Development of fuel and heat management systems for liquid hydrogen powered aircraft

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ENABLE·H2

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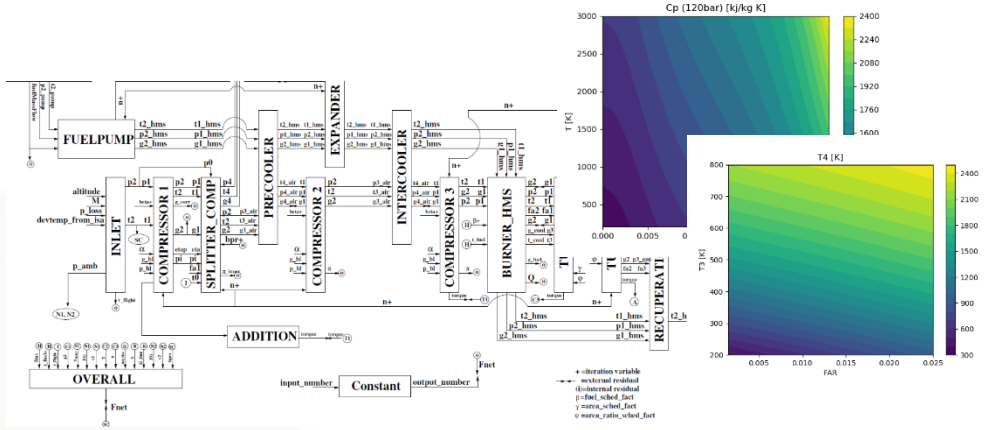
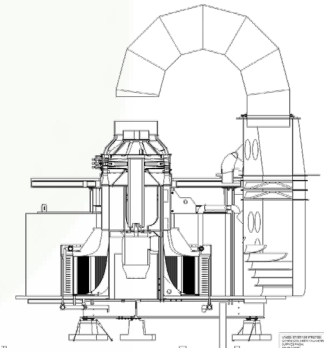
Phase 1: Conceptual Design

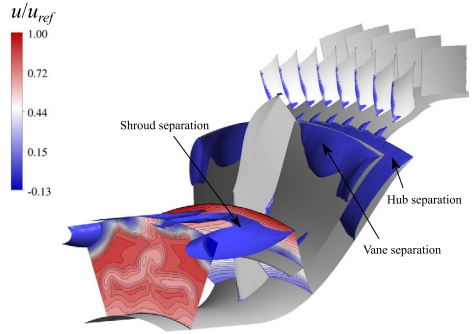
- System Model: Adaptation of components for cryogenic fuel simulation.
- Parametric Studies



Phase 2: Preliminary design and validation

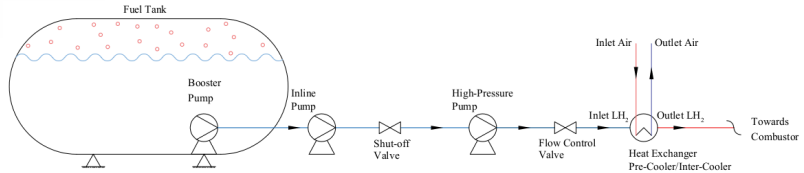
- Heat transfer, flow turning at representative conditions
- Core exhaust heat rejection
- Core flow cooling
- Low speed high Reynolds number annular test facilities





Phase 3: Heat Management System

- Final heat management system to be down-selected
- Optimize solutions applicable to the ENABLEH2 aircraft concepts
- TRL 2 achieved



Heat management potential

- High specific heat
- Cryogenic storage temperatures (22 K)
- From cryogenic to up to 800-1000 K about 14 MJ/kg can be recovered

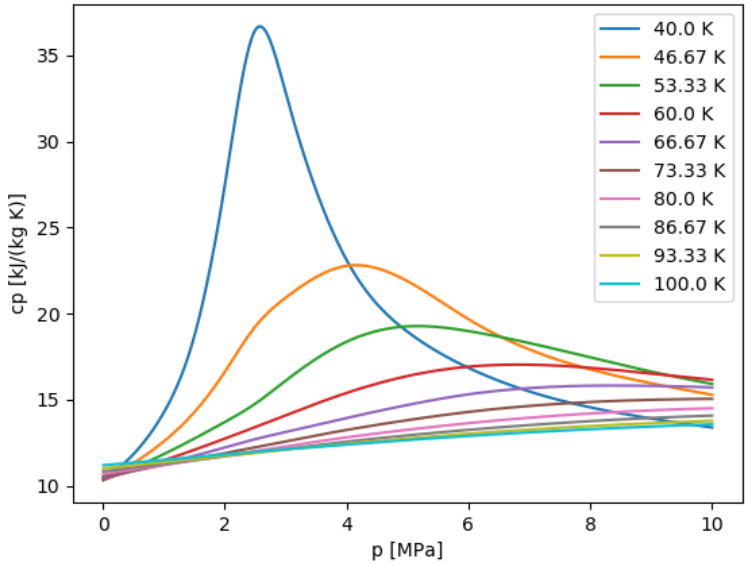


Fig: Hydrogen specific heat variation with pressure and temperature

Heat management potential

- Multiple options for heat recovery from the cycle exist
- Different designs can be explored
- Impact of tank and sub-system performances must be taken into consideration
- Engine performance, CFD and experimental work

