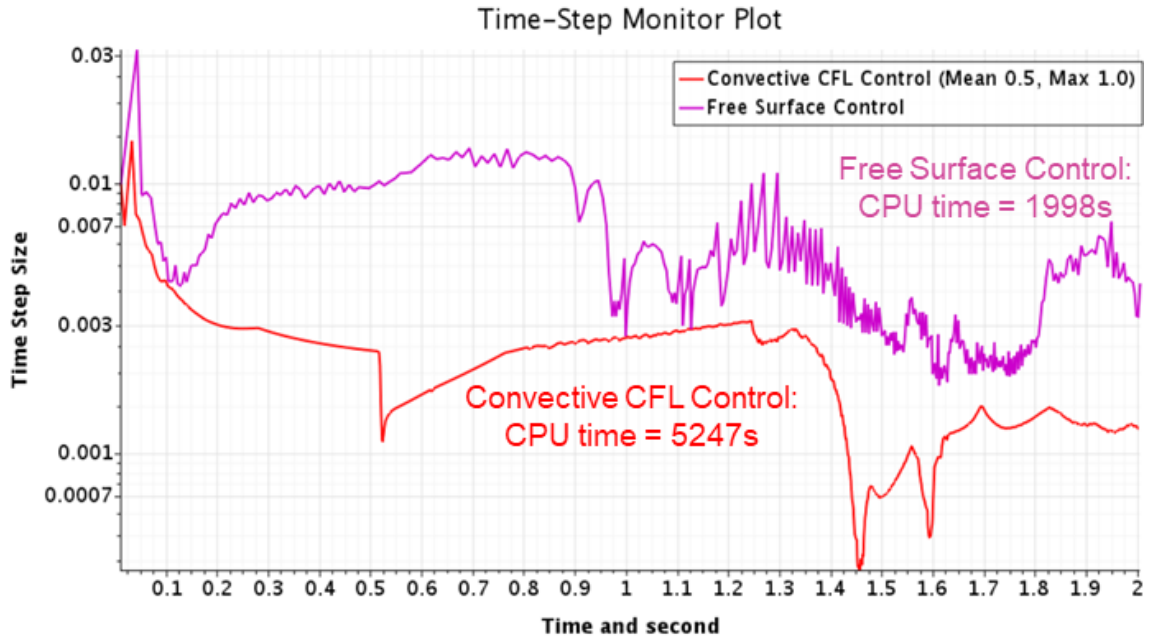
Dam Break Example – Speed-Up 2.6x Compared to Convective CFL Control

- **Interface Turbulence Damping (ITD) for VOF D3328**
  ○ Improved accuracy where there is significant shear between phases
    ▪ Prevents excessive momentum transfer between phases
  ○ Improved stability
    ▪ Removal of spurious mixing and generation of small time-scales
  ○ ITD damps turbulence in the vicinity of a free surface
    ▪ Allows for the presence of an unresolved boundary layer
  ○ Only available for k-omega turbulence models

Interface Turbulence Damping for VOF
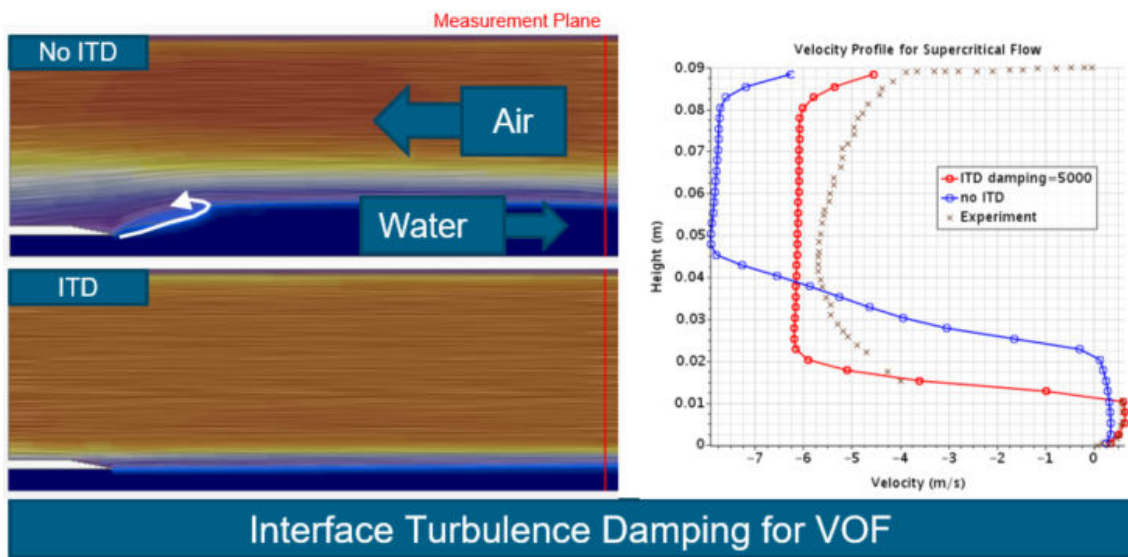
Fluid Film

