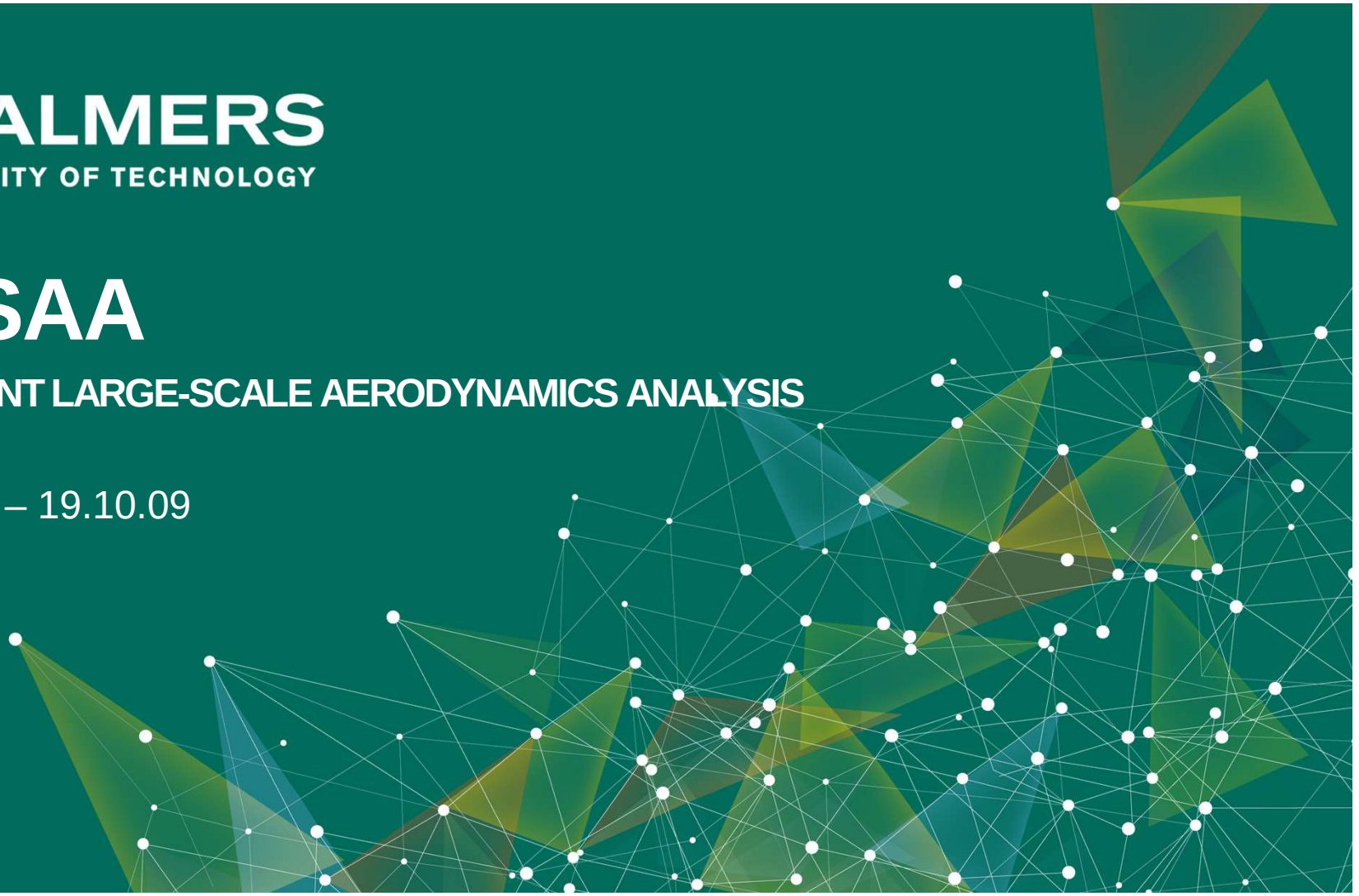
CHALMERS
UNIVERSITY OF TECHNOLOGY

ELSAA

EFFICIENT LARGE-SCALE AERODYNAMICS ANALYSIS

FT2019 – 19.10.09



OUTLINE

- Introduction
- Intermediate Compressor Duct (ICD)
- Trubulence modelling
- Software
- Results
- Conclusion