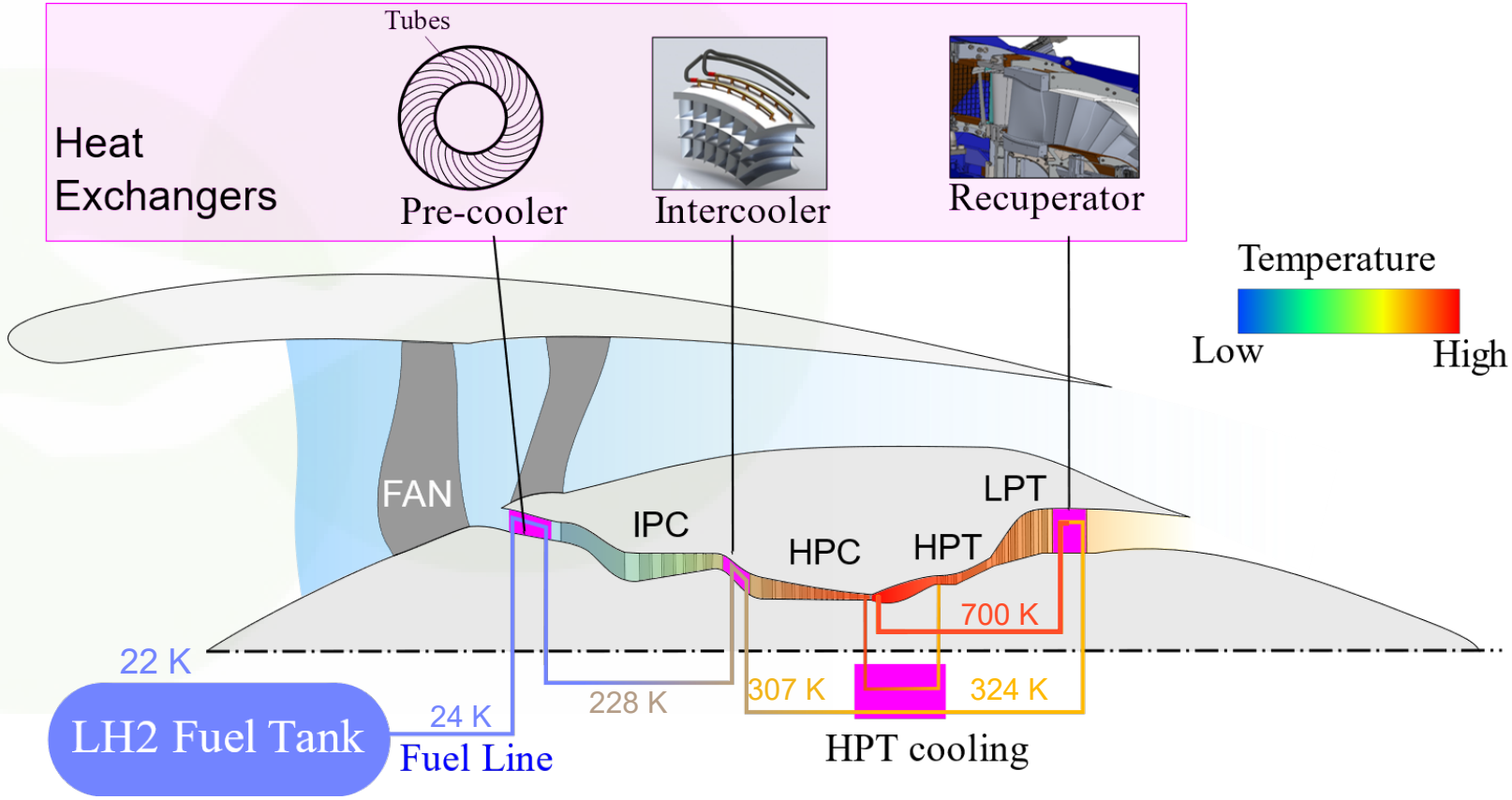
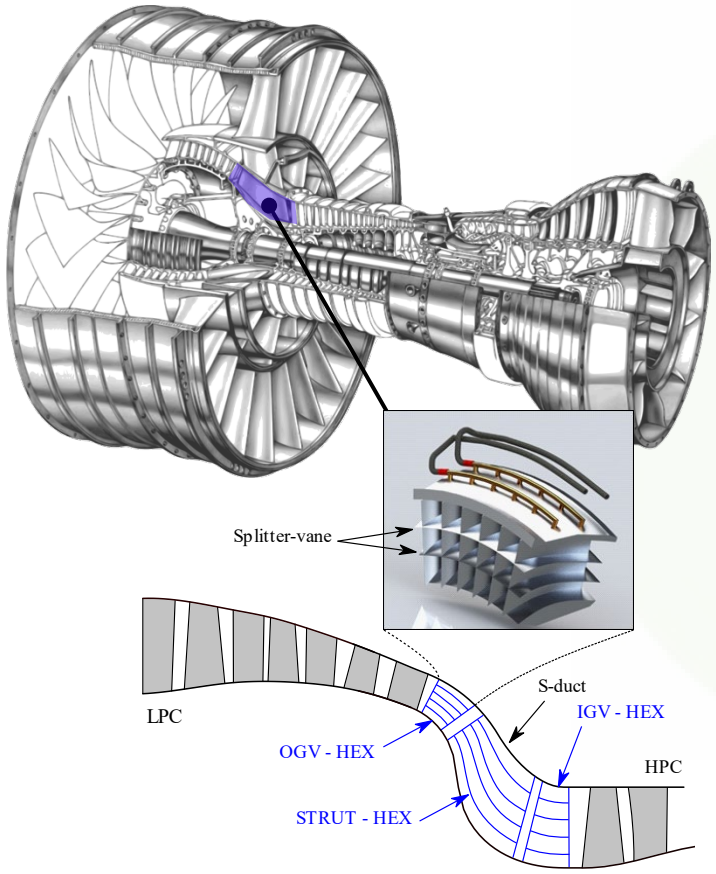
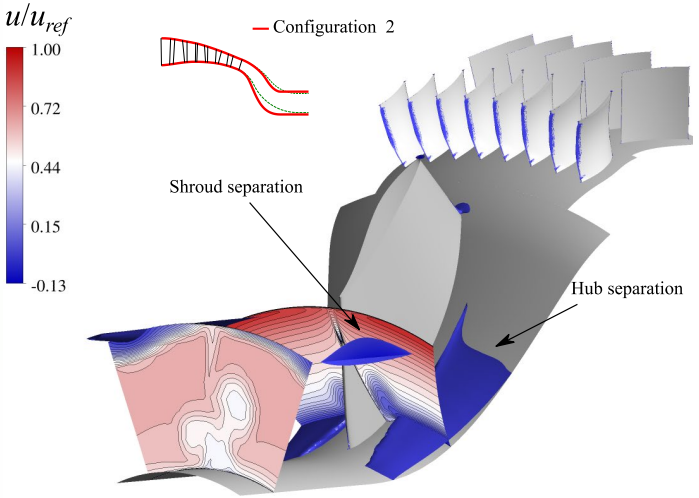


