DOD HPC DEPARTMENT OF DEFENSE HIGH PERFORMANCE COMPUTING MODERNIZATION PROGRAM

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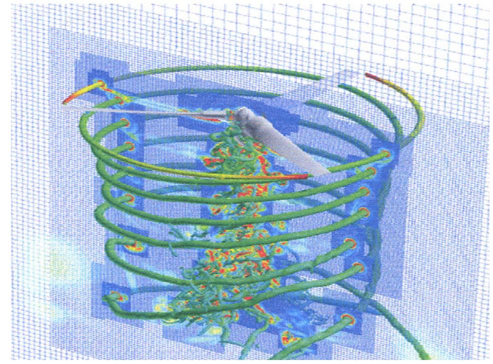
HELIOS Software on the HPCMP Portal



The HELIcopter Overset Simulations software (HELIOS) is a multi-disciplinary computational suite being developed by the DoD HPCMP CREATE-Air Vehicles (CREATE-AV) and the US Army. It includes modular software components for near-field and far-field computational fluid dynamics (CFD), off-body adaption, domain connectivity, rotorcraft comprehensive analysis, mesh motion and deformation, and an exact fluid-structure interface module. The HELIOS aerodynamics solution procedure applies a dual-mesh paradigm that consists of unstructured meshes in the near-body region and Cartesian meshes in the off-body region. The unstructured meshes allow ease of grid generation for complex configurations, while ensuring proper resolution of the wall-bounded viscous layer region. The Cartesian meshes enable the use of efficient high-order spatial discretization and adaptive mesh refinement (AMR) to accurately resolve the off-body flow structures. The near-body CFD solver in HELIOS is the NSU3D code, which is an unsteady Reynolds-averaged Navier-Stokes (URANS) code for unstructured meshes. It utilizes a node-centered scheme that is second-order accurate in space and time. A backward Euler formulation along with a dual time-stepping scheme is employed for iterative convergence at each physical time-step. HELIOS uses the Spalart-Allmaras turbulence model. The Cartesian off-body solver in HELIOS (SAMARC) is a combination of the Structured Adaptive Mesh Refinement Application Infrastructure (SAMRAI) and the off-body CFD single-block solver (ARC3DC) which solves the in viscid Euler equations. The off-body CFD solver uses a temporally third-order explicit Runge-Kutta time integration scheme and a fifth-order central difference spatial scheme with scalar artificial dissipation. The fully automated domain connectivity formulation is provided by the Parallel Unsteady Domain Information Transfer (PUNDIT) component. The Rotorcraft Comprehensive Analysis System (RCAS) has been used with HELIOS for CFD/CA coupled analyses. The procedure is the standard loose (delta) coupling. The conservative fluid structure interface within HELIOS is a grid-topology-independent (for structured and unstructured mesh) and exact (total air loads/energy) formulation.

Rotorcraft computations are challenging because they are inherently multidisciplinary, requiring the solution of moving-body aerodynamics coupled with structural dynamics for rotor blade deformations, as well as vehicle flight dynamics and controls. In addition, rotorcraft flow fields need to resolve multiple spatial and temporal scales in the unsteady problem, including 3D unsteady transonics in the advancing side, multiple dynamic stall cycles in the retreating side, wake roll-up and blade vortex interaction in the near-field, and wake intertwining and propagation in the far-field. HELIOS is based on an overset framework that employs unstructured mixed-element meshes in the near-body domain, combined with high-order Cartesian meshes in the off-body domain and Adaptive Mesh Refinements (AMR).

HELIOS consists of multiple components performing different parts of the multi-disciplinary application CFD, computational structural dynamics (CSD), six degree-of-freedom (6DOF) dynamics, etc. The different components are written in different languages: FORTRAN90, C, and C++, which are integrated through a high-level Python-based infrastructure.

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