2020 Sessions

Sheng, C., Zhao, Q., Baugher, S., "Numerical Investigation of Rotor Aerodynamics Using High-Order Unstructured Grid Schemes," AIAA-2020-0528, AIAA SciTech 58th Aerospace Sciences Meeting, 6-9 January 2020, Orlando FL.

> Rotor aerodynamic performance and flow physics of a NASA pressure-sensitive rotor are investigated using a vortex-centered, finite-volume unstructured grid CFD solver. One-dimensional high order polynomials originally developed for structured grid WENO schemes are extended to unstructured grids by introducing the least-squares approximation in the construction of adaptive stencils. In this study, numerical accuracy and applicability of a new high order WENO scheme are evaluated for both isolated rotor and a full configuration. Effects of the high order WENO scheme are assessed in terms of rotor hover predictions as well as capturing critical flow physics such as boundary layer transitions and flow separations on rotor blade surfaces.

Park, S., Kwon, O., "Numerical Study of Isolated and Full Configuration PSP Rotor Using a Mixed Mesh Flow Solver," AIAA-2020-0529, AIAA SciTech 58th Aerospace Sciences Meeting, 6-9 January 2020, Orlando FL.

> In the present study, numerical simulations of the PSP rotor in hover were carried out by using a Reynolds-averaged Navier-Stokes CFD flow solver based on unstructured mixed meshes. The improved model was adopted for the prediction of laminar-turbulent onset phenomena involving crossflow induced transition and flow separation. In order to capture vortex with high resolution, an improved scheme ESWENO-P was used for computing the inviscid fluxes on Cartesian meshes. The predicted results such as transition onset locations and rotor aerodynamic performances in terms of thrust coefficient, torque coefficient and figure of merit were compared with experimental data. The effects of the fuselage and facility walls on PSP rotor performance in hover were also investigated.

Hariharan, N., "An Overview of Wake-Breakdown in High-Fidelity Simulations of Rotor in Hover," AIAA-2020-0530, AIAA SciTech 58th Aerospace Sciences Meeting, 6-9 January 2020, Orlando FL.

> Wake breakdown is a well-documented computational phenomenon associated with highly resolved computational hover predictions. As the computational state-of-the-art for hover predictions has progressed, allowing for higher resolution of the rotor wake, the formation of secondary braids in computed helical wake systems has manifested in various forms. The formation of 3D secondary braids between two parallel convecting vortex filaments, under the right conditions, is physical. Recent hi-definition rotor-hover experiments do confirm their presence. However, computed wake breakdown is more pervasive, and the question of whether high-fidelity methods exaggerate the extent of the secondary vortex production has been a topic of research in the past decade. In this paper, we survey the computational ingredients that make up a high-fidelity hover solver, highlight interesting recent developments and try to summarize what we know (and what we do not know) about computed wake breakdown.

Abras, J., Narducci, R., Hariharan, N., "Impact of High-fidelity Simulation Variations on Wake Breakdown of a Rotor in Hover," AIAA-2020-0531, AIAA SciTech 58th Aerospace Sciences Meeting, 6-9 January 2020, Orlando FL.

Wake breakdown is a well-documented computational phenomenon associated with high-resolution CFD hover predictions. As the computational state-of-the-art for hover predictions has progressed, allowing for higher resolution of the rotor wake, this phenomenon has become more severe; thus, resolving this open question has become more important to increase understanding of how and why it occurs and define a path forward. The present work investigates the wake breakdown phenomena using the S-76 isolated rotor. This investigation includes a thorough analysis of physical flow features that are felt to influence wake breakdown as well as an analysis of the computational inputs that can influence these flow features. This ongoing investigation has covered a variety of variations and theories. The current work contains an investigation of parameters that increase the fidelity of the simulation and also reinvestigates and expands upon previous results using alternate perspectives. The results show that grid structure and motion have more of an impact on wake breakdown than changes made to the solution resolution.

Kara, K., Brazell, M., Kirby, A., Mavriplis, D., Duque, E., "Hover Predictions Using a High- Order Discontinuous Galerkin Off- Body Discretization," AIAA-2020-0771, AIAA SciTech 58th Aerospace Sciences Meeting, 6-9 January 2020, Orlando FL.

Hover performance of a four-bladed Sikorsky S-76 rotor is studied using a high-order discontinuous Galerkin (DG) off-body discretization. Time accurate Navier-Stokes calculations are performed using the WAKE3D code, which combines solution technologies in a multi-mesh, multi-solver paradigm through a dynamic overset framework that employs an unstructured mesh Navier-Stokes method as a near-body solver and a high-order adaptive discontinuous Galerkin discretization as an off-body solver. The rotor with a swept-tapered tip is simulated. The tip Mach number was 0.65, and the Reynolds number based on the reference chord is 1.2 million. A constant coning angle of 3.5 degrees is applied. The effect of time step size and sub-iterations on the integrated parameters is investigated and convergence results are presented. The effect of the maximum order of accuracy of the adaptive h-p discretization in the off-body solver on solution accuracy and efficiency is also investigated. Thrust coefficient, torque coefficient and figure of merit are calculated and compared with available data in the literature, and good agreement is found. In general, higher order off-body simulations are found to result in a better accuracy/cost metric.

Quackenbush, T., Whitehouse, G., Silbaugh, B., Danilov, P., "Download and Rotor Installed Performance In Hover and Low Advance Ratio Flight," AIAA-2020-0772, AIAA SciTech 58th Aerospace Sciences Meeting, 6-9 January 2020, Orlando FL.

This paper documents recent developments in ongoing work on the prediction of installed performance of rotors in hover and near-hover conditions featuring configurations with strong rotor/airframe interaction. The focus is on the application "mid-fidelity" analysis tools to representative problems in modeling coupled rotor/airframe aerodynamic systems. The work reported here extends prior activity on this topic by assessing the performance of a previously studied mid-fidelity CFD model in capturing both hover download and thrust recovery, as well as on extending the range and configurations used for validation to additional full-scale systems. The overall goal is to provide a more complete assessment and validation of tools that are currently supporting conceptual and preliminary design of novel rotorcraft configurations.

Carnes, J., Coder, J., "Effects of Crossflow Transition on the S-76 and PSP Rotors in Hover," AIAA-2020-0773, AIAA SciTech 58th Aerospace Sciences Meeting, 6-9 January 2020, Orlando FL.

The Amplification Factor Transport model has been extended to include crossflow transition. Validation of the crossflow model implementation has been performed using standard test cases. Due to the innate rotationality and crossflow strength experienced, the S-76 and PSP rotors are simulated in hover for various collective pitch angles as test cases for the transition model. The OVERFLOW 2.2n solver is used with laminar-turbulent transition modeling and hybrid RANS/LES enabled. Grid generation, numerical methods, and transition modeling are described. The effects of crossflow transition is qualitatively and quantitatively assessed through comparisons to experiments and to a transition model without crossflow.