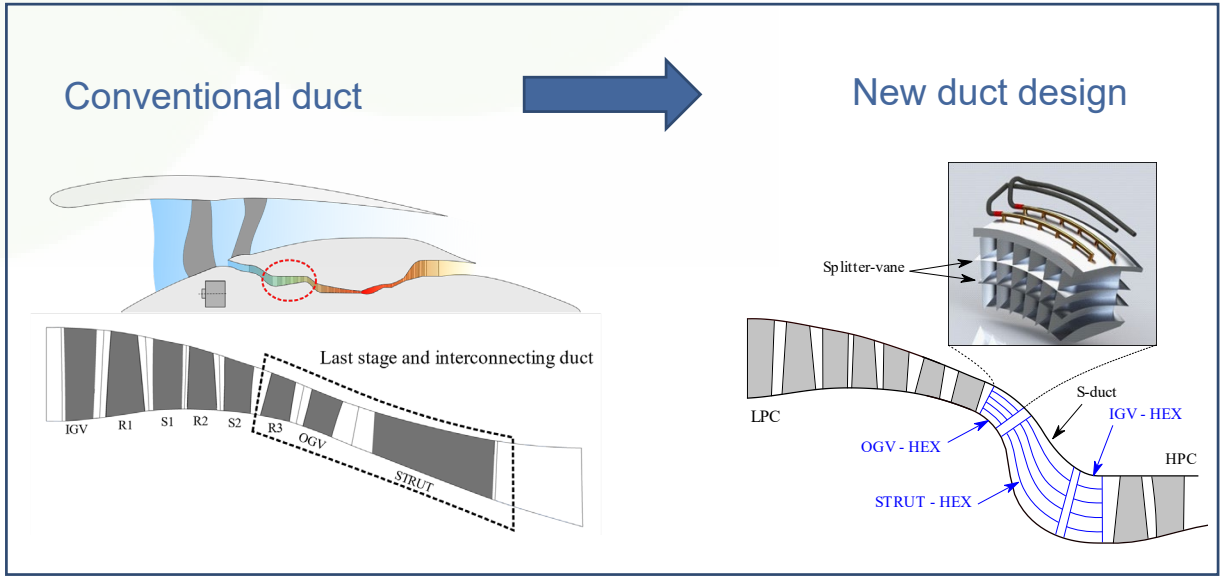
Fig: Cross-sectional meridional cut of a turbofan engine, including possible locations for core heat rejection to the hydrogen fuel

