2022 Sessions

Jain, R., "CFD Hover Performance and Transition Predictions on the PSP and HVAB Rotors using CREATE™-AV Helios," AIAA-2022-1549, AIAA SciTech 60th Aerospace Sciences Meeting, San Diego, CA, 3-7 January 2022.

> Computational Fluid Dynamics (CFD) predictions of hover performance and laminar-turbulent boundary layer transition locations are obtained for the Pressure Sensitive Paint (PSP) and the NASA/US Army Hover Validation and Acoustic Baseline (HVAB) rotors. The PSP is a 11.08 foot diameter, 4-blade, Mach-scaled rotor, installed on a modified Rotor Body Interaction (ROBIN-mod7) fuselage. It has a tip Mach of 0.58 and tip Reynolds number of 1.05 million. The HVAB rotor has the same size and planform as the PSP. It is installed on the ARTS test stand. It operates at a higher tip Mach of 0.65 and a higher tip Reynolds number of 1.26 million. Calculations are made using CREATE-AV Helios with NASA Overflow and NASA FUN3D as near-body solvers. PSP rotor predictions are obtained using the Langtry-Menter γ-Re_θt (LM) model with and without a crossflow transition model. A modified version of the LM is used that accounts for Galilean invariance. The predictions agree well with the test measurements obtained in Rotor Test Cell (RTC) at NASA Langley Research Center. Pre-test predictions are reported for the HVAB. Besides the LM, predictions are also with the Amplification Factor Transport (AFT) model and good overall agreement is seen between the two.

Zhao, Q., and Sheng, C., "Predictions of HVAB rotor in hover using hybrid RANS/LES Methods – II," AIAA-2022-1550, AIAA SciTech 60th Aerospace Sciences Meeting, San Diego, CA, 3-7 January 2022.

> Aerodynamic performance and flow physics of a Hover Validation and Acoustic Baseline (HVAB) rotor is further investigated using hybrid RANS/LES simulation methods. A wall-adaptive local eddy-viscosity model (WALE) is coupled with two Reynolds averaged Navier-Stokes models: the Spalart-Allmaras one-equation turbulence model (SA) and the Menter Shear Stress Transport two-equation turbulence model (SST). Computational results are validated with the experimental data and are compared with the RANS solutions in the prediction of HVAB rotor in hover.

Abras, J., and Hariharan, N., "Machine Learning Based Physics Inference from High-Fidelity Solutions: Vortex Core Data Extraction," AIAA-2022-1683, AIAA SciTech 60th Aerospace Sciences Meeting, San Diego, CA, 3-7 January 2022.

> The field of machine learning is broad, covering many different areas and applications. The current paper focuses on the application of machine learning techniques for the automation of vortex core extraction from 3D computational results from hovering rotor wakes. The methodology leverages a combination of supervised convolutional neural networks and unsupervised clustering machine learning techniques. This effort builds on prior work with the addition of object localization and unsupervised clustering methods to enhance the efficiency and robustness of the process. The combined machine learning process to extract vortex core data is successfully demonstrated on multiple rotor wakes. Application of this methodology to investigate computed hover-wake breakdown is further explored. Extraction of vortex core properties such as peak-to-peak tip vortex profiles from 3D rotor wake computational data is an intensely manual and time-consuming process – the current work makes this process fully-automated using Machine Learning underpinnings.

Carnes, J., and Coder, J., "Impact of Off-body Schemes on Hovering Rotor Wake Breakdown and Predicted Performance," AIAA-2022-1684, AIAA SciTech 60th Aerospace Sciences Meeting, San Diego, CA, 3-7 January 2022.