- **Wave Stripping accounting for curvature effects**
 - More accurately predict film stripping on curved surfaces
    - Centrifugal forces due to curvature now included in the wave stripping model
  - Curvature effects accounted when the Centrifugal Force model is active
  - Stripping model redesigned to appear as a single model rather than separate Edge and Wave stripping models with three sub-options:
    - Edge Stripping
    - Wave Stripping
    - Edge and Wave Stripping
- **Shell face quality metrics** <mark>D3540</mark>
  - Allows users to determine likely sources of Fluid Film instability and poor convergence times due to bad mesh
    - Provides metrics as basis for improving shell mesh on which Fluid Film is solved
    - Fluid Film shells have different mesh quality needs to volume cells making them particularly sensitivity to bad mesh
  - New metrics provided:
    - Shell Area
    - Shell Area Change
    - Shell Face Aspect Ratio
    - Shell Face Chevron Quality
    - Shell Face Warpage Quality
    - Zero Shell Edge Length Indicator
    - Zero Shell Face Area Indicator
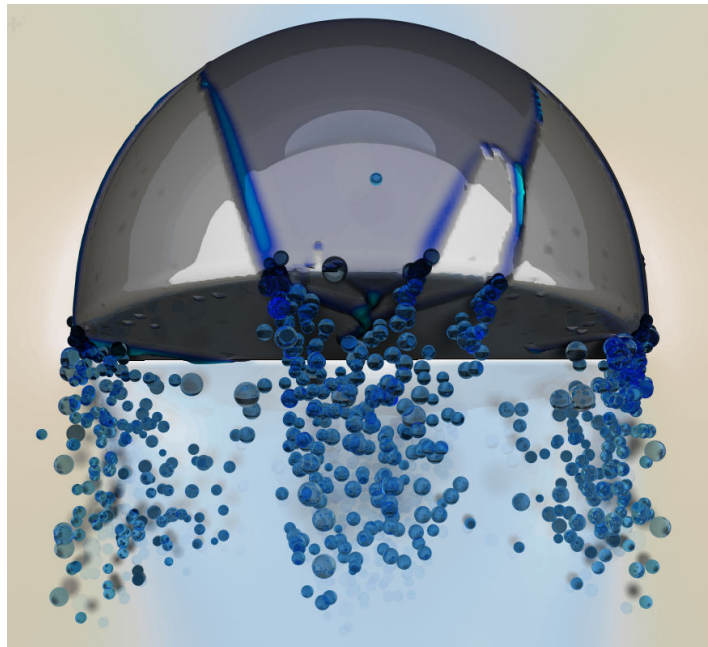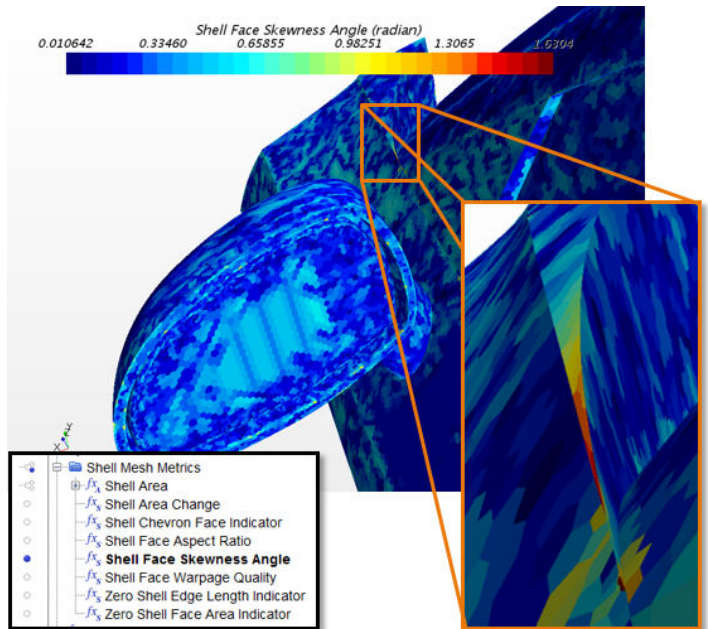
Lagrangian Multiphase (LMP)

- **Mixing plane compatibility with LMP** <mark>D3651</mark>
  - Enables new applications and expands modeling capabilities
    - Enable simulation of multi-stage turbomachinery flows with Lagrangian sprays positioned away from rotating components of geometry. In these cases particles never cross or approach mixing planes of multi-stage flow.
      - For example, enable single model containing a turbocharger which needs a mixing plane between rotating and stationary components, and Lagrangian spray injections of Urea Water Solution in the SCR device downstream of the turbocharger

- ○ Lagrangian Multiphase model can be selected if mixing planes are present in the model
- ○ Mixing plane is an "Escape boundary" for any type of Lagrangian particle
- **Lagrangian Boundary Heat Transfer field function <mark>D4953</mark>**
  - ○ Provide additional insight into physics of droplet-boundary interaction
  - ○ For Selective Catalytic Reduction applications simplifies setting up decoupled Film/Spray co-simulation
  - ○ New field function returns the value of heat transfer between particle and boundary
    - ▪ Defined on boundary faces
    - ▪ Result of integration of all collisions with a singe face over timestep
    - ▪ Available when Temporary Storage Retained option is checked on

Droplet-wall heat transfer monitored in SCR simulation
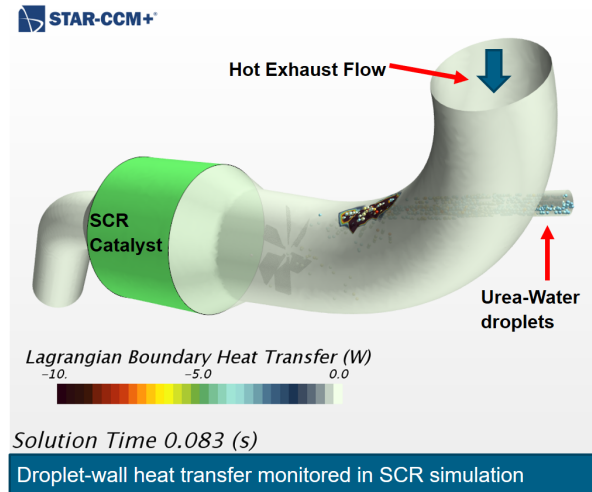
- **Optimized Lagrangian Boundary Interaction**
  - ○ Improves Lagrangian solver performance with particle-boundary interaction algorithms optimized
  - ○ Maximum performance gain for cases with
    - ▪ High frequency of boundary impacts
    - ▪ Large number of boundaries
    - ▪ Boundary mode being Composite mode with Bai-family impingement model active

Discrete Element Method (DEM)

- **Expressions and field functions as input for Work of Cohesion parameter**
  - ○ Expand the regime coverage of Linear Cohesion model
    - ▪ Enable simulating particle flows with time dependent or space dependent cohesive forces between particles
  - ○ Work of Cohesion parameter can be specified using one of the following options
    - ▪ Constant
    - ▪ Field Function
    - ▪ Table (four types)
    - ▪ Uniformly distributed
    - ▪ User Code

Cohesion strength decreases from left to right
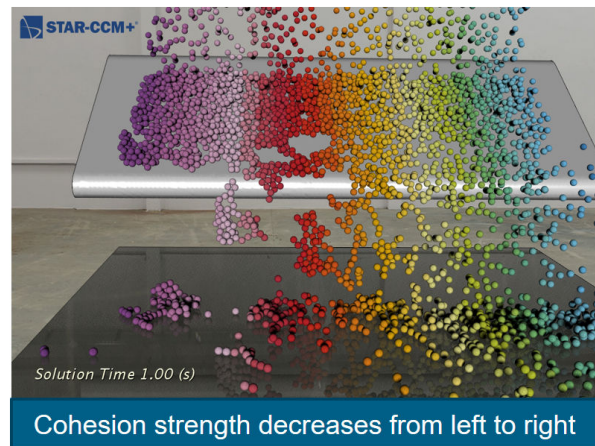
Computational Rheology

- **Decoupled Viscoelastic Flow Solver**
  - Reduced time to solution
    - Benefits viscoelastic flows with many modes
    - Examples show up to 24x speed-up with 8 modes
  - Reduced memory consumption
    - Examples show up to 10x reduction in memory with 8 modes
  - Viscous Flow Solver now has a node for Viscoelastic Mode Coupling with two options:
    - Coupled (default and previous approach)
      - Full system solved in a coupled manner
      - Stability benefits, but memory and CPU intensive
    - Decoupled (new option)
      - Viscoelastic modes solved in segregated manner
      - Reduced memory and CPU costs
- **Thixotropic Constitutive Model** <mark>D4081</mark>, <mark>D1806</mark>
  - Model applications with thixotropic fluids
    - Examples include inks, paints, toothpaste, foodstuffs, and clay-water suspensions
  - Thixotropic rheological constitutive model allows users to model fluids that exhibit time-dependent shear-thinning behavior

