Numerical Analysis and Heat Transfer Simulations of Components in Secondary Air System

ThermoXchange

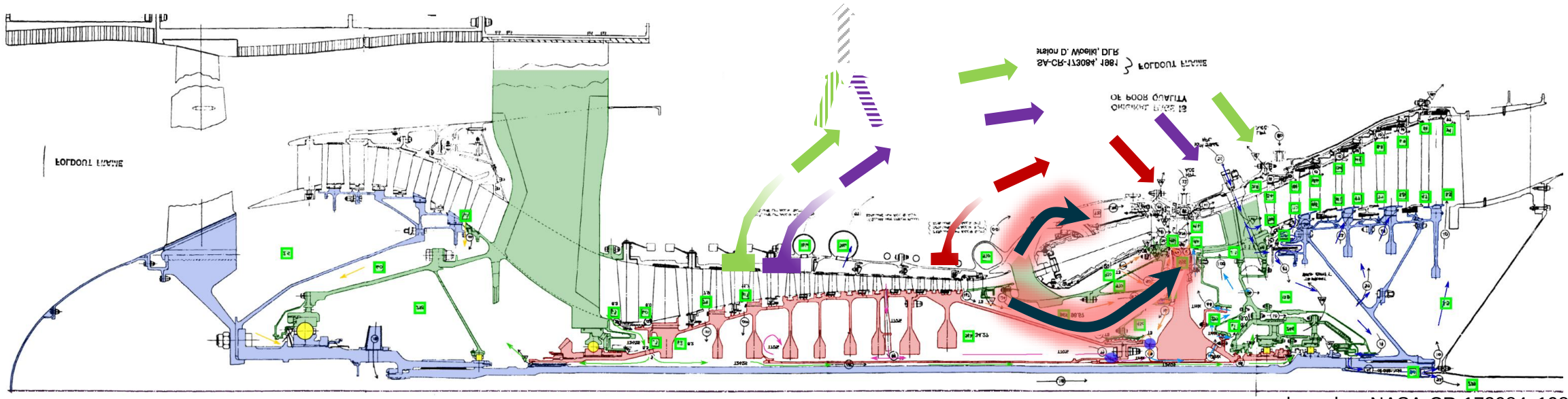
07.10.2026

Sadiya Tabassum, Yogesh Chodvadiya

SG-VTM

DLR

Secondary Air System



based on NASA-CR-173084, 1981

Modelling → Understanding → Optimizing

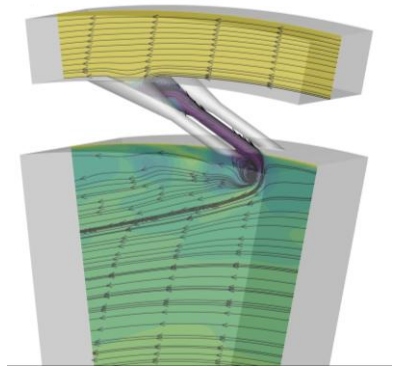
Components in Secondary Air System

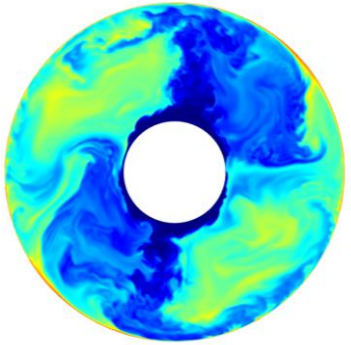
Vortex reducers

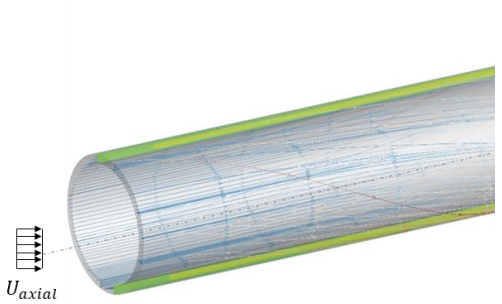
Rotor-rotor cavity

