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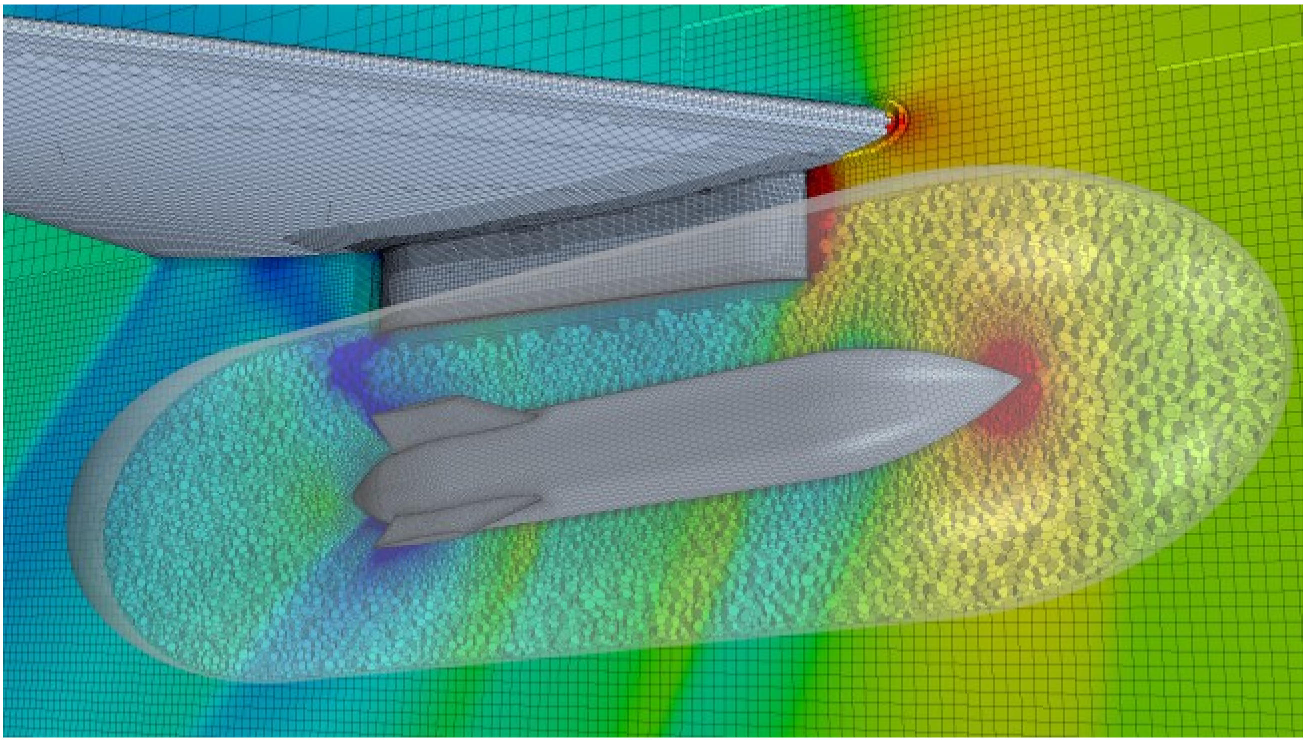
New & Upcoming Capabilities for the Aerospace Industry



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Overset Mesh

Advantages of overset meshing have been recognized for many years. In the case of steady flow around bodies at various relative positions, one needs to generate individual grids only once, and then compute the flow for many combinations or relative positions and orientations by simply moving grids, with no need to re-mesh or change boundary conditions. Applications include control surface deflection studies, parametric studies, or even simple angle-of-attack sweep studies. Flow around bodies moving relative to each other is often easier to handle with overset meshes than with sliding interfaces or deforming grids.

The flow field and 6-Degree-of-Freedom (6DoF) motion of bodies can be simulated by moving the grid attached to each moving body (with little or no deformation) while the background grid remains stationary. Applications include, to cite but a few, store separation, silo or tube launches, stage separation, etc..
In the past, several drawbacks of overset meshing have limited its widespread use, such as requiring block-structured meshes, tedious pre-processing, and reduced accuracy and stability due to weakly coupled solution approaches. CDadapco has developed an overset mesh approach that resolves these drawbacks
and will move the technology into mainstream CFD simulations.

Each mesh can be of any type, whether you prefer the general polyhedra mesher, the trimmer mesher, or to import existing grids. In fact, mixing mesh types is not
a problem. This means each mesh can be arbitrarily complex, which reduces the number of individual overset meshes needed. A novel solution approach has been
developed, where all grids are implicitly coupled within the linearized coefficient matrix of every equation solved.

