Public Abstract

Compute Project: nii00230

Project Title: Flow simulations for highly integrated propulsion systems

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With thermal and propulsive efficiencies approaching their physical limits in conventional transport aircraft, further improvements require a higher level of integration between propulsion systems and the airframe. Integrating propulsion systems into the aft fuselage, as in SynTrac configuration 1a, enables additional benefits such as drag reduction and energy savings through Boundary Layer Ingestion (BLI). However, this high level of integration introduces strong aero-thermodynamic coupling between intake, fan, and exhaust, leading to significant deviations between installed and uninstalled performance. These effects are further intensified in future low specific thrust engines with low pressure ratios, where the exhaust system operates in a highly sensitive regime.

Building on the completed thermodynamic engine design andreference fan stage development during the first phase of the compute project, the current phase focuses on analyzing intake–fan interaction under distorted inflow conditions. High-fidelity RANS simulations of the fan coupled with a 180° BLI intake will be performed using boundary-layer-resolving meshes and advanced turbulence and transition models. Simulations will cover key operating conditions, including cruise, descent, and take-off, with full-annulus frozen rotor computations used to capture circumferential flow non-uniformities. Selected operating points will be further investigated using computationally intensive uRANS simulations.

Fan performance and sensitivity will be assessed using distortion descriptors such as DC60, CDI, and RDI. Based on these results, the redistribution of intake stagnation pressure deficit will be explored to better understand the governing radial and circumferential distortion characteristics. The insights gained will guide an aerodynamic redesign of the fan stage to improve efficiency and enhance robustness against inflow distortion and downstream disturbances. Ultimately, the study will employ a fully integrated simulation framework, coupling internal engine flow with the external farfield, to provide a comprehensive assessment of the propulsion–airframe interaction.