Vane-integrated HEX

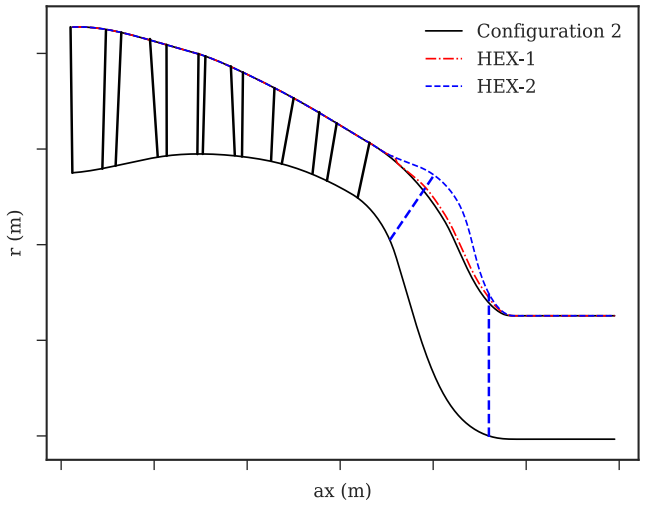
- Compressor vane integrated HEX
- Enhanced radial turning
- Reduced Core size







First insight into the design



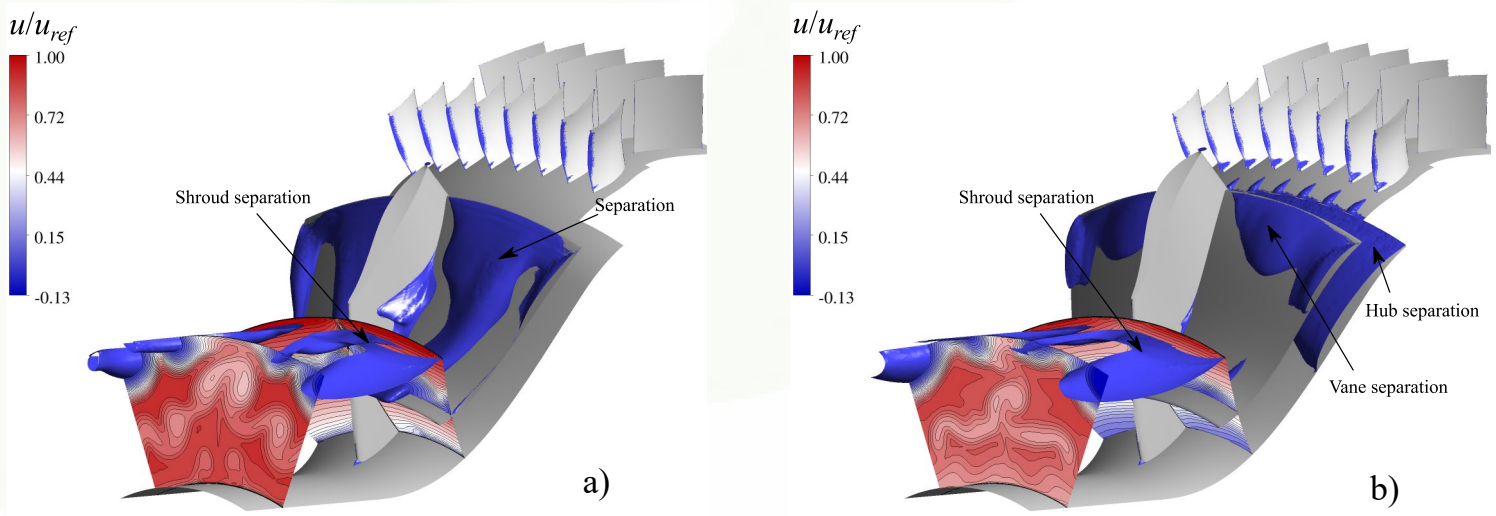


FIG: Normalized axial velocity computed for the HEX-1 (a) and HEX-2 (b) duct design. The Iso-surface shows regions of flow separation.

