Clean Sky JOINT UNDERTAKING PROPTER

Propeller analysis and design via eCFD

Program and invitation list to Webinar

NLR – Netherlands Aerospace Centre

1 Introduction

Within the Clean Sky 2 (CS2) research programme, the PROPTER project addresses the analysis and design of lateral rotors which must operate in a complex interactional flow field around the RACER (Rapid And Cost-Effective Rotorcraft) compound helicopter being developed by Airbus Helicopters. The PROPTER consortium consists of Netherlands Aerospace Centre NLR and Delft University Technology (TUD) collaborating with Airbus Helicopters as the topic leader.

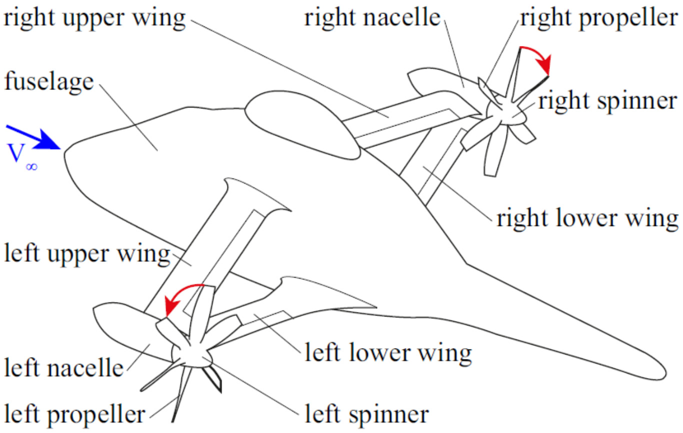

Figure 1 Sketch of the Airbus RACER without tail planes (see Ref. [1]).

Figure 1 shows a sketch of the helicopter configuration with its tail planes removed. The lateral rotors are installed as a pusher on the tips of a box-wing. The two lateral rotors are driven by the same turboshaft engines driving the main rotor. Large-scale time-accurate unsteady CFD simulations have been performed to analyze the flow around the compound helicopter. The simulations were conducted using ENFLOW, which is a CFD code suite developed in-house at NLR (e.g. see Ref [2]). ENFLOW employs a central-difference finite-volume scheme in a multi-block structured grid.

For the assessment of installation effects, CFD simulations have also been performed for the lateral rotors in an isolated configuration with an axial incoming flow. For this configuration, the steady-state Reynolds-Averaged Navier-Stokes (RANS) equations formulated in a rotating frame of reference are solved.

Unique innovations have been generated during the course of the project. Some of the innovations are considered to have a high potential to deliver significant benefits to propeller manufacturers, e.g.

- Typical for the analysis of aerodynamic performance of propellers is that there is a **large variation of the blade pitch**, i.e. not only to determine the polar curve, but also to achieve either a specified thrust or a specified power. An **innovative domain decomposition** has been conceived to allow an efficient **automatic procedure for CFD simulation** with varying blade pitch.
- The large-scale CFD simulations have been conducted in a collaborative fashion between NLR and TU Delft through an **eCFD framework** (see Ref. [3]). The CFD simulations are parameterized by the flight speed, altitude, RPM of the lateral rotors, and blade pitch. Such a parameterization allows an efficient remote execution of the CFD simulations by TU Delft, **through an email interface**, where the simulations are performed on NLR's high performance cluster computing facility.

In the scope of **dissemination and exploitation of the PROPTER project** results, an eCFD framework has been constructed for **TU Delft's XPROP propeller**. The potential benefits to the propeller industries will be demonstrated by means of a Webinar. An eCFD framework will be explained during the Webinar. A similar parameterization as in the large-scale CFD simulations is used, i.e. in terms of flight speed, altitude, RPM, and blade pitch. Example results of an eCFD session are shown in Figure 2. One **eCFD session** consists of a cycle of (1) sending an e-email requesting simulations to an email server, (2) receiving a request-for-confirmation email from the server, (3) sending a confirmation email to the server, and (4) receiving an e-mail that simulation results can be downloaded.

