Master Thesis or term paper

CFD/CAA investigation of aerodynamics and sound emission from Polimi's Vario C12 propellers in single and tandem configuration

Master- oder Semesterarbeit

CFD/CAA-Prognose von Aerodynamik und Schallabstrahlung von Polimi's Vario C12 Propellern in Einzel- und Tandem-Anordnung

Background

Noise emission from propellers on airplanes, UAVs and drones is an important issue with respect to its acceptability and usage for civil and military purposes. Quantitative prediction of sound is important for the understanding of installation effects and the interferences with fuselage and other propulsors. For the validation of hybrid acoustic prediction methods used in CAA (computational aeroacoustics) within the Garteur action group AG 26 a number of test cases on small-scale set-ups with rotor diameter below 300 mm have been studied in wind-tunnels, anechoic chambers and by numerical simulation. At Politecnico die Milano (Polimi) various measurement campaigns have been carried out for a 3-bladed Varioprop C12 geometry in single and tandem configuration both for hover and for flight conditions with different advance ratios. Some results are published in Zanotti et al. 2025. For hover cases measurements of thrust, torque and radiated sound are available for comparison with numerical predictions. A special challenge for CFD is posed by the low chord Reynolds number on the blades implying the necessity to use transition models for the prediction of the boundary layer evolution along the blades.

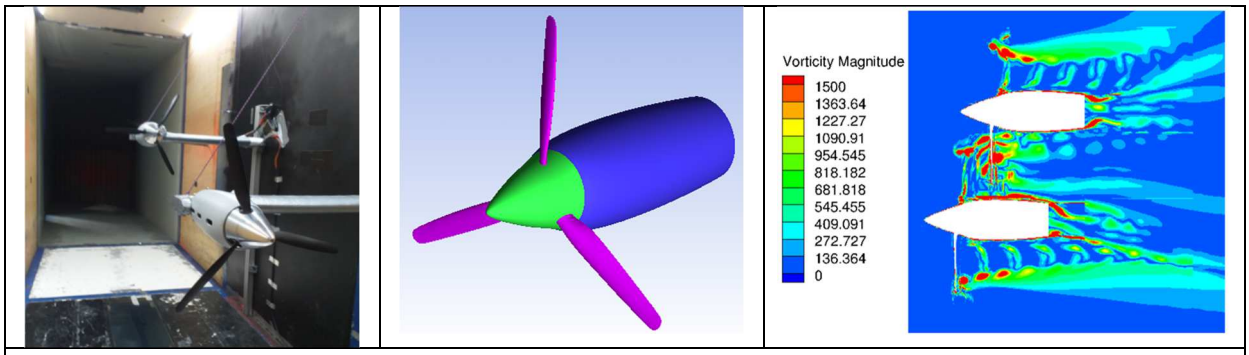

Fig. 1: Polimi's Varioprop C12 in single and tandem configurations.

Goals and Tasks

An existing simulation framework combining Ansys Fluent CFD simulations on sliding meshes and the in house Ffwocs-Williams Hawkings solver Spysi developed at FAU Erlangen (Scheit et al. 2012) shall be used for the assessment of tonal noise radiation from single and hover configurations with varying lateral spacing between two propellers in an axial distance of 0,5 diameter as shown in Fig. 1. Using the

grid generator ICEM-CFD the quality of an existing multi-block mesh has to be improved and meshes for a systematic grid refinement study shall be prepared. For a single rotor in hover the influence of mesh quality, turbulence resp. transition model, and of set-up (steady case in rotating frame of reference versus sliding mesh technique for an inner rotating domain) on aerodynamics and tonal noise shall be studied systematically. Thereafter tandem configurations shall be investigated for different lateral spacing. If time allows the influence of the phase-shift between the two rotors in tandem configuration is to be investigated.

Requirements, supervisor

Prerequisite is background in CFD methods and experience with commercial solvers from ANSYS, especially FLUENT. Good knowledge on the use of the grid generation software ANSYS ICEM CFD is mandatory as well as the ability to work in a Linux environment on PCs / workstations at TUM and on the Linux cluster of LRZ.