Design tools

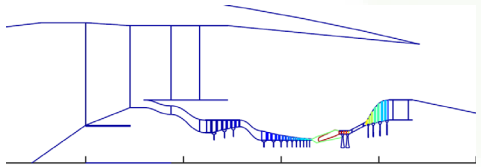
OPTIMIZE

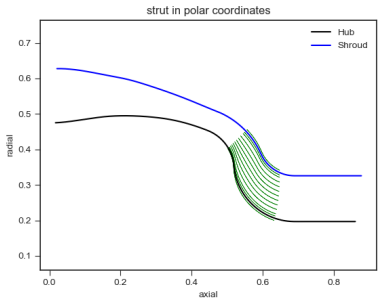
Performance
- Gestpan, WEICO

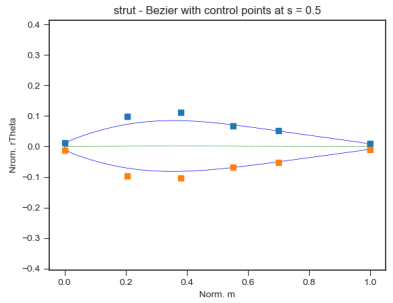
1D design
- Meanflow design

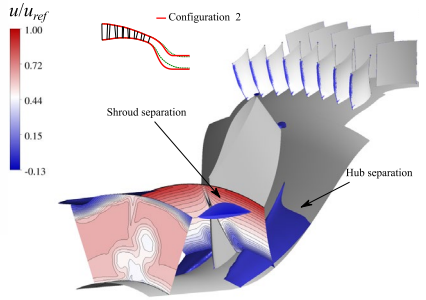
2D design
- Streamline
- Profiling

3D Design
- Stacking
- CFD viscous



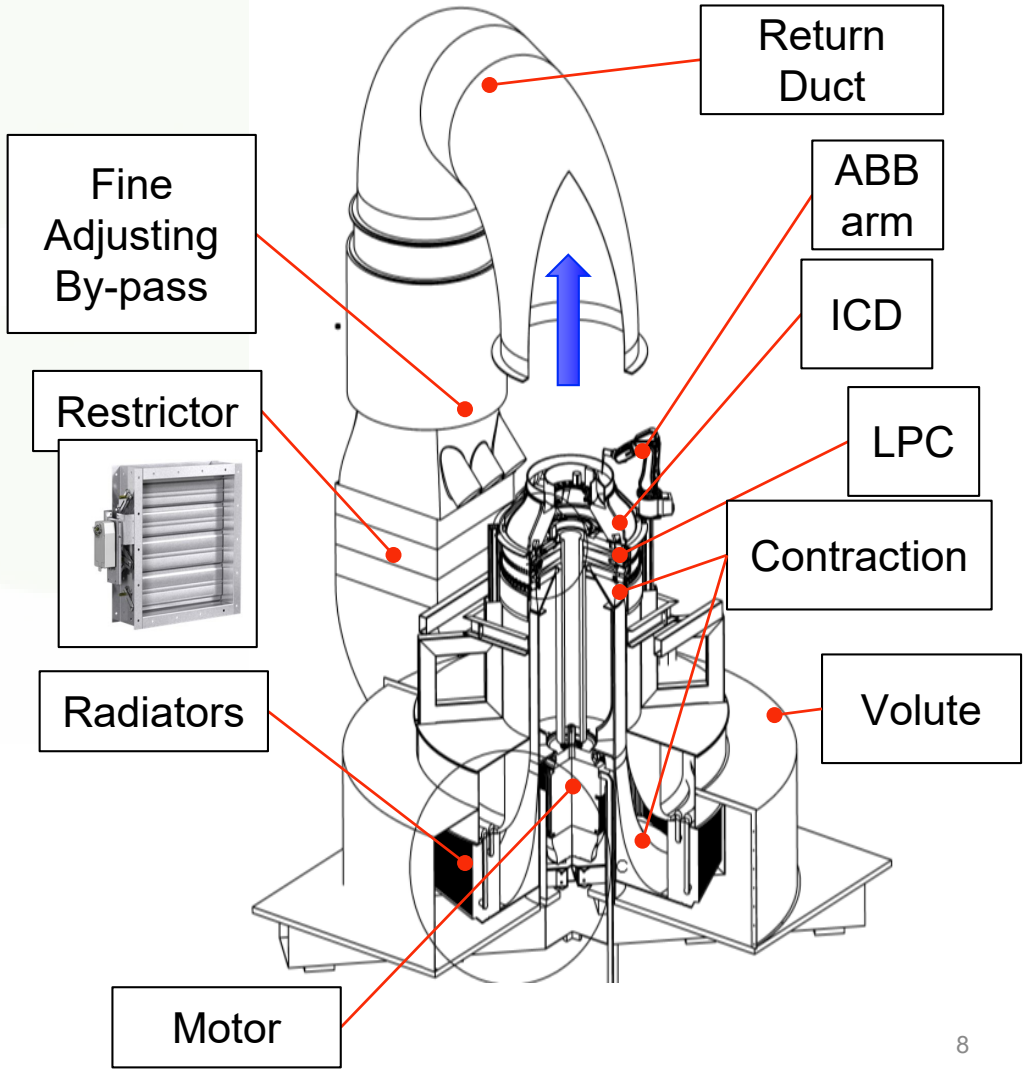






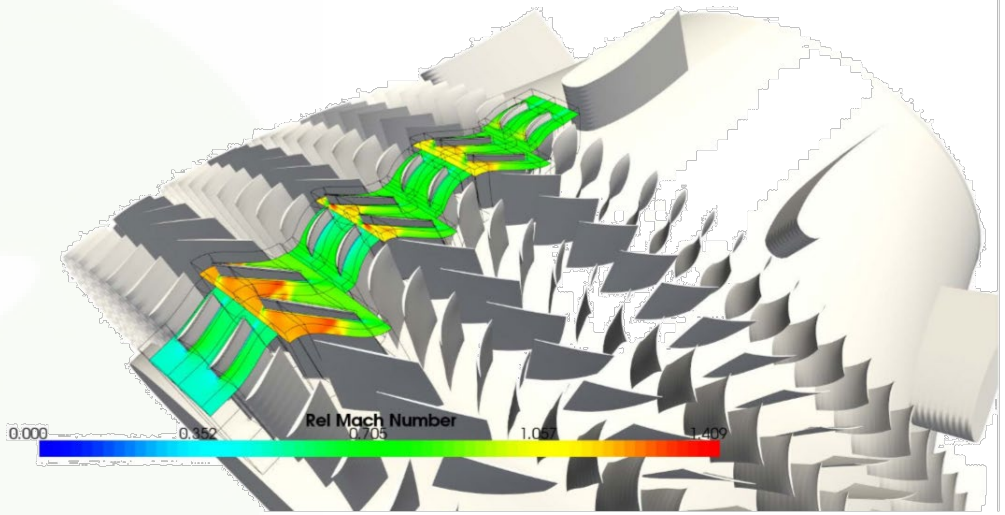
Compressor rig

