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Body Force Modeling for Ultrahigh Bypass Ratio Engine Fans

Background:

Nacelles housing engines on aircraft require a complete facelift to keep up with the next generation of engines. The wider fan diameter of the ultra-high bypass ratio (UHBPR) type engine – a conventional shrouded turbofan type configuration – requires a new design for nacelles (see Figure 1). The introduction of UHBPR engines poses new challenges on optimal nacelle design, both in geometry and in location. To tackle with the challenges, a critical step is to accurately simulate the low-pressure fan embedded at the nacelle intake. As shown in Figure 2, the curved shape of the nacelle intake lip can easily introduce flow separation, which interacts with the downstream fan. Simulation of this complex flow phenomenon needs to take the rotating fan into account. However, including all fan details in the simulation leads to incredibly high computational costs, which are usually difficult to afford for early stage designs. A feasible method is to model the fan so that the computational costs for resolving the fan are reduced. An advanced method recently advocated for this purpose is body force modelling (BFM).

The project will study the BFM for UHBPR engine fans. This study is linked to the project IVANHOE (Installed adVAnced Nacelle uHbr Optimisation and Evaluation, the grant agreement ID 863415). The project is financed within in the funding scheme of Clean Sky 2 - Research and Innovation action. Refer the project to https://cordis.europa.eu/project/id/863415

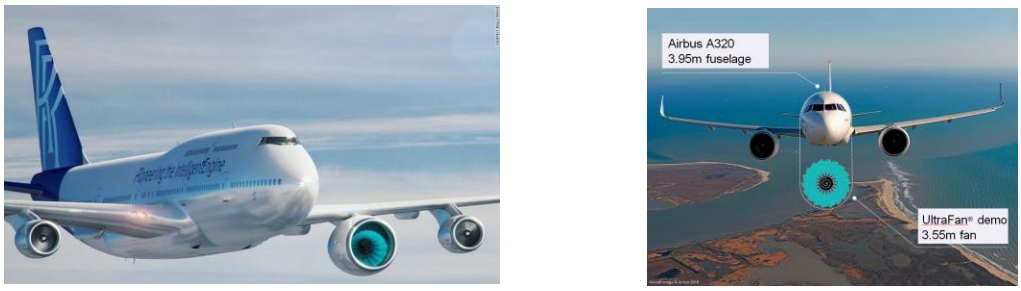
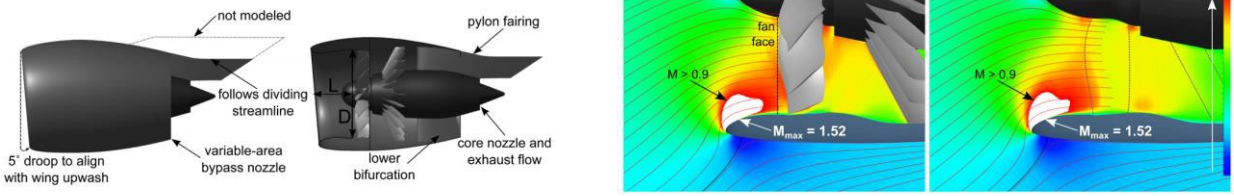


Figure 1: (a) Three engines installed on an aircraft. The middel one is an UHBPR engine (termed UltraFan) produced by Rolls-Royce and the others are normal engines. (b) Comparison of the diameters between UltraFan and the Airbus A320 fuselage.



(a) (b)

Figure 2: (a) Schematic of a nacelle and low-pressure engine fan. (b) Flow near the nacelle intake. Left: the fan directly simulated using RANS; Right: the fan modelled with BFM (A. Peters et al., J. Turbomachinery, 2015).

Objectives:

The project aims to develop a body force model for a classical UHBPR engine nacelle. A literature survey will be conducted to review the state of the art of this technique. Different models in the BFM family will be compared, and the pros and cons of the models will be identified. The developed model will be validated by comparing with the existing databases. The model parameters and their functions will be addressed.

Methodology:

An isolated nacelle under the cruise condition will be simulated. Unsteady RANS (URANS) simulations will be carried out, in order to assess the occurrence of unsteady phenomena at the intake lip and in the exhaust jets. The fan will be modelled using a BFM method, while the core engine components (i.e. combustion chamber, compressors and turbines) will not be modeled in details. Fluent™ is the CFD tool. The BFM module will be developed using the UDF of Fluent™.

Special Prerequisites:

Knowledge in CFD. Interest in fluid dynamics, aerospace engineering, and turbomachinery.

Examiner

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