Thixotropic Waxy Oil in a Static Mixer
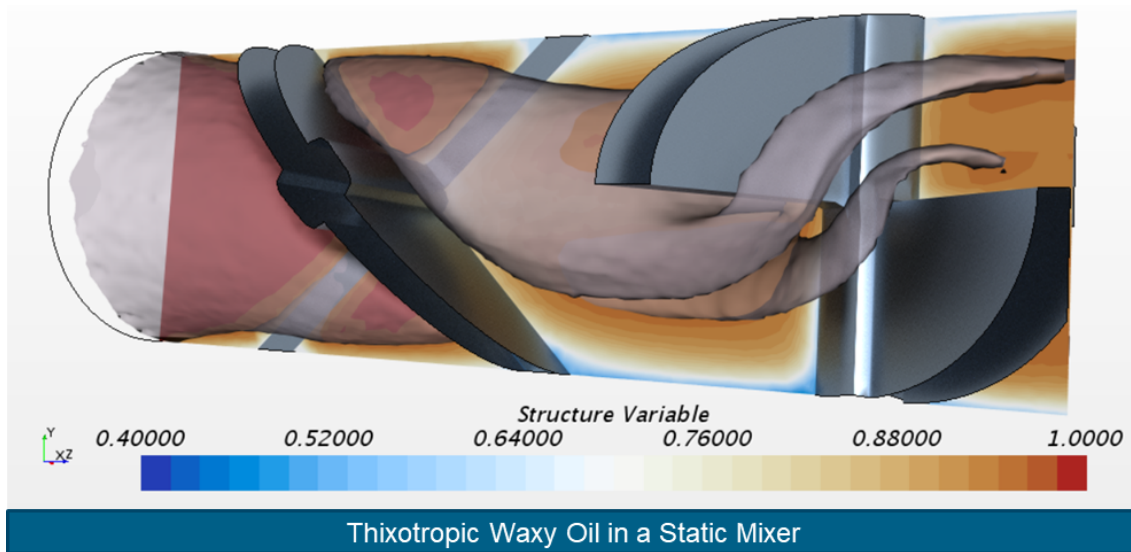
Computational Solid Mechanics

- **Curve Segments** <mark>D5112</mark>
  - Allows specification of line loads and line constraints
  - Any Part Curve can be used in a Curve Segment
    - Meshes generated with the Thin Mesher are currently not supported
  - Available constraints are:
    - Fixed
    - Displacement
  - Available loads are:

- Force - To specify the load as total force [N]
- Line Load - To specify the load as a distributed force [N/m]
- **Surface to surface formulation for mapped contact interfaces**
  - Mapped contact interfaces are used to interface non-conformal solids
  - For the Mechanical Interaction method Bonded it is now possible to choose how the interface constraints are being mapped
  - The constraint mapping method can be set to:
    - Node to Surface (Default)
    - Surface to Surface (New)
  - The Surface to surface formulation significantly improves accuracy especially for quad meshes with mid-side nodes

Electromagnetics and Electrochemistry

Electromagnetics

- **Total Electromagnetic Force and Torque Report in FV-TMP - Induced Electromotive Force Report in FV-TMP**
  - Improves understanding of results with dedicated report of Total EMAG Force, Torque and EMF for 2D and axisymmetric geometries
    - Used for 2D Electric machines
  - The Maxwell approach has been implemented to calculate the local magnetic force in the 2D Transverse Magnetic Potential model
  - The region on which the forces are computed must be surrounded by a force-free medium
  - Group of regions must be continuous and not enclose a region not included in the report
  - For overset the EMF report is not valid
- **Multi-Part Solids support for Total Electromagnetic Force Report**
  - Increased flexibility in set-up for multi-part solid regions
    - Simpler physics setup in the Region section of the tree
    - Reduced number of continua, improving partitioning and performance
  - In the report the parts selection allows for regions and now parts
- **Anisotropic non-linear BH**
  - Performance and robustness improvements for anisotropic non-linear BH
    - Better convergence properties
    - Removed costly numerical evaluations
- **BH curve import consistency check**
  - Checks the validity of a user imported BH curve to prevent solution instabilities
    - Curve must be monotonic
    - B and H data columns not inverted
- **Hypre solver convergence monitor**
  - Improved results quality by ensuring time step convergence is satisfied with the iterative solver
  - User receives an error message if the convergence tolerance is not met within the specified number of solver iterations

Electrochemistry

- **Electrodynamic Potential in Fluid Films D4434**
  - Simulate atmospheric corrosion more easily
    - Account for fluid film thickness in galvanic corrosion rate calculation to include the effect of various weather conditions
  - New model "Shell Electrodynamic Potential" in Fluid Film model
    - Combine with relevant Electric Potential Specification boundary condition between fluid film and wall to calculate corrosion rate
- **Ohmic heating at interfaces between solids and solid phases in phasic porous media**
  - Improved accuracy of simulations including interfaces between phasic porous media and solids, where the interface transmits a current and has a non-zero electrical resistance
  - Ohmic heating is now accounted for at interfaces between solid continua and solid phases in phasic porous media when
    - An electrical resistance is applied at the interface
    - The Ohmic Heating model is enabled

Aeroacoustics

- **Post FW-H to simultaneously process multiple receivers**
  - Improved turn-around time for Post FW-H with large number of microphones
  - Improved memory handling to allow for larger number of microphone through optimized algorithm for data IO
  - Note: the Data Source option has been required to be moved from receiver to node level to allow for optimization

## Motion, DFBI, Overset, and Mapping

- **Overset – Improved performance for large number of interfaces**
  - Faster simulations for cases with very many single overset interfaces
    - Example: 100 drone swarm simulation now 1.4x faster on 112 cores
- **Overset – Easier control of overset hierarchy**
  - Easier to ensure robust overset hole cutting
    - Quickly view and re-order overset hierarchy
  - Previously regions had to be swapped one by one
  - Now easily view and reorder priority through the Interfaces property Overset Hierarchy
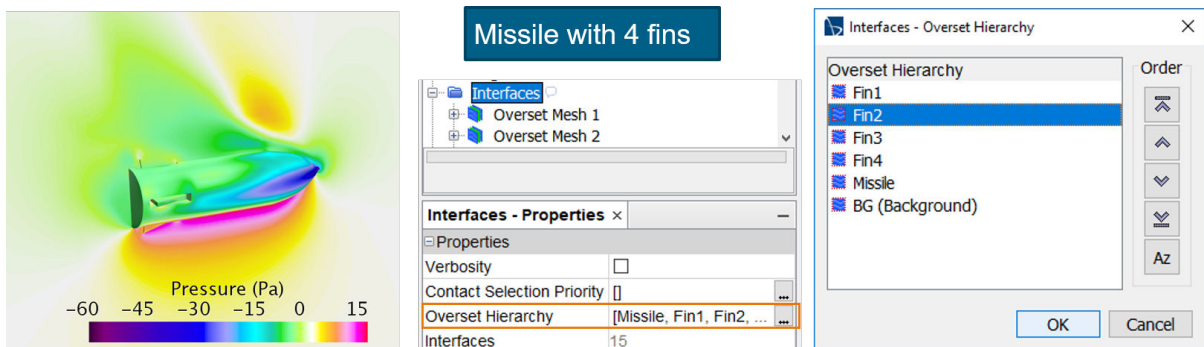
- **Virtual disks - Reduced memory consumption**