- 2.5 stages, low-speed
- Vane integrated cooling system
  - Calibration
    - Heat transfer
    - Transition

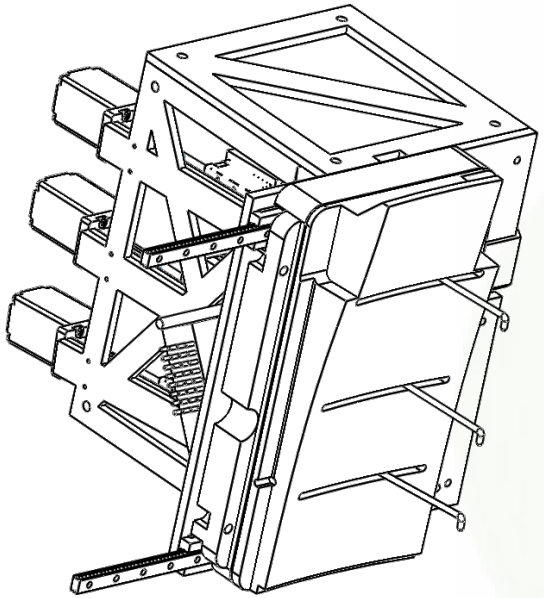


Compressor rig

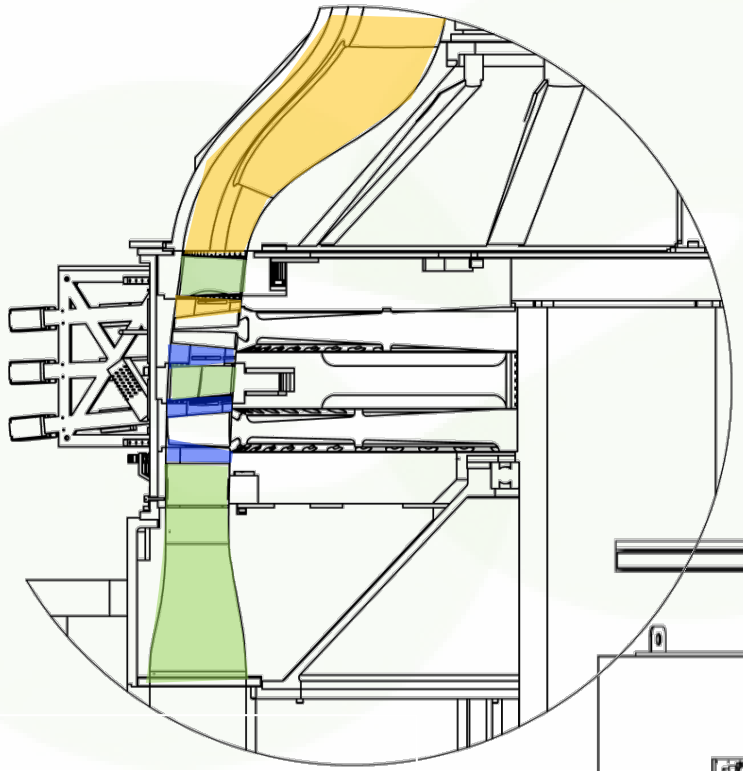
- Version VINK (National Collaboration; GKN, KTH, Chalmers, LTH, Swerea)
- Geared turbofan, 70klb thrust
- Replicate similitudes: Re, ϕ (flow coef.), ψ(stage loading),hub-to-tip ratio, de - $Haller$ number



