Universität Stuttgart
Institute of Aerodynamics and Gas Dynamics

Validation of ACD and ACL Propeller Simulation

using Blade Element Method based on airfoil charcteristics

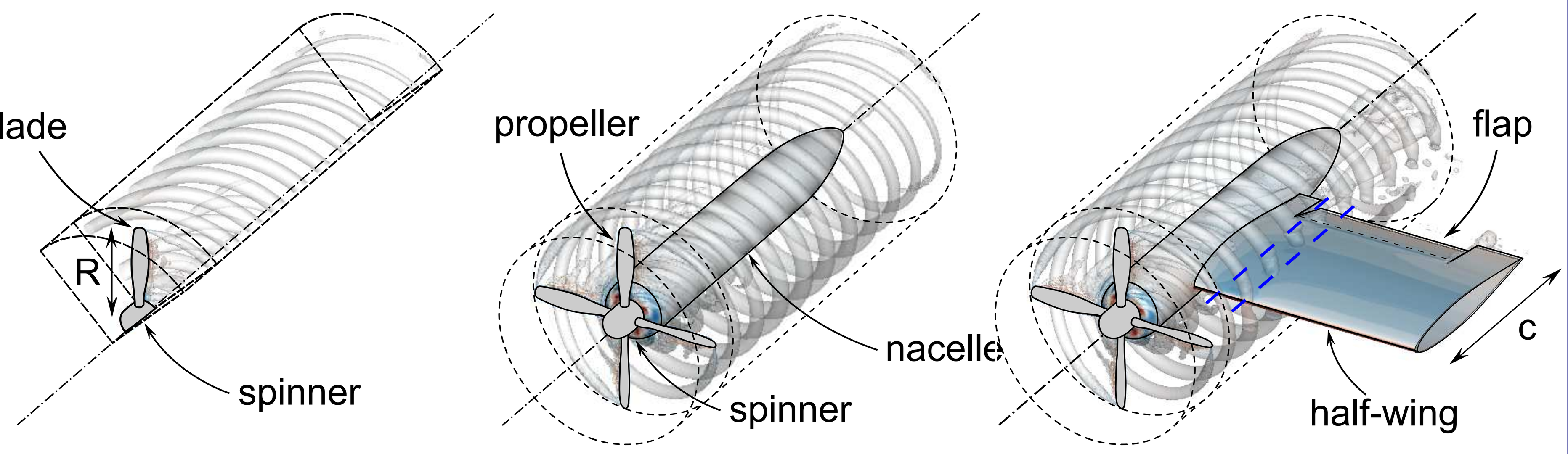
Michael Schollenberger, Mário Firnhaber Beckers, Thorsten Lutz

24^th RESULTS AND REVIEW WORKSHOP OF THE HLRS, 2021

Introduction

Airfoil characteristics of the propeller blades (lift and drag polars) are first extracted from a steady state single blade simulation and then used for BEM-based ACL and ACD methods and compared with fully resolved simulations and experimental data from [1,4,5] for:

- an isolated propeller
- an installed propeller

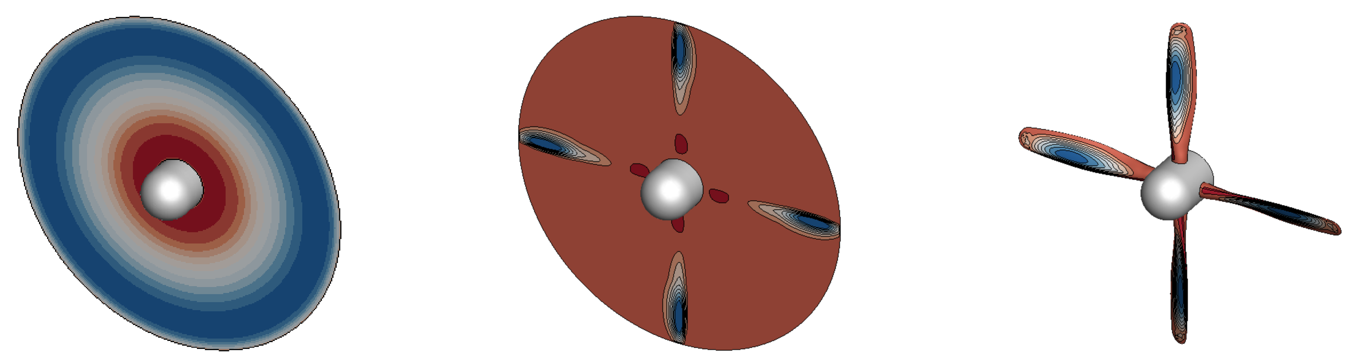


single blade | isolated prop | installed prop

Geometries of the Simulated Configurations

Simulation Methods

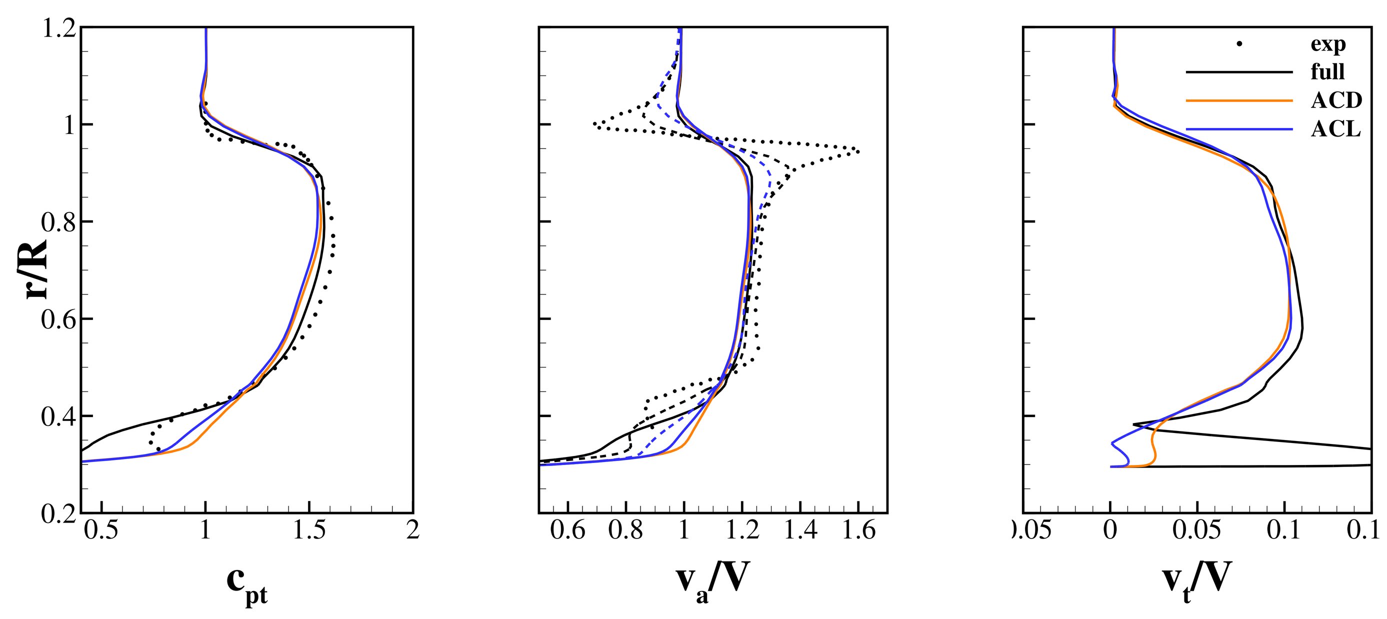
The DLR TAU-code is used with three different approaches to model the propeller impact:



Actuator Disk (ACD), see [2] | Actuator Line (ACL), see [3] | Fully resolved propeller (full)

Isolated Propeller Results

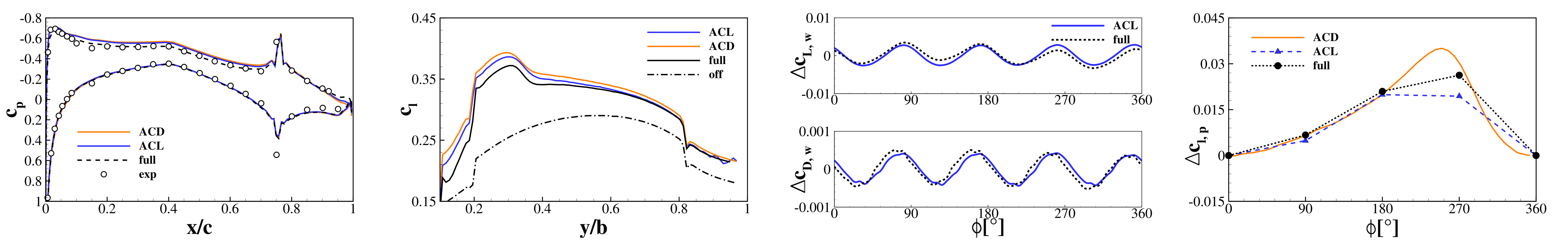
Slipstream values are captured well by ACD/ACL



total pressure | axial velocity | tang. velocity

Installed Propeller Results

Influence of the propeller slipstream on the wing and influence of the wing on the propeller blade



pressure in slipstream | spanwise lift | phase dependent lift/drag | phase dependent blade lift

References

[1] Stokkermans,T.C., v. Arnhem, N., Sinnige, T., Veldhuis, L.L.: Validation and Comparison of RANS Propeller Modeling Methods for Tip-Mounted Applications. AIAA SciTech Forum, (2018).
[2] Raichle A.: Flusskonservative Diskretisierung des Wirkscheibenmodells als Unstetigkeitsfläche. PhD thesis, DLR. (2017).
[3] Schollenberger M. , Lutz T. and Krämer E.: Boundary Condition Based Actuator Line Model to Simulate the Aerodynamic Interactions at Wingtip Mounted Propellers. New Results in Numerical and Experimental Fluid Mechanics XII, (2020) .
[4] Sinnige T., de Vries R., Della Corte B., Avallone F., Ragni D., Eitelberg G., and Veldhuis L., Unsteady Pylon Loading Caused by Propeller-Slipstream Impingement for Tip-Mounted Propellers, Journal of Aircraft, (2018).
[5] Stokkermans, T. C., Aerodynamics of Propellers in Interaction Dominated Flowfields: An Application to Novel Aerospace Vehicles, (2020).

Conclusion

Force, pressure and velocity distributions by ACD and ACL agree well with fully resolved and experimental data. BEM based propeller models are suitable for design studies to consider the interactions between propeller and wing in both directions.

IAG