- ○ Reduced memory consumption for simulations with many virtual disks

Case	Nbr of Cells	Memory (GB), 2019.1	Memory (GB), 2019.2	Decrease
Drone, 8 blades	2M	6.05	5.61	1.08x
Wind park, 49 turbines	19M	48.7	18.1	2.7x
Oil platform, 8 propellers	5M	8.9	7.8	1.14x
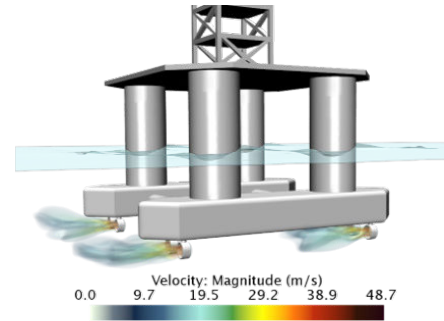
- **Automatic creation of coordinate systems for superposed rigid motions**
  - ○ Easier setup of superposed rigid motions with less opportunity for error
    - ▪ Previously the coordinate system for each superposing motion had to be created manually
  - ○ A local coordinate system is now automatically created for any superposing motion
    - ▪ Named as the motion, with added prefix -CSys
    - ▪ Automatically set as defining coordinate system for superposing motion and added to managed coordinate systems of parent motion
- **Morpher - Improved handling of edges**
  - ○ Improved morph quality for multiple simultaneously morphed adjacent surfaces
    - ▪ Consistent edge movement in parallel and when both connected surfaces are morphed
  - ○ Previously edges between morphed surfaces could move inconsistently, and partition boundaries could give distorted edges
  - ○ Now morphing is more consistent and independent of partition boundaries

Design Exploration

Adjoint

- **New Adjoint solver and best practices**
  - ○ Improves accuracy of exact differentiation and automated consistency test
  - ○ Reduces memory usage allows for improved overall robustness and 2nd order adjoints on industrial cases
  - ○ New optimized defaults applicable for almost all cases
    - ▪ Improves stability and convergence
- **Adjoint of Spallart-Allmaras turbulence model** D2593
  - ○ Improves accuracy of the adjoint solution in cases where turbulent effects are important
    - ▪ Most suitable for aerospace applications
  - ○ New differentiated Spallart-Allmaras model with differentiated wall functions
    - ▪ High, low y+ and all layer models supported
- **Cost functions definition moved under the adjoint solver**
  - ○ Improves workflow and easier setup of multi-objective optimization cases
    - ▪ Allows more comprehensive multi-objective setup
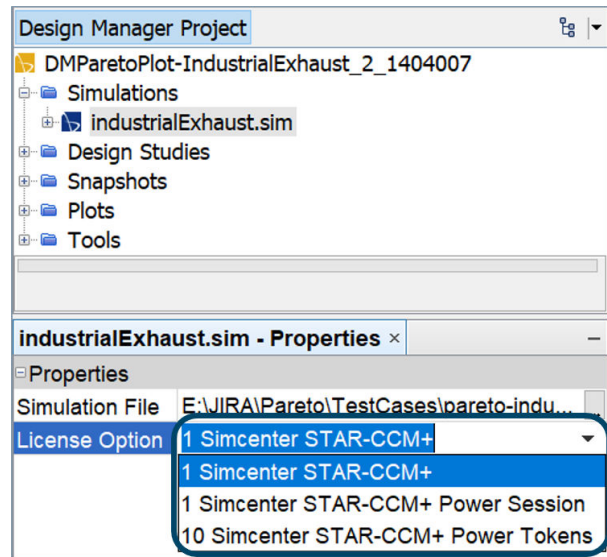   - - Reduces travelling up and down the tree

Design Manager

- **Support of all license schemes for reference .sim file update** D4684
  - Efficient use of license resource to
    - Increase return on investment
    - Manage priorities
  - Support for all license types when updating reference .sim file from Design Manager when no simulation server already running
    - 1 Simcenter STAR-CCM+ session license
    - 1 Simcenter Power Session license
    - 10 Simcenter Power Tokens
- **Enhanced import of manual and manual seed tables using .csv files**
  - Flexible management of file content
  - Save time with improved workflow robustness
  - Provides explicit user guidance
  - Design Table populated with all available data
    - *Include response* box to optionally import existing responses (or choose not to)
    - If a parameter/response data, column or header is missing, remaining data is still imported and explicit feedback provided to user
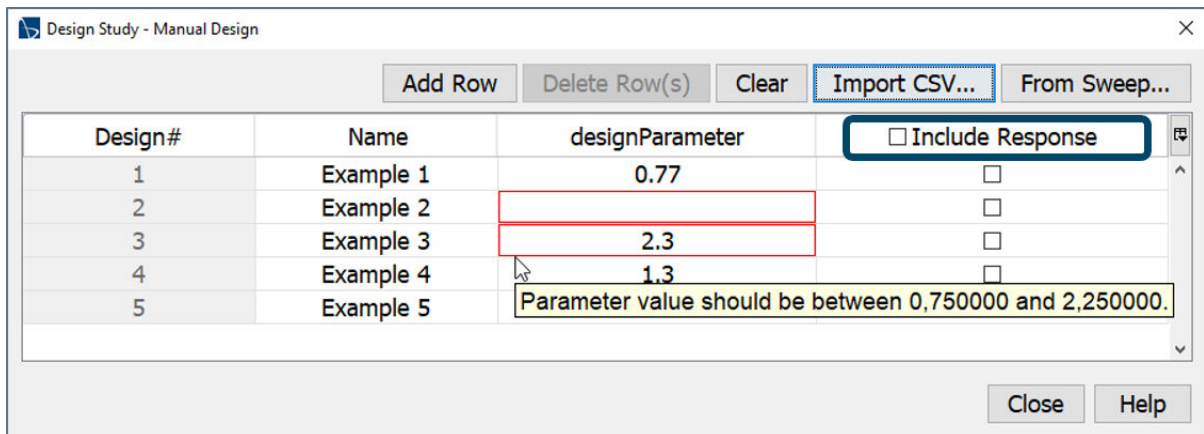
- **Identification of values violating constraints in Design Table**
 - Save time during post-processing
    - Easily and quickly detect constraints issues
  - Design Table uses highlighting (in red) for values that violate constraints
  - Hover-tip indicates the constraint range
  - Table update is automatic if the constraint changed after the study execution

