2023 Sessions

Narducci, R., and Hariharan, N., "A Common Simulation for Hover Validation of a Helicopter near the Ground," AIAA-2023-1187, AIAA SciTech 61st Aerospace Sciences Meeting, National Harbor, MD, 23-27 January 2023.

> The AIAA Hover Prediction Working Group has made significant progress in refining methodologies for hover performance predictions. Several excellent experimental datasets have been utilized to validate improvements though much has been focused on isolated rotor simulations. More realistic hover simulations would involve the helicopter airframe, the ground, light winds, and multiple rotors, such as the addition of a tail rotor. Validation datasets for the "real" helicopter in hover are sparse and not available to the public with sufficient information to make them useful for validation. Creating an experimental database would be very costly. Instead, a series of hover scenarios is proposed. Practitioners are encouraged to simulate the scenarios using their methodology and share results among the community of practice. Though an experimental truth set is not available, sharing results from these simulations is valuable for gaining insight into the predictive capabilities of one's method. This paper presents a series of simulations intended to address installed hover performance, download, groundwash, and the impact of light winds. A few representative results are shared.

Klimchenko, V., Min, B.Y., and Wake, B., "Model and Full-Scale Rotor Hover Performance Analysis using HELIOS/OVERFLOW," AIAA-2023-1188, AIAA SciTech 61st Aerospace Sciences Meeting, National Harbor, MD, 23-27 January 2023.

> CREATE-AV Helios/Overflow hover simulations were performed for the S-76® model-scale rotor out-of-ground effect. The two blade planforms with blade tip variations that are investigated in this study include the swept-tapered and swept-tapered-anhedral tips. Performance calculations for the two S-76 blade planforms were compared with the publicly available experimental data set. Sensitivity to coning angle were investigated, and sensitivity to light wind conditions. In addition, full-scale rotor hover simulations were performed for out-of-ground effect conditions, and with the tower/ground effects included to compare directly with full-scale whirl-test results. STAR-CCM+ simulations were also performed and compared with full-scale test results and HELIOS, for both in-ground-effect and out-of-ground effect. Correlation with full-scale results is very good, when the integration effects are included. Model-scale results tend to be low in Figure of Merit versus test using a baseline mesh for the AIAA hover workshop. Full-scale rotor calculations used a finer mesh and provided good correlation with test.

Steininger, R., Barakos, G., and Woodgate, M., "Numerical Analysis of HVAB and STAR Rotor Blades Using HMB3," AIAA-2023-1189, AIAA SciTech 61st Aerospace Sciences Meeting, National Harbor, MD, 23-27 January 2023.

> Computational Fluid Dynamics simulations of the Hover Validation and Acoustic Baseline, Smart Twisting Active Rotor, and Active Twist Rotor blades in hover are presented. For these blades, the effect of twist in hover is examined, using the in-house simulation tools of Glasgow University. Rigid and aeroelastic methods are also compared for these rotors. In forward flight, high-twist may be associated with increased blade vibration. For the Smart Twisting Active Rotor blades, the effect of static twist and of a 2/rev harmonic active twist input are also investigated at a high advance forward ratio flight conditions. A vibration index is used to quantify the harmonic components of hub forces and moments. The hover simulations were computed on grids of 10–16m cells, coupled with structural updates. The results show the strong effect of blade twist on hover performance. The forward flight cases were computed on a 36m cell grid and using a modal aeroelastic method.

Shankar, S., Sankar, L., and Chen, P.W., "Effects of Anhedral Tip on Hover Performance," AIAA-2023-1380, AIAA SciTech 61st Aerospace Sciences Meeting, National Harbor, MD, 23-27 January 2023.

Numerical simulations of the hover performance of the S-76 rotor with and without an anhedral tip in hover are presented. The near field over the rotor blades are solved using a 3-D compressible Navier-Stokes solver, coupled to a free wake model. The effects of turbulent mixing are modeled using a one-equation Spalart-Allmaras Detached Eddy Simulation (SA-DES) model. The effects of transition have been assessed by empirically modifying the eddy viscosity production term the SA-DES model to be driven to zero in the flow laminar regions. Sample results are presented for 2-D airfoils and 3-D baseline S-76 rotor to assess the improvements to the prediction with the transition model. The effects of anhedral tips are next analyzed. The radial loading and the induced inflow along the rotor are examined to determine how the anhedral modifies the induced power consumed by the rotor. Comparisons with other published data are presented.

Anderson, R., and Ning, A., "A Coupled Source Panel, Actuator Line, and Viscous Vortex Particle Method in an O(n) Scheme," AIAA-2023-1381, AIAA SciTech 61st Aerospace Sciences Meeting, National Harbor, MD, 23-27 January 2023.

Wake interactions play a significant role in aerodynamics. However, common modeling approaches are either expensive or lack fidelity, making them unreliable or difficult to use in the design process. The vortex particle method can capture the relevant physics effectively, but imposing boundary conditions with solid surfaces in a computationally efficient way is challenging. We explore two possible methods of imposing solid surface boundary conditions of vortex particle simulations. The first, a novel variation on a pure particle approach, is easy to implement but is moderately expensive, and suffers from some numerical instability. The second, source panels accelerated with a fast multipole code, is promising. This approach is not novel, but several innovations are presented for using the fast multipole method with a conglomeration of different element types (e.g. source panels, doublet panels, vortex lattice, vortex particles, etc.). Preliminary results of the pure particle approach, verification of the panel code, validation of the panel-vortex particle code for a rotor in ground effect, and benchmark comparisons with a direct solver approach are presented.

Fitzgibbon, T., Doolittle, C., Wang, Q., and Spalart, P., "An Application of the Flow360 Solver to the Hover Download Prediction Problem," AIAA-2023-1382, AIAA SciTech 61st Aerospace Sciences Meeting, National Harbor, MD, 23-27 January 2023.

This paper presents the contribution of Flexcompute to the Hover Prediction Workshop, with a focus on hover performance and download predictions. The analysis is focused on HVAB rotor blade simulations at two blade tip Mach numbers of 0.58 and 0.65. First, a rigorous mesh refinement and time step study is performed to assess the discretization error sensitivities for both isolated and installed rotors. The impact of mesh resolution and time step on the performance, sectional loading and flow features is presented with recommendations put forward for engineering level accuracy and high-fidelity solutions. An analysis of loads convergence is also performed, which was found to affect the predictions for installed rotor calculations. Next, a collective sweep study is performed at two blade tip Mach numbers for isolated and installed rotors, and where available comparisons are made with experimental data and predictions from other CFD codes. The Flow360 results showed strong correlation with reference data and resolved high-resolution wake structures, showing the applicability of Flow360 to hovering rotor solutions.