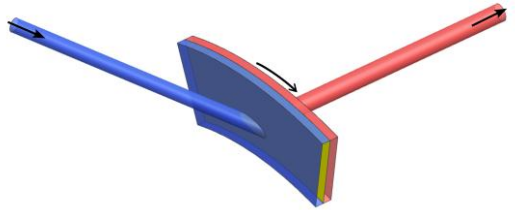
Co-rotating shafts

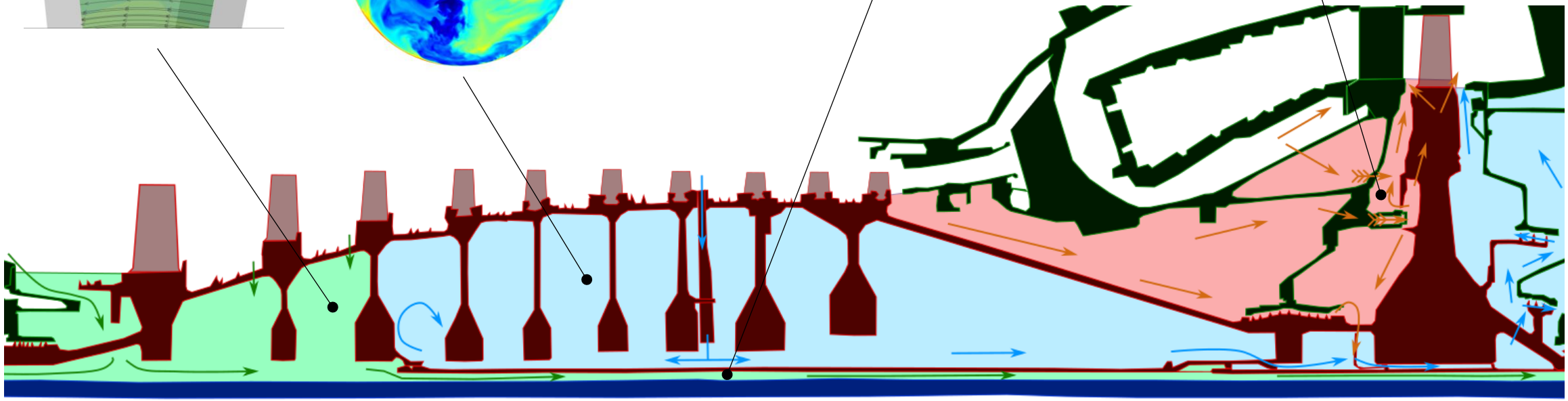
Preswirl cavity







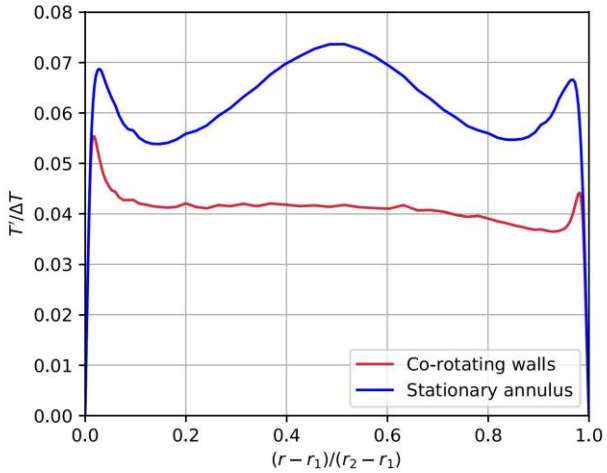




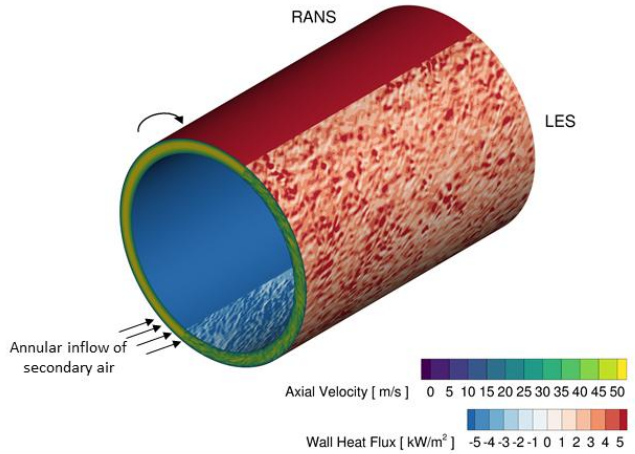
based on NASA-CR-173084, 1981

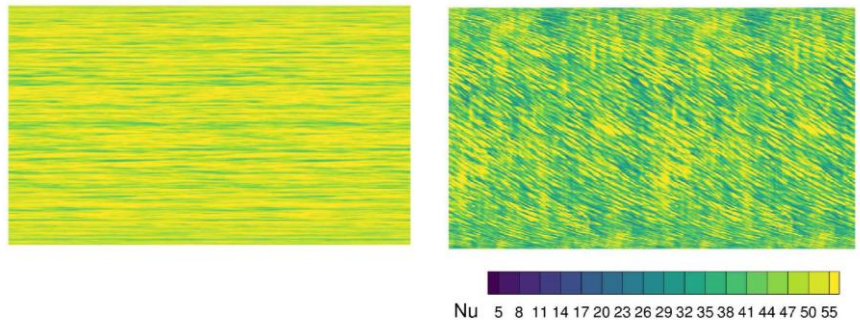
Co-rotating Cylinders

- Data extraction from NASA EEE: axial Reynolds number $Re_x = \frac{u_x D_h}{\vartheta} = 29580$
- Swirl parameter $N = u_\theta / u_x$
- Modeling through RANS-RSM and LES-WALE



