The Influence of Fan-root Flow on the Aerodynamics of a Low-Pressure Compressor Transition Duct

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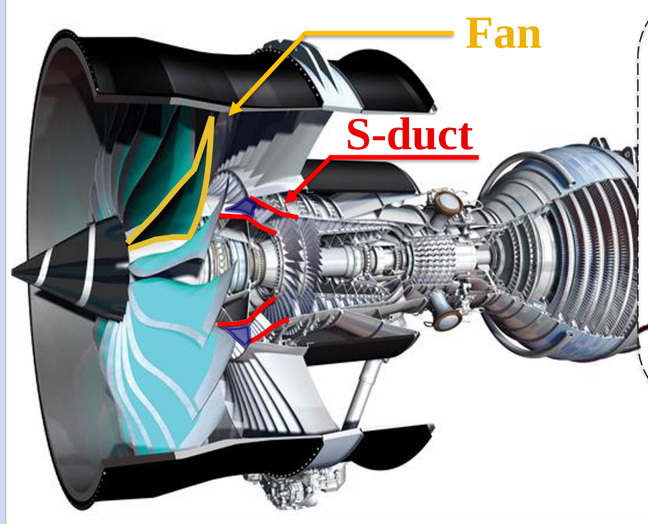
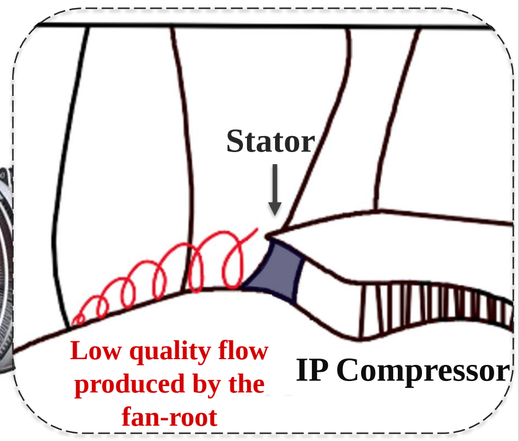
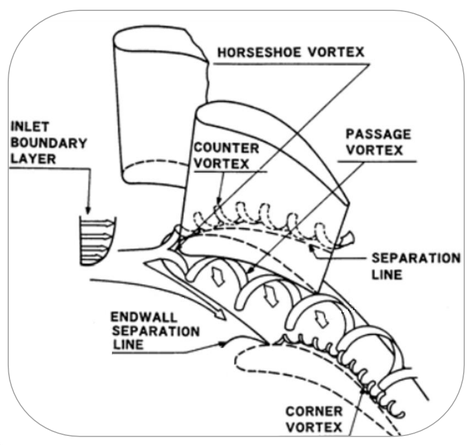
Introduction

- Trend towards high bypass ratio to reduce fuel burn and environmental impact (CO_2 emissions)
- Increasingly large radius change between fan and engine-core leads to very aggressive interconnecting S-ducts







Takeishi et al., 1989

- Strong curvature induced pressure gradients
- Unsteady rotating wakes
- Large secondary flow structures

➡ Very complex flow!!
➡ Challenging design!