ACKNOWLEDGEMENT

GKN AEROSPACE

VINNOVA

The Swedish government agency that administers state funding for research and development

SNIC

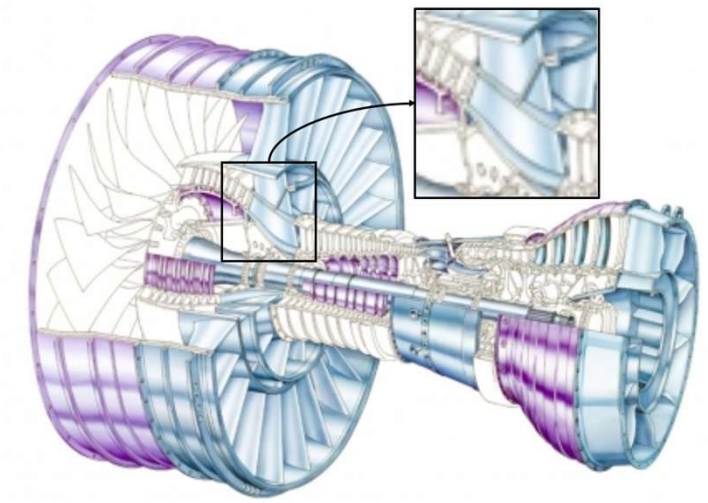
Swedish National Infrastructure for Computing

INTRODUCTION

- Aircraft engine efficiency has risen over the past decades
- Resulted in highly efficient major components
- Getting harder to maintain the steady improvements
- With increased computational power, higher fidelity computational fluid dynamics (CFD) modelling is possible
- Furthermore, allows for larger engine modules
- The aim is to apply high fidelity CFD models to and integrated Intermediate Compressor Duct

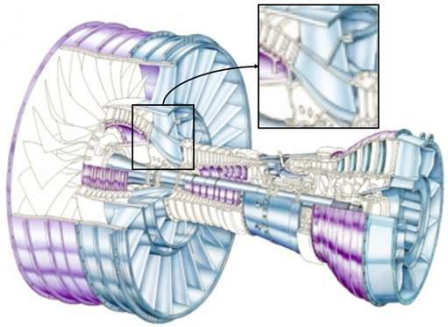
INTERMEDIATE COMPRESSOR DUCT (ICD)

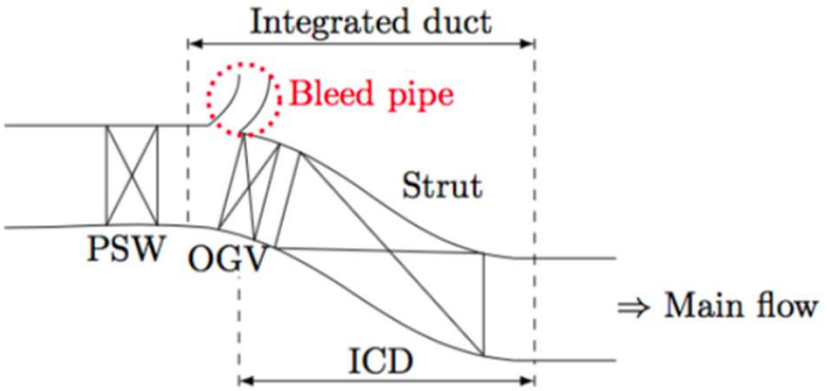
- The S-shaped duct connects the low- and high-pressure compressor systems
- The low-pressure compressor performs better for large radii
- The high-pressure compressor has higher efficiency for smaller radii
- Need aggressive duct (short axial distance and large radial offset) to limit engine weight



EXPERIMENTAL TEST RIG

- Experimental test rig at GKN, in Trollhättan
- Used to study different bleed effects
- The OGV, the duct and strut all represent real engine components
- Pre swirler (PSW) represents the last rotor of the low-pressure compressor