| Design#	State	Uniformity - Velocity MA	Bottom_Angle_Param
40	✓	0.859	25.0 deg
41	❗		25.0 deg
42	✓	0.719	25.0 deg
43	✓		13.0 deg
44	✓	0.50	0.7192033607959747
45	✓	0.8	Violates Minimum Constraint (0.85)
46	✓	0.798	24.0 deg
47	✓	0.831	15.0 deg
48	✓	0.832	14.0 deg
49	✓	0.856	22.0 deg
50	✓	0.858	25.0 deg
51	✓	0.859	25.0 deg
52	✓	0.86	24.0 deg
53	❗		3.0 deg
54	✓	0.854	25.0 deg
55	✓	0.861	25.0 deg
56	✓	0.816	25.0 deg
57	✓	0.856	22.0 deg
58	✓	0.863	25.0 deg
59	❗		20.0 deg
60	✓	0.781	25.0 deg

- **Retain temporary artifacts D5045**
  - Access to relevant information to diagnose and debug runtime failures in clusters environment
    - .mdxruntime folder optionally retained at the end of execution

- **Design Status axis auto range 0 or 1 in plots**
  - Clearer and consistent display of axis numbers
  - Save time during post-processing
   - Automatic 0 to 1 axis range (failed or succeeded) for Design Status in plots
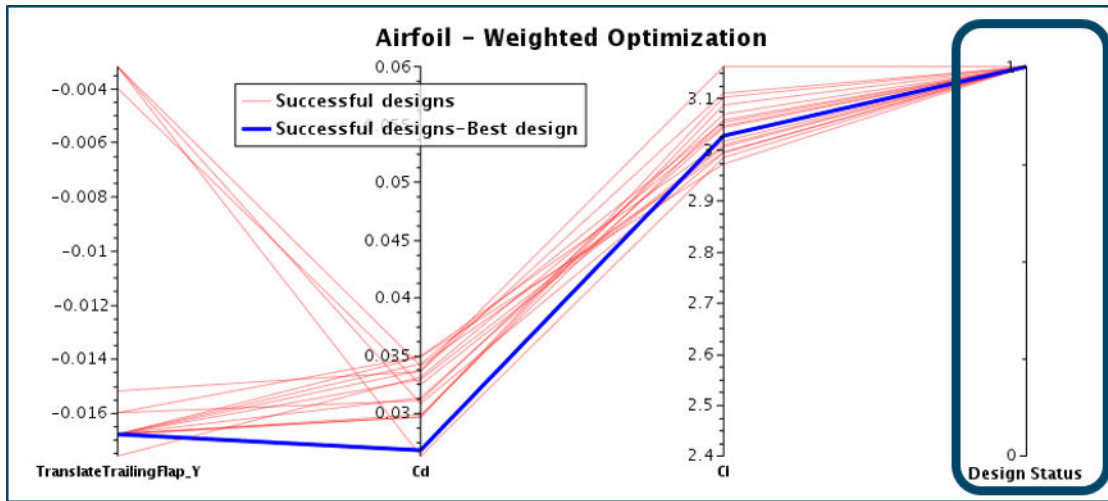
Data Analysis

- **Cotemporal Monitor option for Statistical Min/Max Reports**
  - Broaden your ability to effectively communicate your results
    - Plot cotemporal monitor evaluation during analysis
    - Overcome previous limitation of only being able to evaluate cotemporal monitor at end of analysis
  - Monitors created from Statistical Min/Max reports will have a new option to return the value of a cotemporal monitor
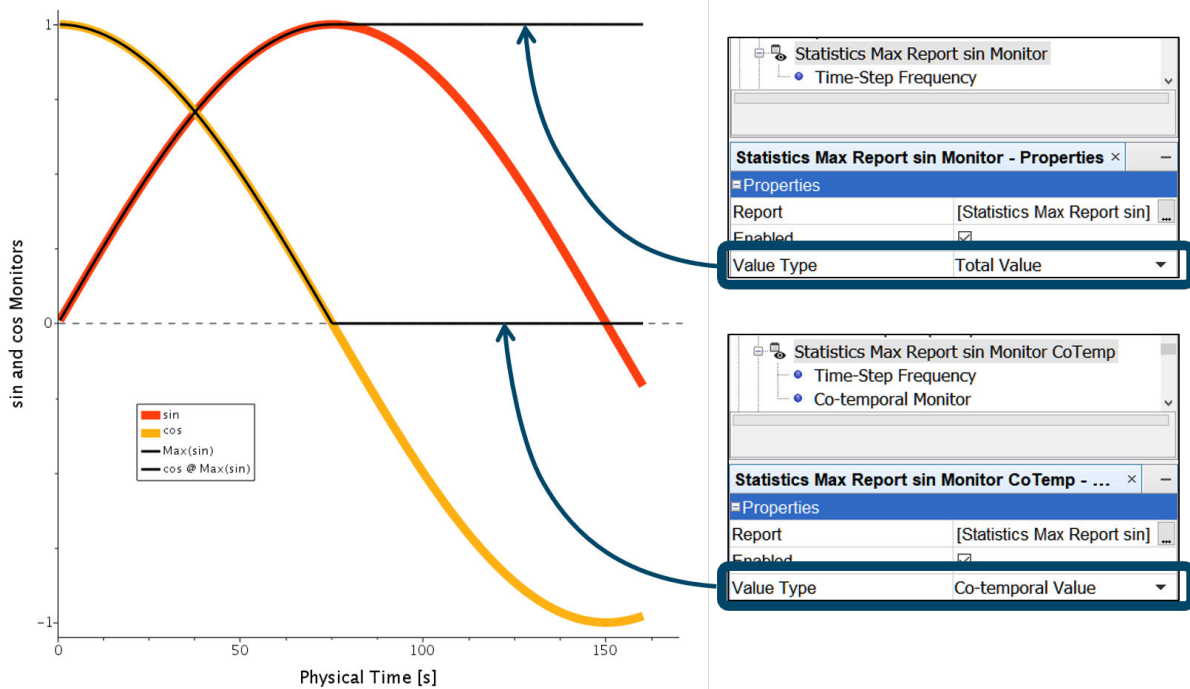
- **Data Set Function evaluation using Solution History representations**
  - Generate Data Set Functions up to 30% faster compared to the .TRN workflow using Solution History Representations
  - New Surface & Line Time Domain Filter Data Set Functions