Objectives

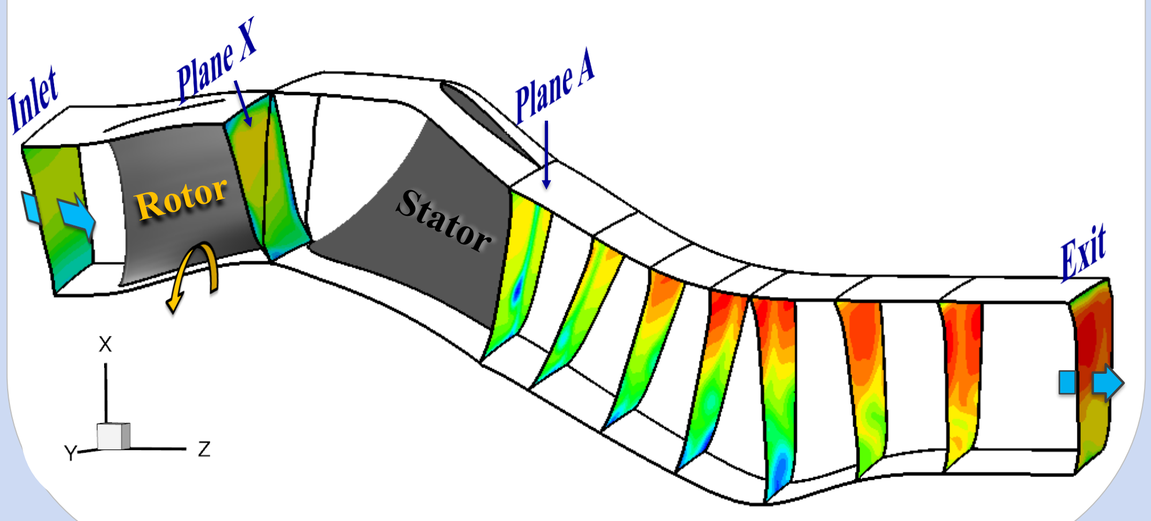
- Investigate the influence of the large rotating wake structures from the fan-root flow on the downstream stator vane and s-duct

Methodology

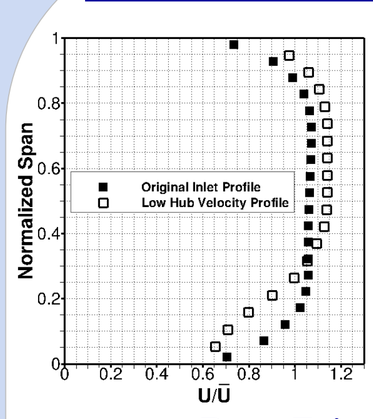
- Based on future very-high bypass ratio turbofan
- Computational Fluid Dynamics - explore the design
- Fully annular isothermal facility for experimental assessment and validation (future work)

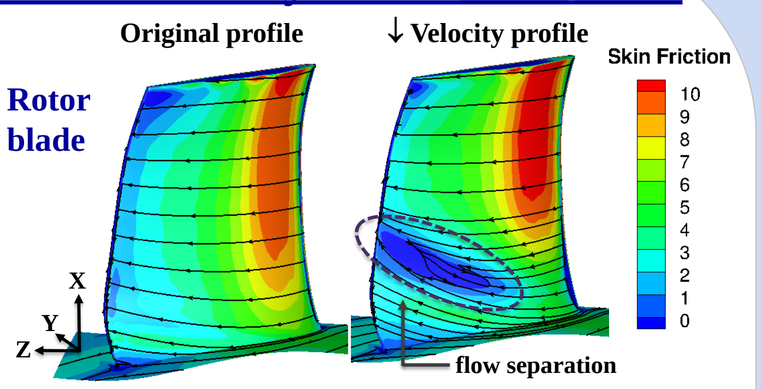
Key Factors Examined

- Poor quality hub-low rotor exit profile
- Increased inlet swirl angle
- Increased boundary layer thickness