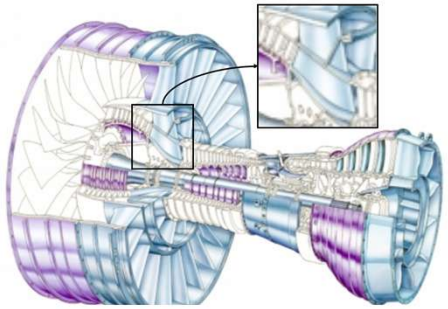


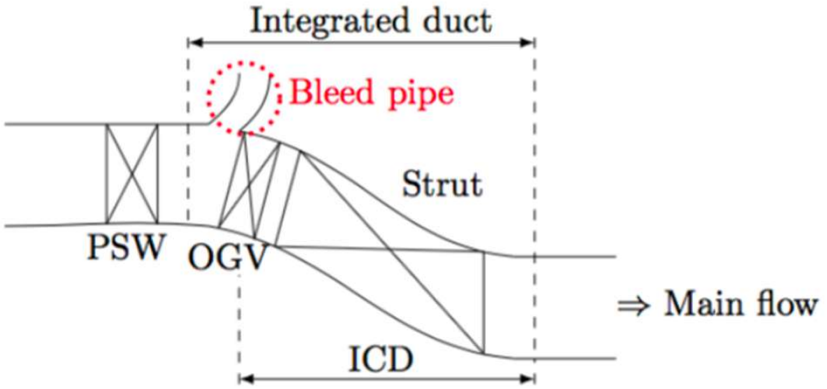


EXPERIMENTAL FACILITY

BLEED PIPE

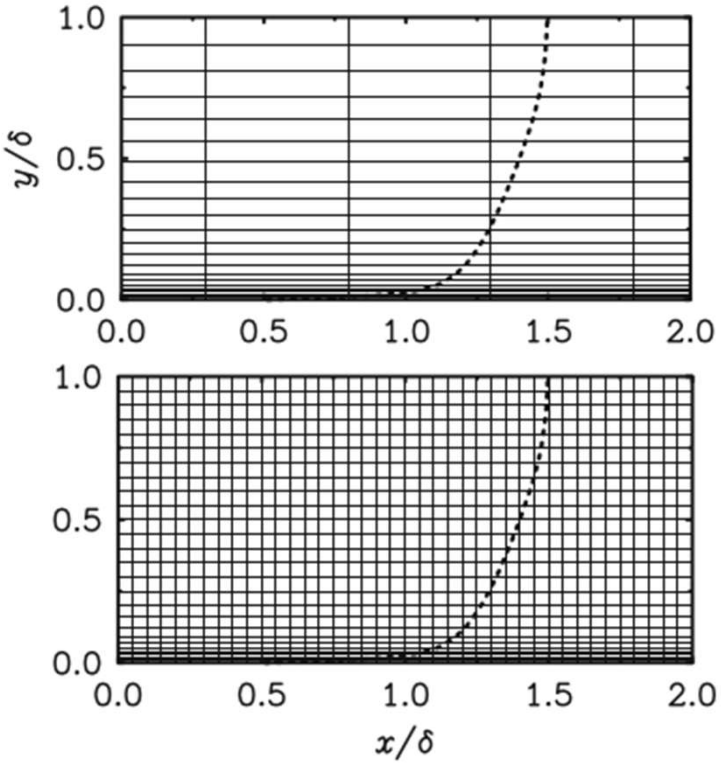
- Gives better control over off-design conditions
- Extraction of flow upstream of the S-shaped duct (called rotor off-take)