Instrumental Overview



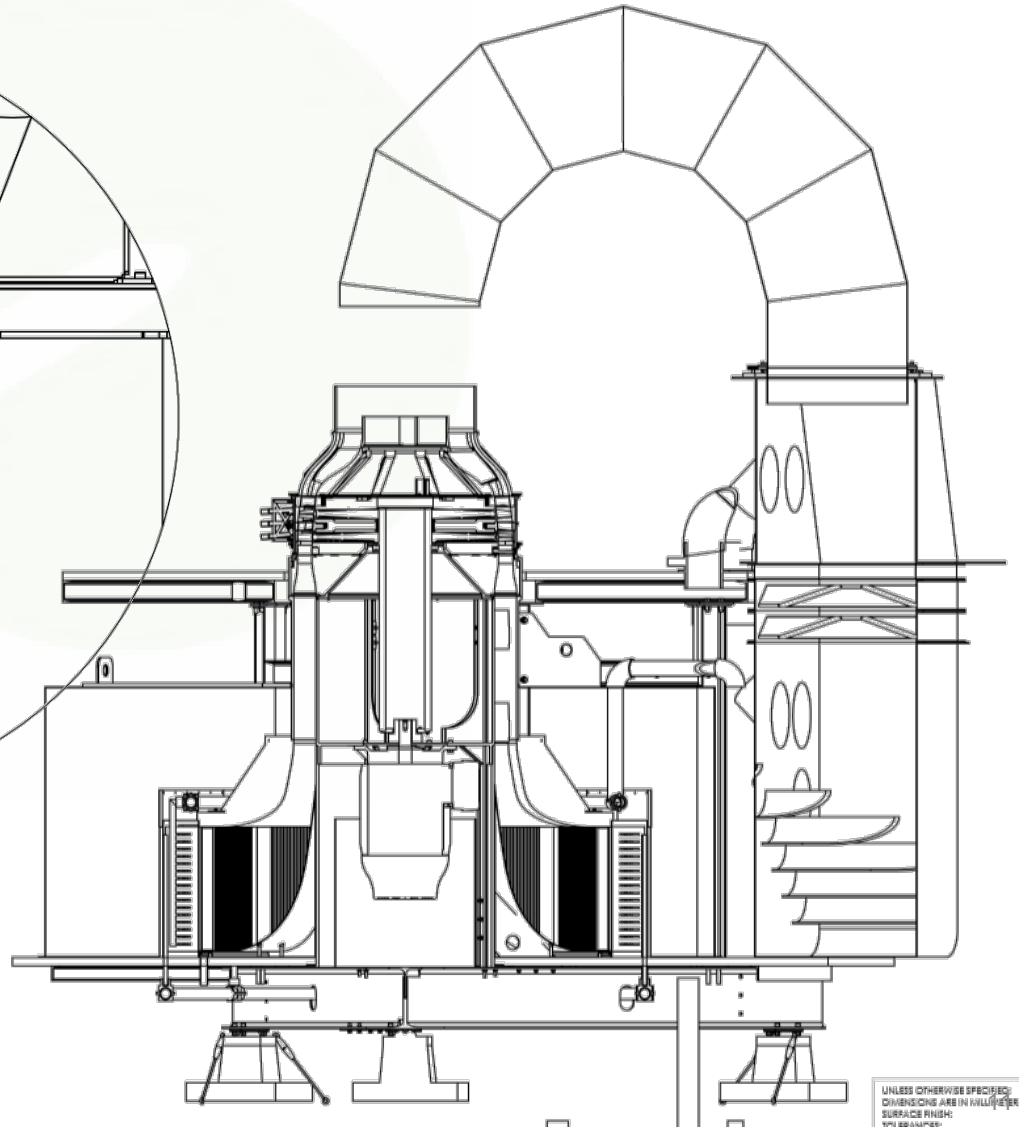
Easy accessible



360°

Static mount
- Pressure taps
- Prandtl tube/rakes etc

Sector Access



Teaser

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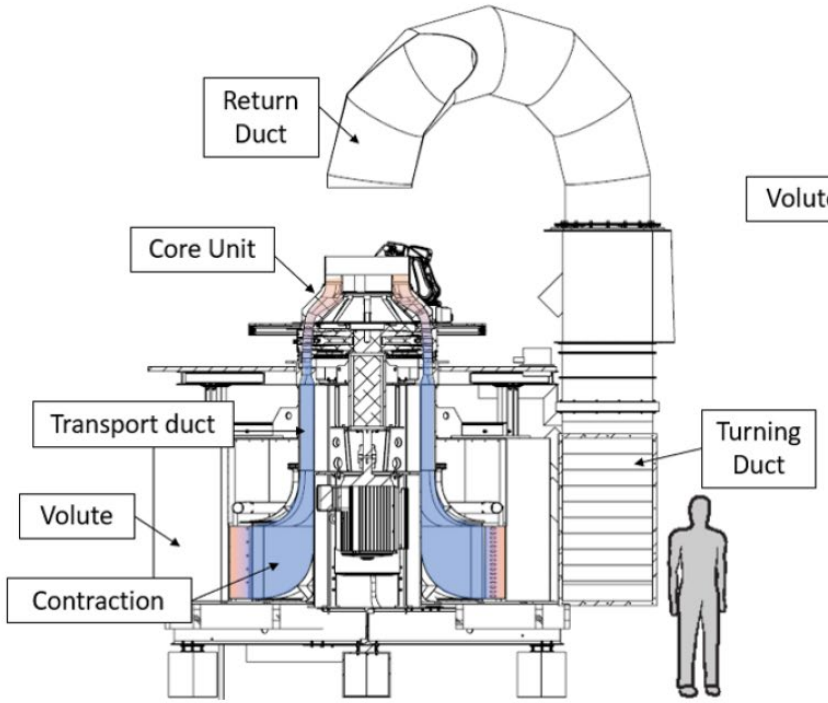

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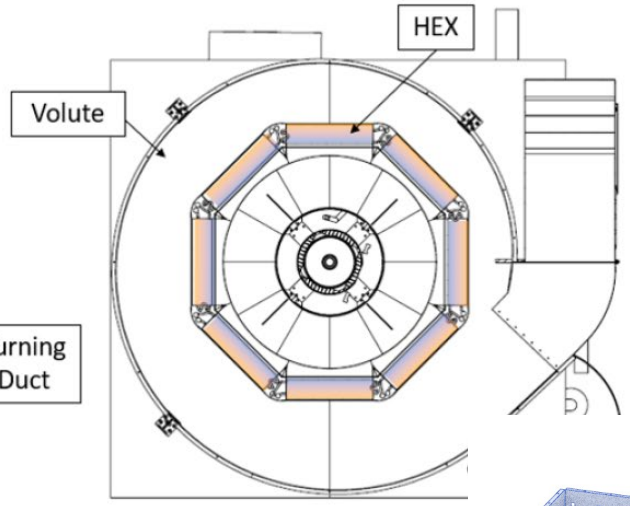

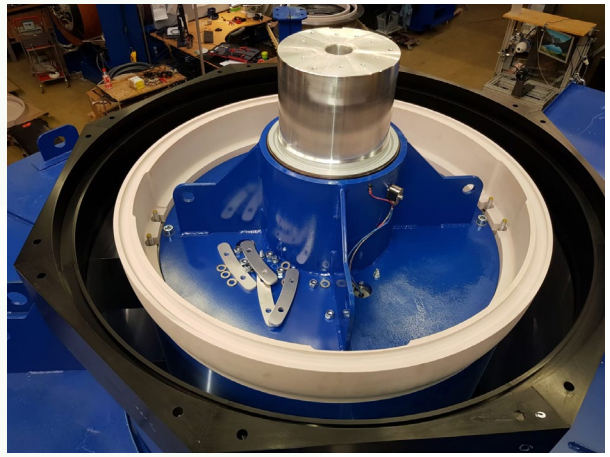

