



Development of an Integrated Flow Simulation Methodology for Mixed UHBR Turbofan Engines in a Farfield Domain

Studien-/Masterarbeit

In the global pursuit of a climate-neutral and universally accessible air transport system, the Collaborative Research Centre 'SFB-TRR 364: SynTrac' (Synergies of Highly Integrated Transport Aircraft; <https://www.trr-syntrac.com/>), examines the synergies arising from the highly integrated design of various propulsion sub-systems. A comprehensive evaluation of synergies and potential benefits promotes the development of novel assessment and design methodologies that effectively capture and enhance the critical interfaces between various aircraft and propulsion modules and disciplines. This study aims to investigate coupled flow simulations of the nacelle and intake, fan stage, the bypass duct with integrated heat exchange capabilities, and the inner mixing nozzle of a geared UHBR mixed turbofan engine with a farfield boundary, thus contributing to the overarching theme.

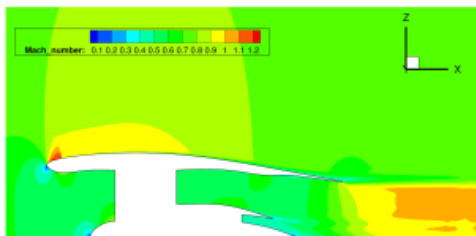


Fig 1: External flow domain

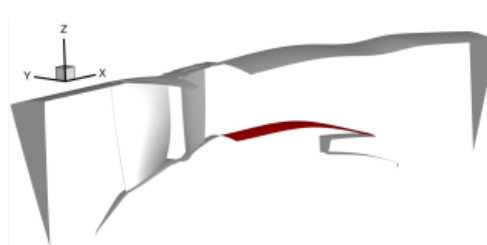


Fig 2: Internal flow domain

Previous studies that explored engine through-flow simulations for duct and nozzle design typically employed simplified inlet and outlet boundary conditions without resolving the fan stage geometry and associated flow dynamics, as shown in Figure 1. This study aims to directly couple the fan stage and nozzle domains without the use of an interface plane, enabling analysis of fan–exhaust interactions, particularly when implementing a variable-area nozzle. To investigate fan–intake interactions in the context of boundary layer ingestion (BLI), the fan stage geometry shown in Figure 2 is to be incorporated into the engine configuration depicted in Figure 1. By integrating the farfield and internal flow domains, the downstream and upstream effects of BLI and nozzle flow expansion to ambient conditions respectively on fan performance can be characterized, thereby providing the necessary criteria for a subsequent rotor redesign. Since the objective of this study is not to optimize an existing design, but rather to establish a methodology for a given reference configuration, the focus remains on methodological development.

Therefore the following tasks are to be carried out within the scope of this work (Depending on the type of coursework, the task list can be adapted.):

- To conduct a literature review on fan stage performance evaluation within highly integrated and interactive flow domains.
- To generate a mesh for the entire internal engine flow path as a single domain, with the only interface defined between the rotor and stator, using Autogrid or Pointwise.
- To develop a meshing routine for the farfield domain using Autogrid or Pointwise, along with a framework to couple the external and internal flow paths within a single simulation, enabling analysis of their interactions.
- To develop a workflow for the flow simulation across the engine using CFD solver, TRACE.
- Characterizing performance and sensitivities of the baseline designs.
- Documentation and discussion of results
- Oral presentation of main findings

Requirements:

- Self-motivated and ability to take initiative
- Prior experience with CFD, particularly meshing routines.
- Experience in Matlab and Tecplot is desirable – Pre and Postprocessing
- The necessary knowledge can also be acquired or deepened during work.

Begin: Immediately

Thesis Language: English, German