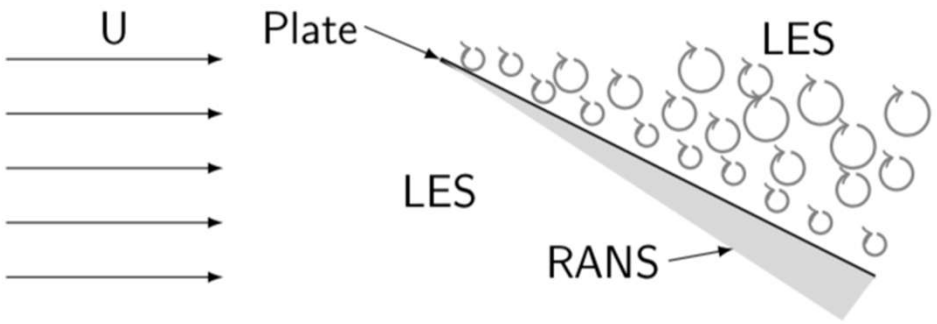
TURBULENCE MODELLING

- RANS more commonly used in industry
  - The flow-field will never exist in real life
- LES to expensive for industrial applications
  - Near wall mesh requirements
  - Smaller cells to resolve larger scales
  - Smaller time-step
  - Sampling to achieve averaged flow-field
  - Over all much more time-consuming process compared to RANS



HYBRID MODELLING

- Hybrid RANS/LES
- Combines RANS and LES
  - RANS capability in simulating flows close to walls with mild separation
  - LES capability in resolving the mean flow and large separated regions



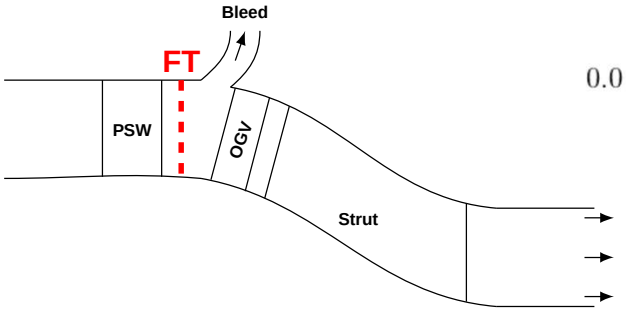
SOFTWARE

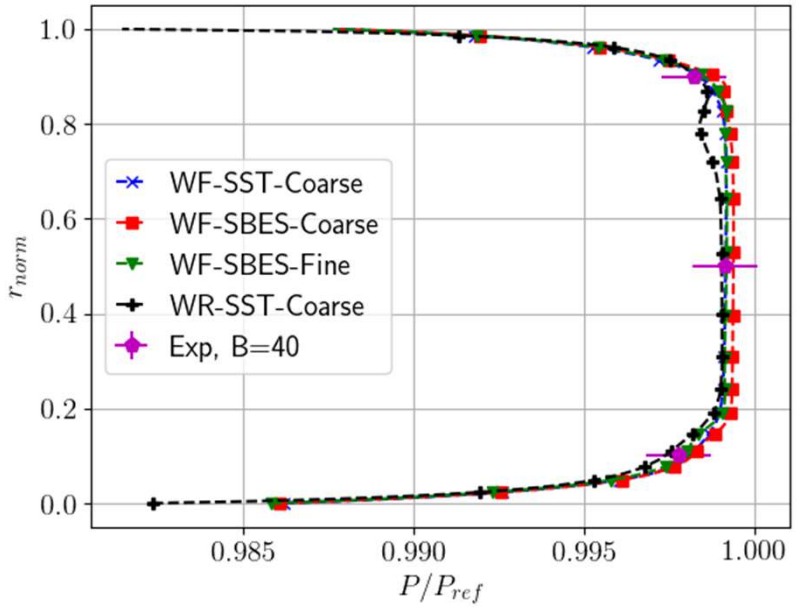
- ANSYS CFX
- Hybrid RANS/LES
    - Stress Blended Eddy Simulation
        - RANS – SST
        - LES – WALE algebraic model
- In-house mesher
    - G3DMesh

RESULTS

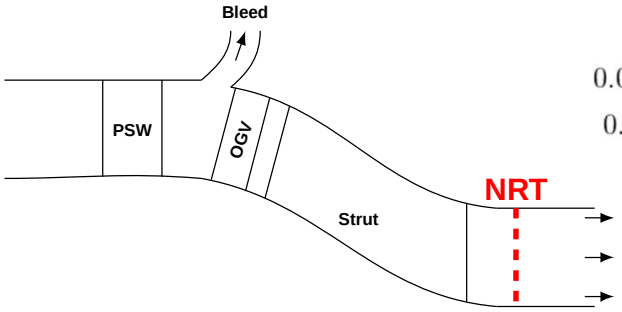
- 3 grids used
  - 2 with wall-functions to save resources
    - CoarseWF – 10M cells
    - FineWF – 34M cells
  - 1 wall-resolved mesh for comparison (RANS only)
    - CoarseWR – 27M cells