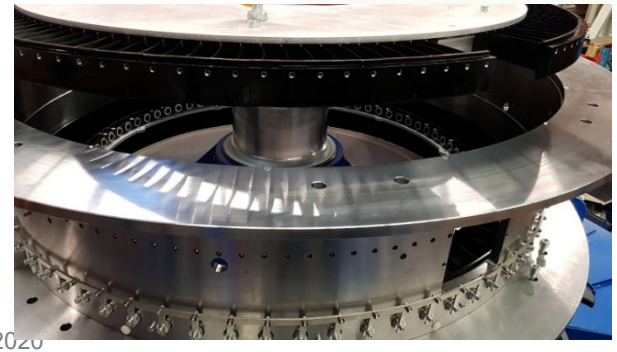

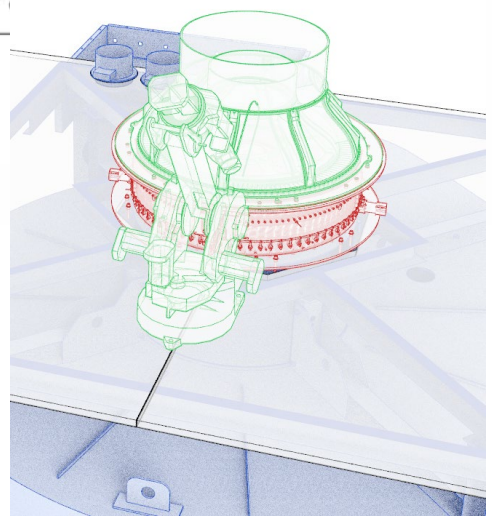

Future steps

- Validation data
- Preliminary design of vane integrated HEX
- Test design in the new facility
- Optimize the design
- Develop and optimize fuel and heat management systems applicable to different ENABLEH2 aircraft concept

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Thank you!

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