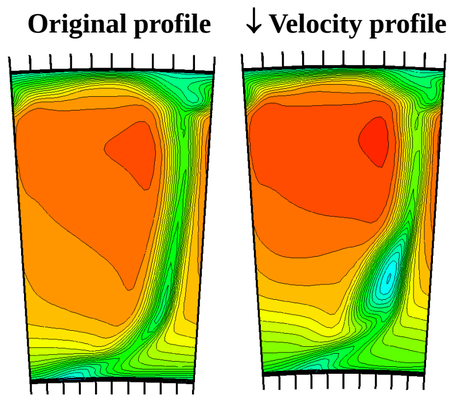


Low Inlet Velocity Profile

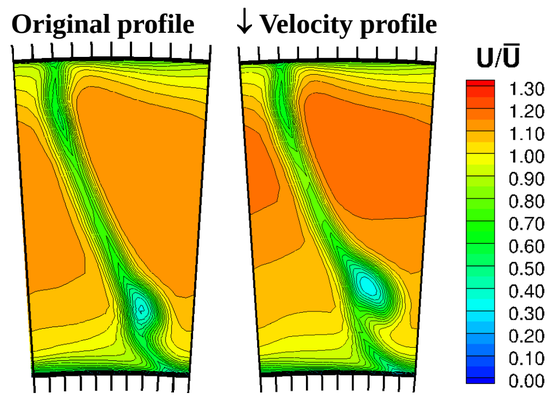




Rotor Exit

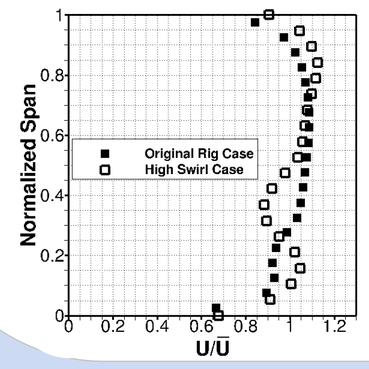


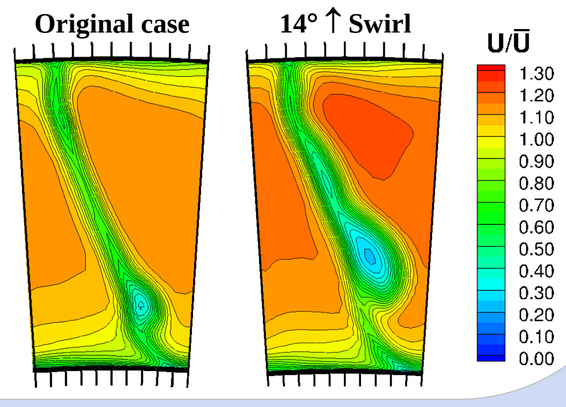
Plane A



High Inlet Swirl

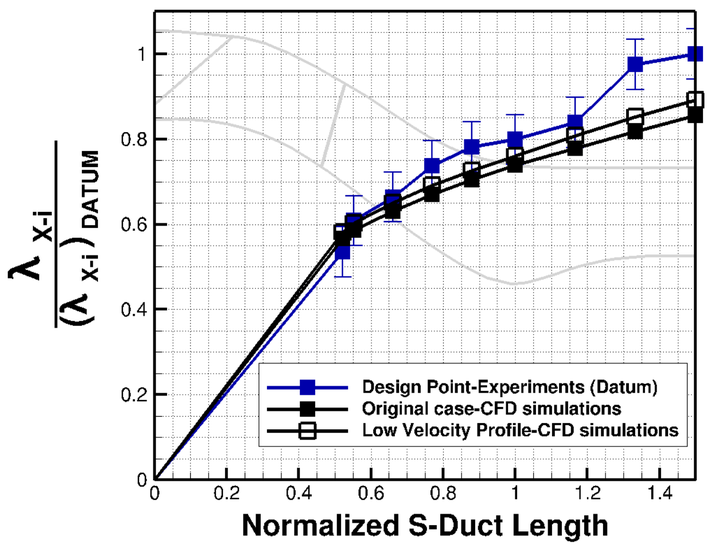
Plane A





Conclusion

- Hub-low inlet profile generates stronger secondary flows increasing pressure losses within the duct
- High inlet swirl enhances the stator wakes modifying the duct flow and feed to the downstream engine core



Loss Coefficient

$$\lambda = \frac{\tilde{P}_X - \tilde{P}_i}{\tilde{P}_X - \tilde{p}_X}$$

X: Rotor exit
i: A→Exit
S-duct planes

Future Work

- Further investigation of the unsteady character of the fan-root loss-core and its impact on the stator/duct
- Develop experimental test facility to replicate rotor loss cores

Acknowledgements

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