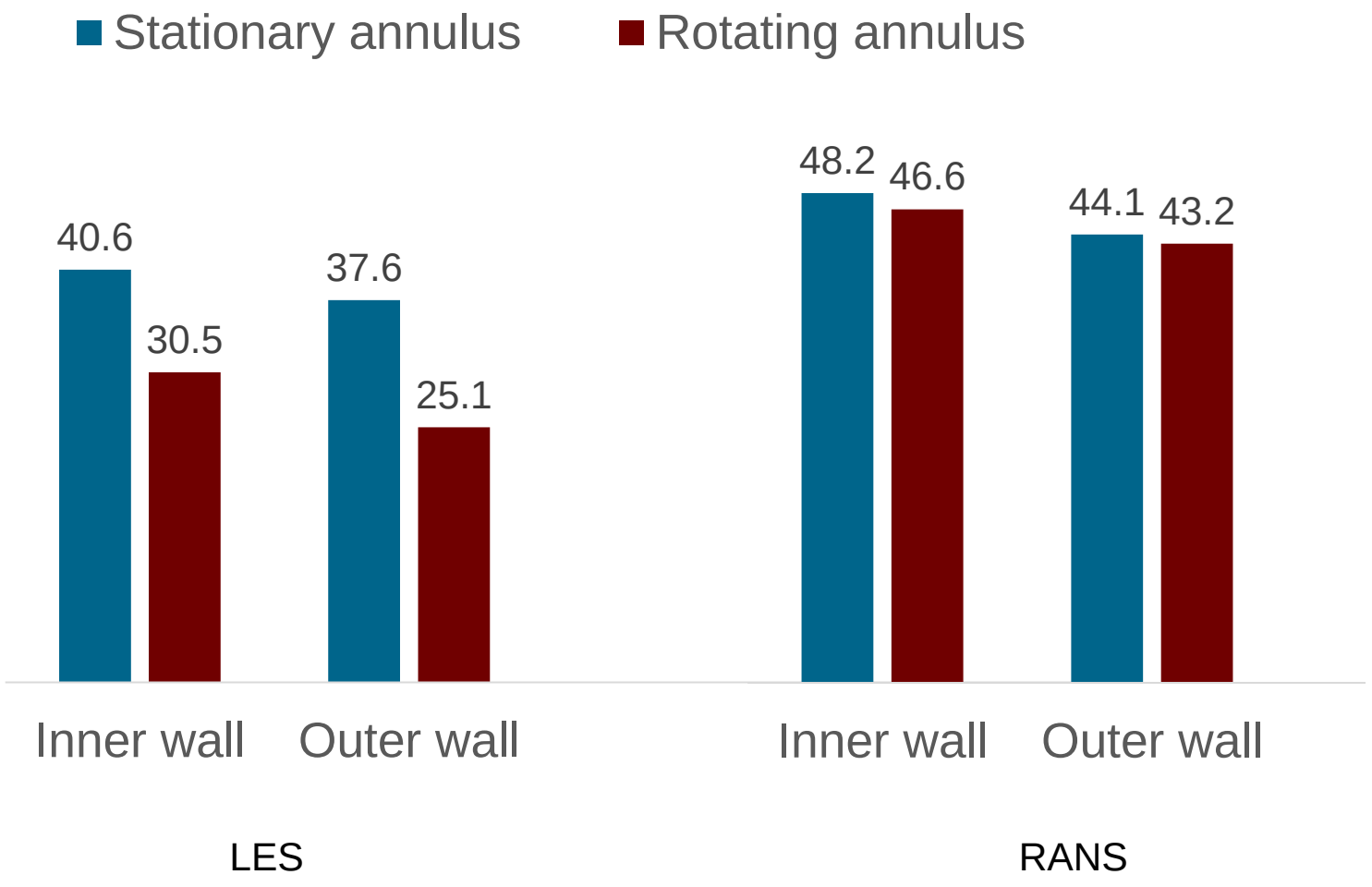
Temperature fluctuation profile in the gap