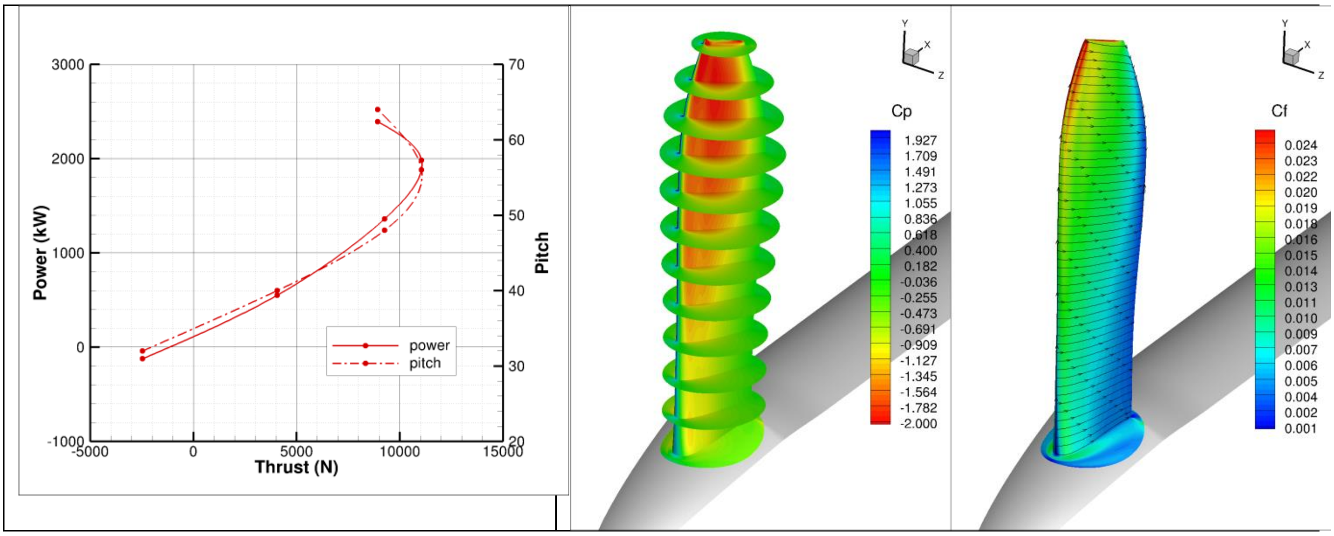

Figure 2 Example output of an eCFD session for the XPROP propeller.

The parameterization possibilities offered by eCFD are practically limitless, which can be tailored to specific needs. It promotes and facilitates multi-partner collaborations. During the Webinar some of the possibilities for extended parameterization will be explained. Finally, participants will be invited to try out the functionality of eCFD, allowing them to perform real CFD simulations around the XPROP propeller as an example.

2 Webinar Program (duration max. 1 hour)

1. Introduction
   - project Propter
2. propeller design CFD methodology
   - Analysis
   - Design optimization
3. Propeller analysis through eCFD
   - Introduction
   - Procedure
4. Demonstration: use-case and functionality
   - XPROP propeller
   - Input/Output description
5. Future perspectives
   - Parameterized airfoil shapes
   - Parameterized planform
   - Parameterized design optimization
6. Closure

3 Invitation List

No.	Company Name	Country	Website
1	Woodcomp sro	Czech	www.woodcomp.cz
2	Avia Propeller Ltd.	Czech	www.aviapropeller.com
3	Kaspar a synove - strojirna Kalnar sro	Czech	www.kasparaero.cz
4	Fiti propeller	Czech	www.fiti.cz
5	Mejzlik	Czech	www.mejzlik.eu
6	Duc Helices	France	www.duc-helices.com
7	UTC Aerospace Systems, Propeller Systems (Ratier Figeac)	France	www.ratier-figeac.com
8	Helices e-props	France	www.e-props.fr
9	Helices evra	France	www.helices-evra.com
10	MT-Propeller Entwicklung GmbH	Germany	www.mt-propeller.com
11	Hoffmann Propeller	Germany	www.hoffmann-prop.com
12	Helix-Carbon GmbH	Germany	www.helix-propeller.de
13	Neuform Composite Propellers	Germany	www.neuform-propeller.de
14	Rospeller GmbH	Germany	www.rospeller-aero.de
15	The Binder Flugmotoren- und Flugzeugbau GmbH	Germany	www.binder-flugmotorenbau.de
16	GT Propellers	Italy	www.gt-propellers.com
17	Alisport Srl	Italy	www.alisport.com
18	Peszke Aero Technologies	Poland	www.peszke.com
19	Born propeller	Romania	born-propeller.de
20	Airpal	Slovakia	www.airpal.eu
21	Aerobat	Spain	www.aerobat.es
22	GE Aviation (Dowty Propellers) (8)	UK	dowty.com
23	Hercules propeller	UK	www.hercprops.com
24	Aero prop	Ukraine	aeroprop.aero
25	KievProp	Ukraine	www.kievprop.com

4 References

1. Stokkermans, T.C.A., Voskuilj, M., Veldhuis, L.L.M., Soemarwoto, B.I., Fukari, R., Eglin, P., *Aerodynamic Installation Effects of Lateral Rotors on a Novel Compound Helicopter Configuration*, Presented at the AHS International 74th Annual Forum & Technology Display, Phoenix, Arizona, USA, May 14–17, 2018.

2. Laban, M., Kok, J.C., Prananta, B.B., *Numerical tools for contra-rotating open-rotor performance, noise and vibration assessment*, 27th International Congress of the Aeronautical Sciences, Nice, France, 2010.

3. Soemarwoto, B.I., Nugroho, A., Baalbergen, E.H. Aribowo, A., *CFD-based collaborative design optimization using eCFD*, presented at 29th Congress of the International Council of the Aeronautical Sciences, St. Petersburg, Russia, September 7-12, 2014.

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