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High quality PIV data for numerical validation

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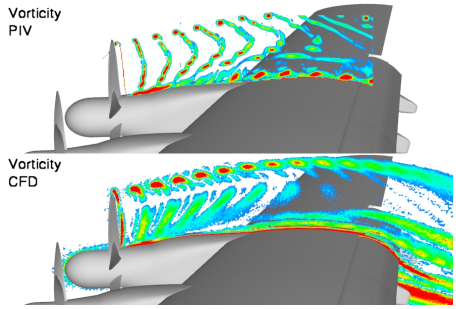
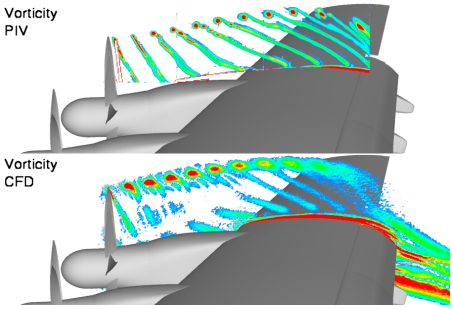
Particle Image Velocimetry (PIV) is in particular suitable, perhaps exclusively, for the analysis of (instantaneous) velocity vector fields. In addition, well prepared PIV measurements provide an extensive database with velocity-derived quantities (vorticity, instantaneous fluctuations, velocity fluctuations, turbulence kinetic energy, Reynolds stresses) that can be used to compare and characterize the capabilities of computational methods with respect to turbulence properties as well as for computational aero-acoustic simulations.

From a point of view regarding the validation of propeller flow for example there is only little literature available. Apart from validation and verification of numerical codes, advanced research on propeller flow influence is needed in order to estimate the effects of airframe engine installation and to establish the propeller slipstream effects on the wing. A mutual approach by considering both vorticity and turbulence properties based on experimental and computational data is believed to be best suited to characterize the overall effect those properties have on the aircraft design.



Comparison of vorticity in propeller symmetry plane



Comparison of vorticity outside propeller symmetry plane

Thus, in a combined effort CFD and PIV has been applied to investigate vortical structures, which dominate propeller flow. There is, however, a remarkable difference between PIV and CFD in the vortex structure organization of the blade wakes and in the wing boundary layer-slipstream interaction due to strong dissipative terms in the uRANS models. This is further supported by the difference in the circulation distribution in the tip vortices region. One objective of this research is to provide a database of experimental and computational data that can be used in a comparison and validation of several velocity derived quantities. This contribution describes the ongoing work of validating and expanding existing CFD tools for the analysis of propeller flow with experimental velocity (PIV) data.

Ref: Roosenboom, E.W.M., Stürmer, A., Schröder, A., "Comparison of PIV measurements with unsteady RANS calculations in a propeller slipstream", AIAA 2009-3626, 27th AIAA Applied Aerodynamics Conference, San Antonio, TX, USA, June 2009 (accepted for publication in Journal of Aircraft)