Information and supervision by Prof. Dr.-Ing. H.-J. Kaltenbach. (hans-jakob.kaltenbach@tum.de) 089.28916397. The thesis work can be started all times.

References

C. Scheit, B. Karic, S. Becker, Effect of blade wrap angle on efficiency and noise of small radial fan impellers—A computational and experimental study, Journal of Sound and Vibration, Volume 331, Issue 5, 2012, Pages 996-1010, ISSN 0022-460X,

Zanotti, A., Granata, D., Savino, F., Caccia, L., Abergo, L., Guardone, A., Yin, J., Wickersheim, R.,Kessler, M., Visingardi, A., Barbarino, M., Haas, A., Kaltenbach, H.-J., Reboul, G., Bernardini, G., and Poggi, C. Acoustic and aerodynamic evaluation of POLIMI tandem propellers in hover and cruise flight conditions within GARTEUR AG26, CEAS Aeronautical Journal (2025). https://doi.org/10.1007/s13272-025-00903-5

Fachgebiet Strömungsbeeinflussung
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Arbeitsschritte Propellerschall-Prognose

Thema	**Umfang**	**Unterlagen**	**Vorkennt-nisse**	**Zeitplan**
Gitterauflösung (wandnormal) abschätzen für geg. Geometrie und Reynoldszahl: low-Re (dh yplus = 1)		Schlichting, Gersten, GS-Theorie		
Gittergenerierung für Einzelblatt und Nabe (CAD-Import aus Iges/step, Definition von Parts der Geometrie, Blocktopologie, Hexameshing)		(Bsp: Habryka, Mütze, …)		
ANSYS-Fluent: azimuthal-period. Berechnung Einzelblatt im rotierenden Rechengebiet bei gleichförmiger Zuströmung		Semesterarbeit K. Mütze (WEA-Rotor), Parth Luhar		
Modellierung der Turbulenz: URANS mit SST. Transition ja/nein, voll-turbulent von Vorderkante des Blattes an		BA Arbeit R. Fricker (Prop. Hinter V-Leitwerk), Parth Luhar, Jaime Villasante		
Propeller Aufgabe 1: Blatt-Polare an verschiedenen Querschnitten (aus Geom extrahiert) in 2D berechnen lokales Blade loading berechnen CL, CA als f(radius) für verschiedene Reynolds-Zahlen				
Export der Blattlasten p(x,y,z,t) als Eingabe für das Curle-(FWH)-Integral Export an poröser Hüllfläche		Sem. Arbeit Habryka		
Sypsi-Verhersage des Schalls		SA Habryka		
Vergleich mit Messungen				
Verfügbare Konfigurationen (mit Schallmessung) aus **Garteur Benchmark**				

Fragen zu Bewerberhintergund

Warum Interesse an dem Thema? (Einschätzung der Relevanz für industrie)	
Hintergrund in Akustik und speziell Aeroakustik?	
Erfahrung Gittergenerierung (ausserhalb angewandter CFD). Speziell in Strukturierte Vernetzung	
Erfahrung Ansys Cfx und Fluent	
Kenntnisse Linux (scp, ftp, tar …)	
Erfahrung mit Batchjobs am LRZ-Linux-Cluster Erfahrung in der Verwendung von remote access tools (putty, x2go, mobaXTerm….)	

Ansys Academic Teaching licencse installiert?	

Weitere Hintergrundinformationen

Risiko: gering, da erprobte Verfahren zum Einsatz kommen

Einarbeitung und Anwendung ICEM-Meshing zeitaufwändig

Gleiche Konfiguration wird von anderen Gruppen untersucht (benchmark verschiedener CAA-Methoden)

Affinität zu IT erforderlich (Umgang mit Linux am RZ, batchjobs, remote arbeiten, dazu Software installieren)

Einarbeitung Vernetzung und Berechnung EInzelblatt

ICEM user guide
ICEM Tutorial
Praktium angewandte CFD Folien P1 und P4
Studentische Arbeiten von Fell und Winkler (submarine)
SA K Mütze (2017), WEA-Rotor und S Habryka (Propeller hinter V-Leitwerk), Parth Luhar, Jaime Villasante, Alexander Haas