- ▪ Underlying data sources can now be based on .simh files
- ○ Solution History representation now available for Point, Line & Surface Time History h(s)
  - ▪ Standalone boundaries
  - ▪ Plane sections
  - ▪ Presentation grids
  - ▪ Line & Point probes
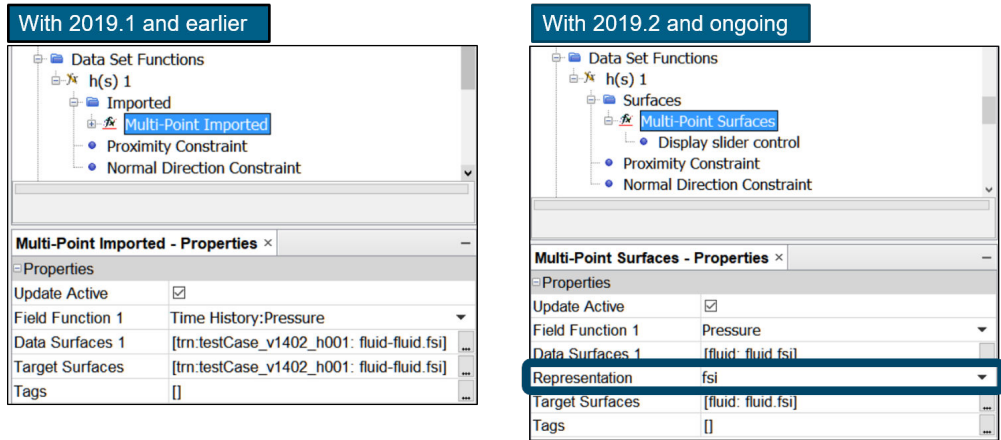
- • **Performance Improvement for Derived Part Sections**
  - ○ Save time when creating or interactively modifying Plane, Cylindrical, and Sphere sections
    - ▪ Reports, Plots and Scenes that use these Derived Part Sections will be faster compared to previous releases
  - ○ Animated Derived Part Section sweeps are 4X to 11X faster (depending on content)
    - ▪ Improved performance is realized via a persistent data structure
    - ▪ Memory increase compared to previous releases is small, ~1% to 2%
- • **Robust error messaging/handling for faster diagnostic assessment**
  - ○ Save time by being able to understand the context of error messages more easily
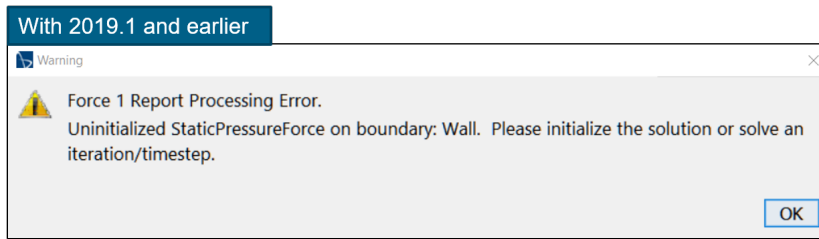   - ▪ Diagnostics are more relevant and appropriate for issues encountered

- ○ Realize a more robust workflow through better handling of report evaluations
    - ▪ Errors are no longer handled via assert dialogs

- Previous behavior could block automation attempts for more complex simulation efforts such as Co-Simulation

With 2019.1 and earlier

Warning ×

⚠ Force 1 Report Processing Error.
Uninitialized StaticPressureForce on boundary: Wall. Please initialize the solution or solve an iteration/timestep.

OK

With 2019.2 and ongoing

```
Reference Pressure = 0.0 Pa
Direction: [1.0, 0.0, 0.0]
Coordinate System: Laboratory
Vectors
[…]
Component in direction: [ 1.000000e+00,  0.000000e+00,  0.000000e+00] in Laboratory coordinate system
Part                            Pressure(N)   Shear(N)      Net(N)        Errors
-----------------------------   -------------  -------------  -------------  -------------------------------
Wall                            0.000000e+00  0.000000e+00  0.000000e+00  unable to compute
-----------------------------   -------------  -------------  -------------  -------------------------------
Totals:                         0.000000e+00  0.000000e+00  0.000000e+00  no data, incomplete computation
```

- **Screenplay** D401, D2264, D3502, D3558, D3952
  - New tool that allows creation of sophisticated animations within Simcenter STAR-CCM+
  - Grab and hold the attention of your stakeholders
    - Visually communicate abstract ideas
    - Simplify complex concepts with memorable content
    - Make decisions faster and easier through improved recollection
  - Create Screenplays quickly and easily
    - The new Screenplay editor distinguishes between Actions, Keyframe Sequences and Keyframes
      - Expert knowledge of keyframe animation basics is not needed
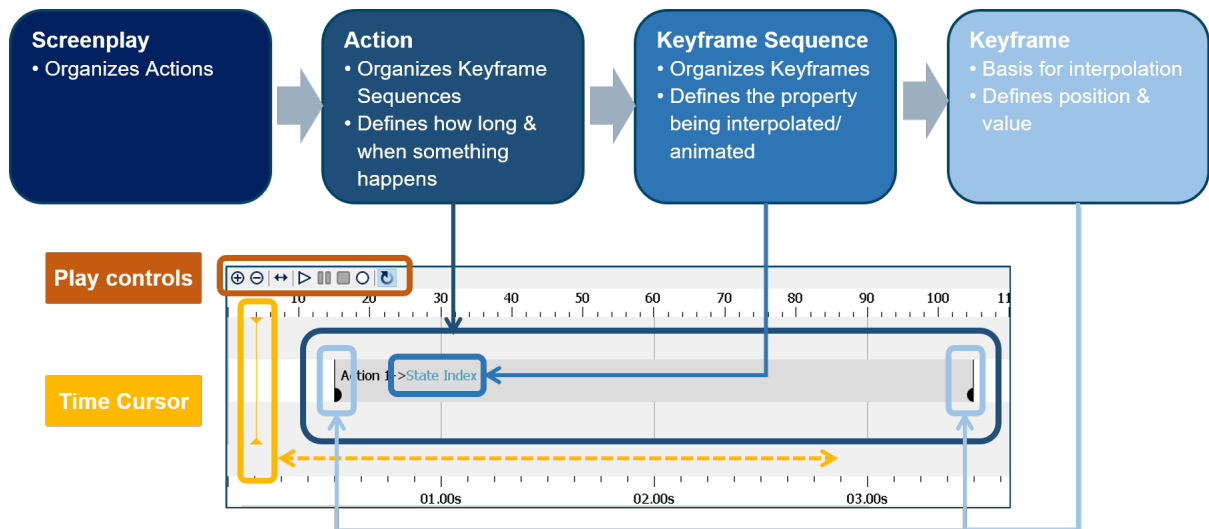