> Wake breakdown is a common phenomenon in eddy-resolving computational fluid dynamics simulations of helicopter rotors in hover. Such breakdown can affect the prediction of rotor torque, which is greatly dependent on the fidelity of the simulation and its ability to resolve rotor tip vortices. In some cases, young-age tip vortices can interact with broken-down features in the wake, which may cause errant predictions of rotor torque. In this work, variations in the choice of off-body numerical scheme are explored in order to determine the impact of

these parameters on the state of the rotor wake and the predicted performance. The NASA OVERFLOW 2.3d solver is employed with hybrid RANS/LES modeling enabled. The wake state of the rotor is compared qualitatively and quantitatively across the parameter sweep. Additional analyses focus on the effect of the quadratic constitutive relation on the preservation of vorticity in the wake.

Whitehouse, G., Wachspress, D., and Quackenbush, T., "Predicting Hovering Rotor Performance with Comprehensive Analyses, Revisited," AIAA-2022-2178, AIAA SciTech 60th Aerospace Sciences Meeting, San Diego, CA, 3-7 January 2022.

> Predicting and understanding hovering rotor performance is critical to the design and development of conventional and unconventional rotorcraft. Comprehensive rotorcraft analysis methods, because of their relative ease of use, can be effective in reducing the cost and risk of new designs. This paper builds upon prior Hover Prediction Workshop papers demonstrating the ability of three contemporary analysis methods – EHPIC, CHARM and VTM - to predict the hover performance of rotors with different tip shapes by presenting blind predictions of hover performance and spanwise loading for the HVAB rotor that forms the basis of the 9th set of Hover Prediction Workshop papers.

Aksoy, E., and Sahin, M., "An Application of Anisotropic Mesh Refinement to Solve Flow Around the S-76 Main Rotor with Swept-Tapered Tip," AIAA-2022-1319, AIAA SciTech 60th Aerospace Sciences Meeting, San Diego, CA, 3-7 January 2022.

> Solving a flow around a rotor via CFD techniques is still very expensive due to the complex behaviours of the air flow around a rotor. This study attempts to analyze the S-76 main rotor configuration with swept-tapered tip in the hover position. The SU2 software is utilized with an anisotropic adaptive mesh refinement process provided by pyAMG software in this respect. Thoroughly capture of tip vortices is aimed with a significant reduction in the number of nodes compared to studies in the literature, taking advantage of anisotropic mesh adaptation process. Three different Euler simulations are designed to study either the effects of Mach and entropy sensor functions and also the effects of different anisotropy levels. The results are examined in different aspects.

Fitzgibbon, T., Steininger, R., and Barakos, G., "Investigation of Wake Breakdown in Hover Using The HMB3 Solver," AIAA-2022-1320, AIAA SciTech 60th Aerospace Sciences Meeting, San Diego, CA, 3-7 January 2022.

> The present study forms an investigation of wake breakdown in hover using the HMB3 solver. Simulations are performed for the PSP rotor blade in hover on a grid aimed at resolving the detailed flow structures in the rotor wake. An assessment of different solver settings is per- formed including time discretisation, spatial discretisation accuracy and turbulence modelling on the rotor wake resolution and formation of instabilities. A particular focus is put on the existence and resolution of S-shaped structures due to the interactions of the blade tip vortices with the shear layers.

Chen, P., Mali, H., Benmansour, K., and Sankar, L., "Aerodynamic Simulations of the HVAB Rotor in Hover," AIAA-2022-1321, AIAA SciTech 60th Aerospace Sciences Meeting, San Diego, CA, 3-7 January 2022.

> Numerical simulations of compressible viscous flow over a rotor in hover are presented. A commercial flow solver, ANSYS Fluent, has been used. The effects of turbulence are modeled using a k-omega-SST model, while the effects of transition are modeled using the Langtry-Menter transitional shear stress transport turbulence model. The rotor is assumed to be rigid. The coning and lead lag angle were numerically computed in a post-processing step by setting the moments generated by the aerodynamic forces and the centrifugal forces at the flap and lead-lag hinges to be zero. Comparisons with other published data are presented. These include integrated thrust and power coefficients, figure of merit, surface pressure distribution, and coning angles.