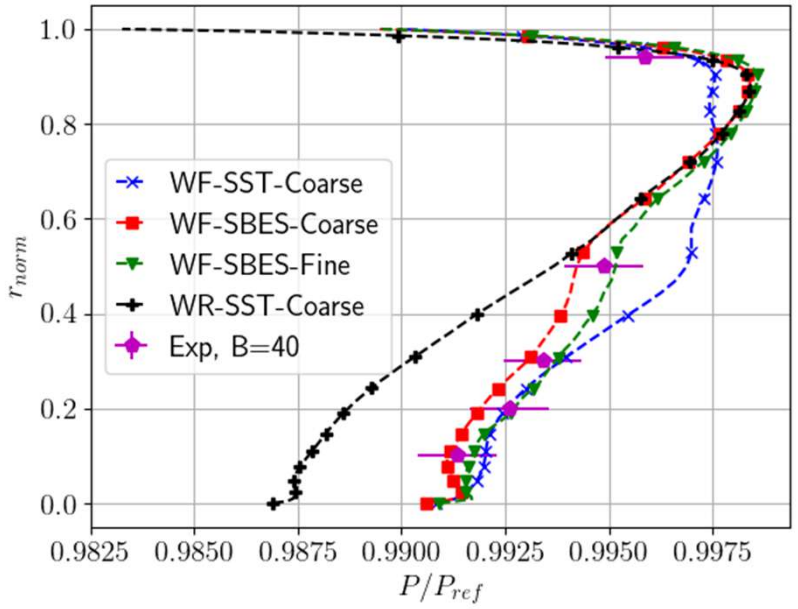
TOTAL PRESSURE AT FT EVALUATION SURFACE



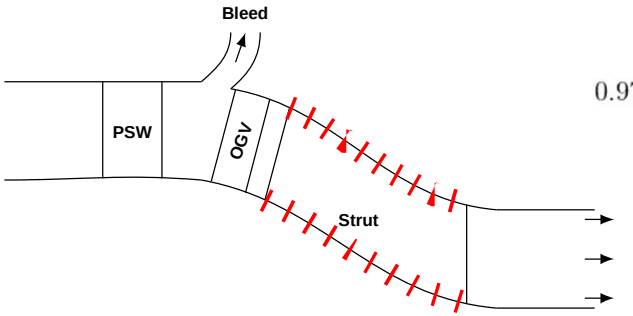


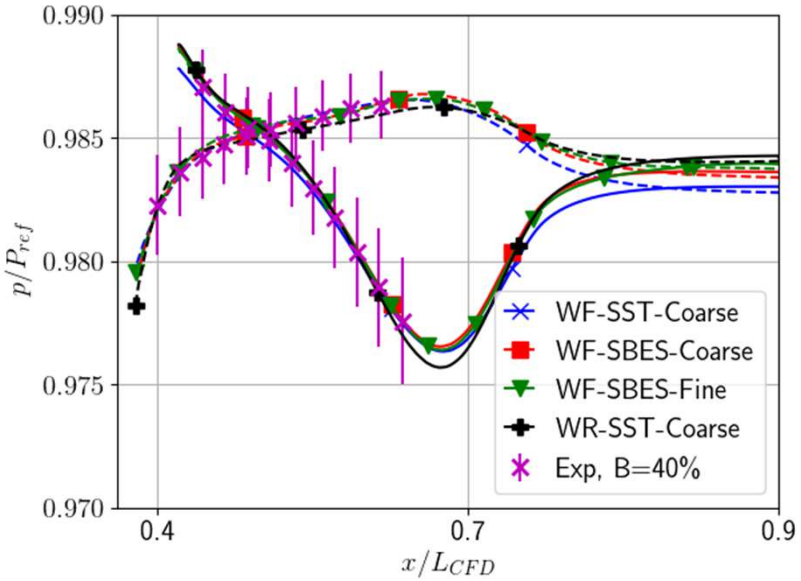
TOTAL PRESSURE AT NRT EVALUATION SURFACE