  - Preview your animations using standard Play, Pause and Stop controls
  - Interactively move back and forth through your Screenplay using the Time Cursor control
  - Write .avi animations directly, with a choice of High Quality, Balanced or small file size output, or

- Save hardcopy images sequentially using standard image aspect ratio and size formats
    - 16:9 aspect ratio for HD, Full HD, 4K UHD
    - 4:3 aspect ratio for XGA, SXGA, UXGA
- A broad drag'n'drop capability simplifies Screenplay content creation/evolution
    - Animate-able Property content within the node tree is easily identified via visual color cues
    - All Simple Transform and View properties can be dragged into the Screenplay editor
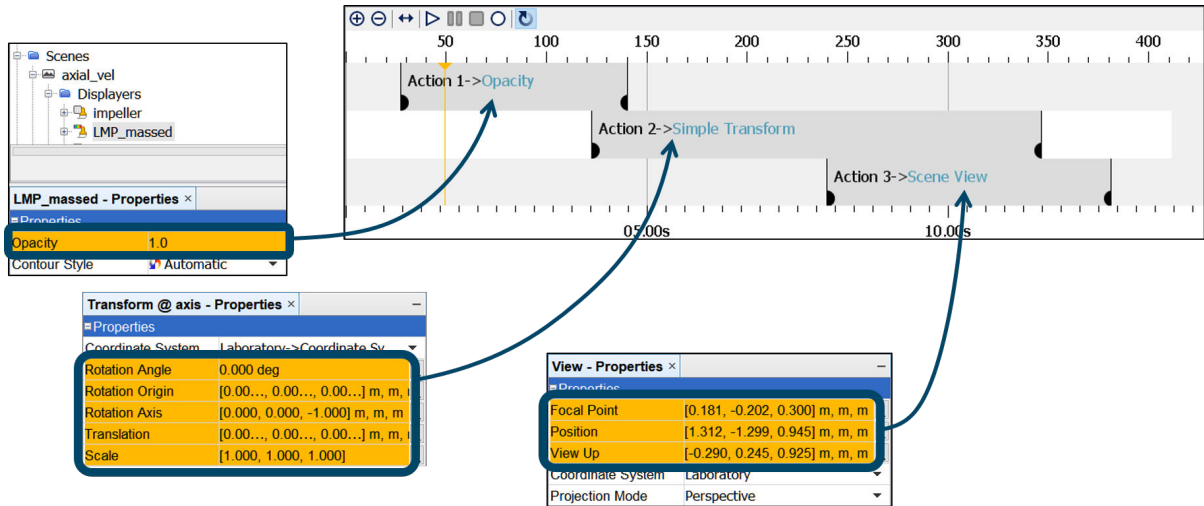
- Screenplays can range from simple to complex
    - Animate a single property for quick understanding
    - Animate many properties to tell your full story
    - Animate properties from different scenes and/or plots to produce compelling content
        - Example illustrated below progressively overlays scalar results on the blank room
        - Properties for the two scenes are manipulated in the same Screenplay
        - Keyframe sequences are created for both scenes for:
            * View interpolation
   * Clipping plane position (in opposing directions for each scene)

Keyframes for "A"

Keyframes for "B"

Interpolation of properties between Keyframes
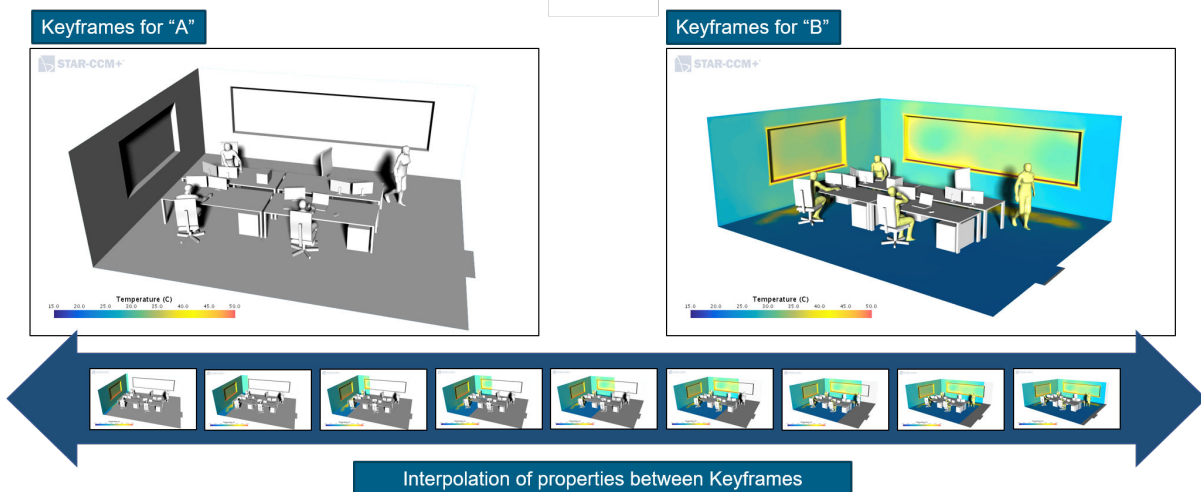
Application Specific Tools

STAR-ICE

STAR-ICE

- **PISO Algorithm Setup**
    - Simulations run more than twice as fast with the PISO algorithm, while maintaining the same solution accuracy as previously achieved with the SIMPLE (Implicit Unsteady) algorithm
    - The PISO algorithm can now be activated from the "Model Selection" panel by deselecting "Implicit Unsteady" and selecting "PISO Unsteady"
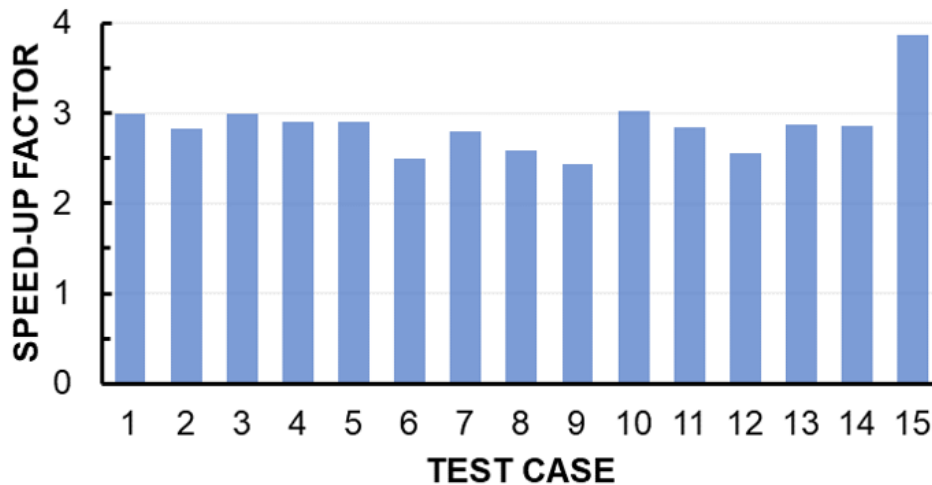
- **Multi-Component Fuel Setup**
    - Quickly and easily specify multi-component fuels through a new panel under the "Fuel" node
        - The liquid components are automatically matched with their corresponding vapor components when an obvious match exists
        - The components are entered mass weighted
        - The sum of the components does not need to be equal to one
        - STAR-ICE will perform a normalization when the specification is completed