There are no ?internal boundaries? used at the mesh interfaces, and the solution is computed simultaneously on all grids at each iteration. This ensures that the iterative solution method can be converged down to the round-off level of residuals, and that the convergence rate is similar to what would be obtained for the same problem on a single grid. In addition, for the case of dynamic fluid-body motion, the equations of motion are fully implicit and fully coupled with the flow solution, allowing larger time steps and better stability than with explicit schemes.

The first set of overset meshing functionalities is available in STAR-CCM+ v7, with many enhancements and improvements planned for the future.

Advancing Layer Mesher

It is apparent that unstructured meshes have come of age, and are now generally accepted as providing excellent handling of complex geometry and sufficient accuracy for both, internal and external flows. This is possible due to the so-called hybrid mesh approach, where prismatic cells are used in regions where the flow is dominated by viscous effects (namely within the boundary layer), and general unstructured cells are used in the remainder of the computational domain. STAR-CCM+ provides a robust state-of-the-art prismatic mesher and general polyhedral or Cartesian unstructured meshers. Still, there are applications where smoothly growing, primarily structured body-aligned meshes are advantageous; for instance, computations involving bow shocks, where the mesh needs to be aligned with the flow direction and gradients of the transported values in order to reduce truncation errors and numerical diffusion.

The Advancing Layer Mesher, first available in STAR-CCM+ v7, uses a pseudostructured mesh approach to generate layered, primarily structured grids from wall
boundaries. Although this may sound similar to the Prism Layer Mesher, there are key differences that make the models suitable for different applications.

In the case of the Advancing Layer Mesher, the prismatic cell layers are generated from the polygonal surface mesh into the volume, rather than using an inflation approach like the Prism Layer Mesher. This allows the Advancing Layer Mesher to generate a thicker layer and maintain a more uniform wall distance, meaning that the layered region can grow beyond the boundary layer to provide smooth, wall-aligned meshes in the mid-field. Users will note a resemblance to structured hyperbolic meshes, but with significantly improved robustness because the algorithm can collapse and split faces and edges, thereby improving mesh quality and reducing cell skewness.

Battery Design

It is nearly impossible to miss the significant development efforts the automotive industry has made in electric vehicles in recent years, specifically in power storage and delivery via batteries. Although it hasn?t received the same media attention, batteries play a crucial and growing role in the aerospace industry. For instance, spacecraft have used batteries to store energy for decades. Lithium-ion batteries are relatively new to this application, but the potential impact of this technology on the industry is significant. The traits that make these batteries attractive to the automotive industry are especially critical to spacecraft, namely lightweight, small volume, high specific energy and long cycle life.

Closer to home, micro- and tactical-sized Unmanned Aerial Vehicles (UAVs) already utilize a fully-electric power solution ? including propulsion. For mainstream aviation, batteries are currently strictly used for start-up and backup power; for instance, to run navigation and critical systems when the Auxiliary Power Unit (APU) is off, or in case of an emergency. H owever, the recent CAFE Foundation Green Flight Challenge was dominated by two fully electric-powered aircraft that delivered as much as 400+ passenger miles-per-gallon equivalent ? more than twice that of the fossil-fuel-powered aircraft in the competition. Clearly, batteries will play an important role in the future of the aerospace industry in much the same way as it will for the automotive industry.

To address this key technology, CD-adapco partnered with Battery Design LLC several years ago to develop a best-in-class simulation environment for battery analysis and design. The resulting STAR-CCM+ Battery Simulation Module (BSM) calculates the 3D thermal, fluid and electrochemical phenomena of Lithium-ion battery cells within a full range of length scale models. These simulations start from the electrode pairs within the battery cell, to the entire pack, including thermally and electrically-conducting parts such as metallic connectors which have a significant effect at high discharge/charge rates. This is all done within the familiar user-friendly STAR-CCM+ user environment.

Specifically, all of the fluid flow and heat transfer capabilities, including multiple fluid/solid domains, conjugate heat transfer, multiphase flow, radiation, etc. available in STAR-CCM+ are coupled to a full range of cell models. By simultaneously solving the electrical and thermal problems, the close-coupled nature of this system can be analyzed, providing engineers with previously unseen data. Moreover, the user has the ability to control the details of the simulation, both in terms of geometric fidelity and appropriate mathematical models, thereby ensuring that analyses are tailored to the user?s needs and resources. These models include a state-of-theart detailed electrochemistry model which can deal with multiple active materials regularly seen in contemporary Li-ion cell design.

One of the key challenges in this type of analysis is establishing a clear engineering process ? from battery pack design and experimental cell data to a reasonable simulation result. Much effort has been devoted to developing this process, and the result is a cutting-edge engineering tool, able to deliver fast and consistently realistic results.

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CD-adapco is the world's largest independent CFD focused provider of engineering simulation software, support and services. We have over 30 years of experience in delivering industrial strength engineering simulation.

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