FMRC Fluid Mechanics Research Seminar Series

Simulation Requirements of Vortices Generated from Wings and Hovering Rotor Blades Ensuring Accurate Predictions

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Abstract: Numerical simulations which were conducted to study the development and turbulent decay of delta wing leading edge vortices, wing tip vortices, dynamic stall vortices, and the helical tip vortices in the wake produced by a hovering rotor blade are presented. The key algorithmic features for accurate capturing and preservation of vorticity are identified. An extensive series of RANS calculations was performed and the results were compared to detailed dual-plane Particle Image Velocimetry (PIV) measurements of a turbulent tip vortex trailed from a single-bladed rotor. The required mesh resolution was investigated and the most suitable turbulence closure models with corrections for rotation and streamline curvature was chosen by assessing their predictions of the tip vortex properties that improve capturing of the overall nature of the rotor wake. It was found that even when using a higher-order spatial discretization scheme is employed, a minimum grid spacing equal was required to accurately predict the core size, peak swirl velocity and strength of the tip vortex. It was found that the rotational/curvature corrections applied to the Spalart-Allmaras turbulence model better preserved the vortex characteristics to later wake ages than the same corrections applied to the k-ω SST model. In both cases, the correction proposed by Spalart and Shur outperformed the simplified correction proposed by Dacles-Mariani et al., with the latter providing little impact on the k-ω SST model. However, despite the reasonable agreement of the mean quantities with the measurements poor predictions of the Reynolds stress distributions was obtained in all cases.

Biography: Dr. John A. Ekaterinaris received his B.S. in Electrical and Mechanical Engineering from the Aristotle University of Thessaloniki in Greece in Oct. 1977. Started graduate studies in the US in 1981 and revived his M.Sc. in Mechanical Engineering in 1982 and his Ph.D. from the School of Aerospace Engineering in 1987, both at the Georgia Institute of Technology, Atlanta GA. Between 1987 – 1995, worked at NASA–Ames Research Center at Moffett Field CA, and at the same time he was faculty at the Naval Postgraduate Scholl at Monterey CA. He took a Senior Research Scientist position at RISOE National Laboratory in Denmark between 1995 – 1997 where he worked on wind energy, he returned to CA and worked at Nielsen Engineering and Research (NEAR) between 1997 – 2000. In Oct. 2000 he took the Research Director position at FORTH/IACM, where he remained until 2005. In Sept. 2005 he joined the faculty of Mechanical and Aerospace Engineering at the University of Patras. He joined the faculty of Embry-Riddle Aeronautical University in August 2012 where he is currently teaching and performing research. His interests are computational mechanics (including aerodynamics, magnetogasdynamics, electromagnetics, aeroacoustics, flow transition, turbulence research, and flow structure interaction), high order methods for PDEs, multiscale phenomena, stochastic PDE's, and biomechanics and more recently machine learning and uncertainty quantifcation. He is author of over 60 journal papers. He has been member American Institute of Aeronautics and Astronautics (AIAA), where he served as member at the Flight Mechanics and Fluid Dynamics Technical Committees, and AIAA associate fellow of since 1985. He performed funded research in the US and in Europe with the European Space Agency (ESA), and through the EU framework programs. He also performed funded research thought the offices of

AFOSR and ARO. He is associate editor of the Journal Progress in Aerospace Science (JPAS) and editor in chief of the Journal Aerospace Science and Technology (AESCTE).