- **User-Specified Interfaces with Custom Morphing**
    - You can now better add geometrical complexity to the model and maintain good cell quality
    - Allows specification of morphing boundary condition of the interface created by the user, and STAR-ICE will not modify it
- **General Robustness Enhancements**
    - You can now specify maximum cell skewness angle and face validity as additional remeshing criteria
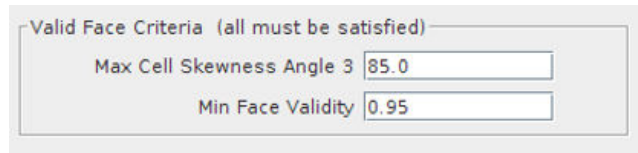
- ○ STAR-ICE now generates a better mesh when the valves are closed as interface intersection is executed only when the valves are open
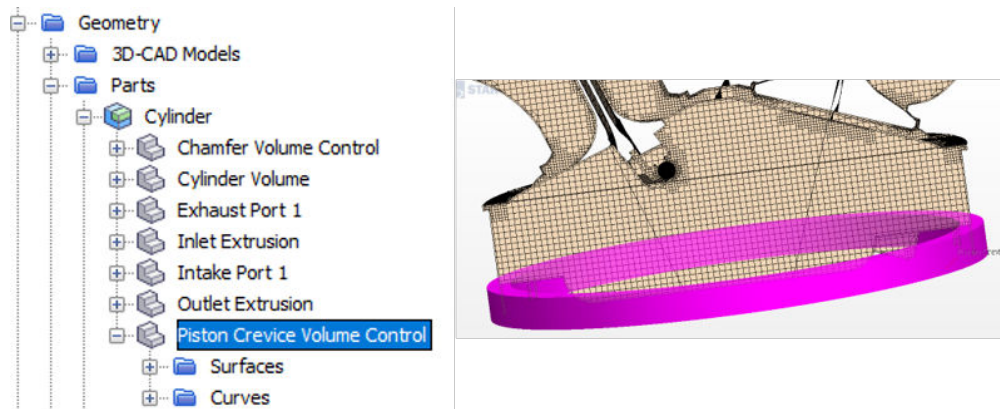

- ○ STAR-ICE now automatically identifies the piston crevice region, and creates a volume control for mesh refinement that moves with the piston
- **General Minor Enhancements**
  - ○ Clicking "Update STAR-ICE" will no longer lock the user interface, for example when changing or updating the geometry
  - ○ STAR-ICE now remembers the state of the "Compression Ratio" and "Piston Position Offset" radio buttons
  - ○ Text field labels lacking translation have been localized
- **Important Change Due To Simulation Operations**
  - ○ The introduction of Simulation Operations in Simcenter STAR-CCM+ changes the STAR-ICE workflow
  - ○ The Simulation Operations toolbar now appears in STAR-ICE
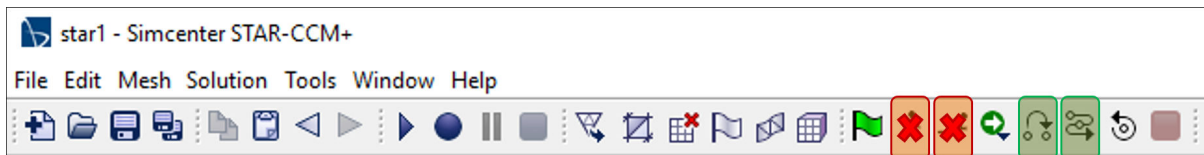
  - ○ Use the "Play to Next Operation" or "Play/Resume In-Cylinder" button instead of the "Step" or "Run" button to execute the STAR-ICE workflow

User Guide

- **New Tutorials**
  - ○ Analysis Methods
    - ▪ Screenplay Animation: Assessing Vehicle Aerodynamics
  - ○ Incompressible Flow
    - ▪ Polymer Melt Extrusion: Film Casting
  - ○ Design Manager
    - ▪ Part-Replacement Using Design Manager
  - ○ Heat Transfer and Radiation

- Simulation Operations: Multi-Timescale Conjugate Heat Transfer

  This tutorial was previously released as the Multi-Timescale Conjugate Heat Transfer: Exhaust Manifold tutorial. It now uses simulation operations for solving the continua alternately.

- **Modified Tutorials**
  - Arbitrarily Shaped Particles: DEM Polyhedra — updated procedure
  - Abaqus Co-Simulation: Thermal Coupling — updated input files
  - FSI and 6-DOF Motion: Stress Analysis on Boat Propeller — revised input file and procedure
  - FSI with Prescribed Solid Motion: Flapping Wing — revised to use new motion setup
  - Adjoint Flow Solver: External Flow over a Dual Element Wing — revised to include the Adjoint Spalart-Allmaras model
  - Adjoint Flow: Wing Shape Optimization — updated to reflect latest user interface
  - Adjoint Flow Solver: Flow through an S-Bend — updated to reflect latest user interface
  - Gasoline Engine: Motored — now uses the PISO algorithm
  - Gasoline Engine: Charge Motion — revised to use a multi-component fuel
  - Fluid Film: Binary Liquid Film Flow with Evaporation and Edge Stripping — updated to reflect latest user interface
  - Fluid Film - VOF: Rivulets on an Inclined Plane — new mesh provided for input
  - Basic Gravity Sand Casting — revised to use adaptive time step
  - Reacting Channels: Steam Methane Reforming (renamed from Steam Cracking Furnace) — now uses CVODE solver instead of DARS for reacting channel; combustion model changed to FGM

- **Retired Tutorials**

  The following tutorials were removed for this release:
  - STAR-Cast: Investment Casting
  - Turbo Wizard: Single Row
  - Turbo Wizard: Multiple Rows
  - 3-Step Eddy Break-Up: Non-Premixed Propane
  - Geometry Parts: CAD Assembly

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About Siemens PLM Software

Siemens PLM Software, a business unit of the Siemens Digital Factory Division, is a leading global provider of product lifecycle management (PLM) and manufacturing operations management (MOM) software, systems and services with over 15 million licensed seats and more than 140,000 customers worldwide. Headquartered in Plano, Texas, Siemens PLM Software works collaboratively with its customers to provide industry software solutions that help companies everywhere achieve a sustainable competitive advantage by making real the innovations that matter. For more information on Siemens PLM Software products and services, visit www.siemens.com/plm.