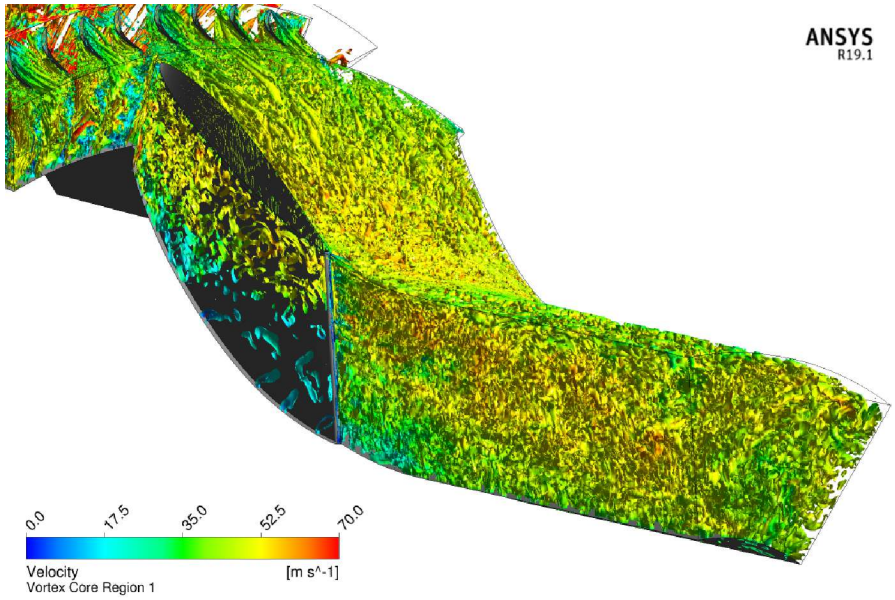
WALL PRESSURE IN THE DUCT



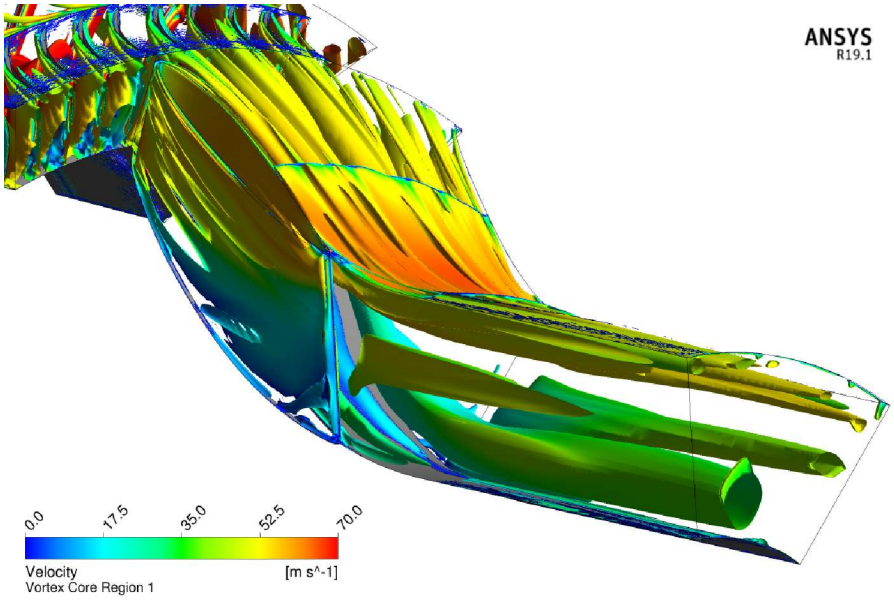


Q-CRITERION

Hybrid



RANS



CONCLUSION

- Integrated design
- Hybrid simulations capable of reproducing the measurements
- Steady state boundary layer resolved simulations over predict separation on the OGV
- The transient simulations provide important information regarding the true nature of the flow behaviour
- Flow with large separation regions should to be studied to take full advantages of the hybrid methods
- WR simulations needed

CHALMERS

UNIVERSITY OF TECHNOLOGY