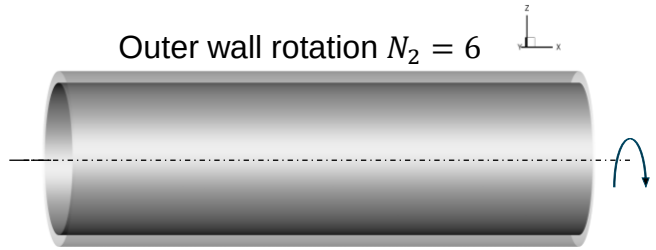




Flow and heat transfer computations on stationary and rotating annuli with streamwise periodicity

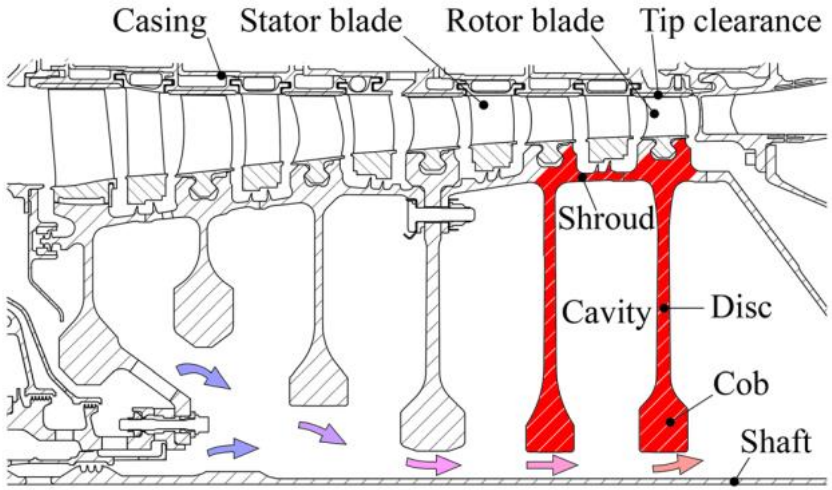
Co-rotating Cylinders



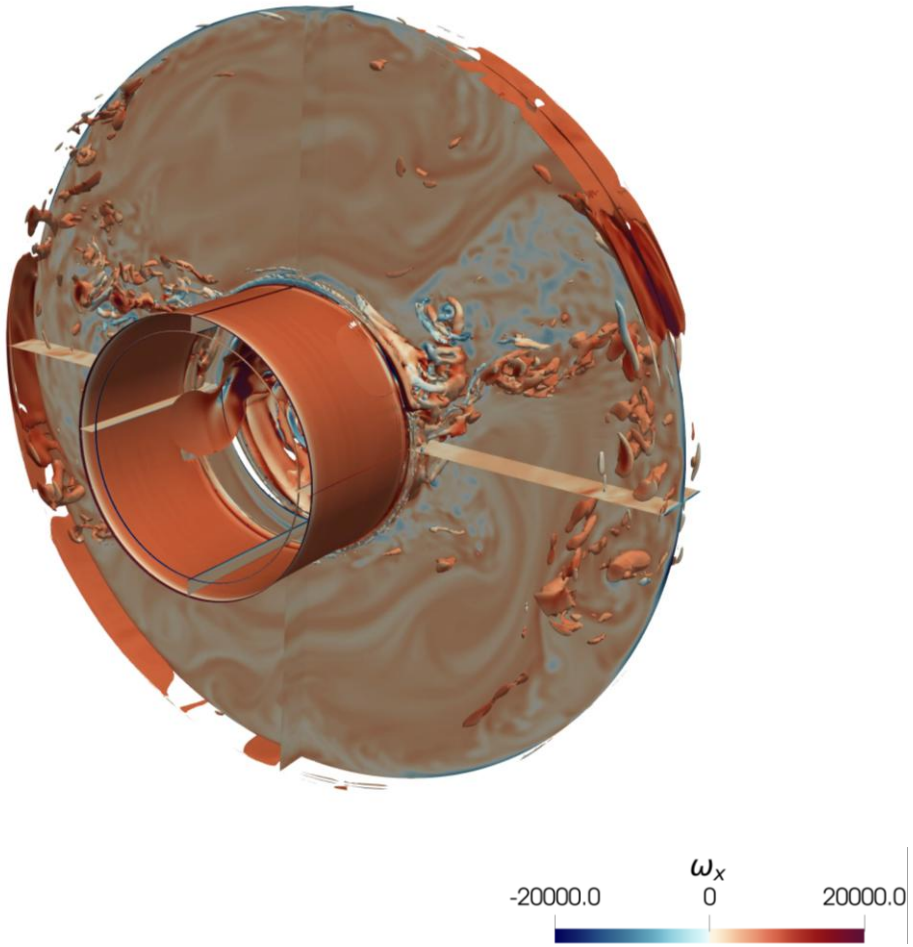


Compressor Drum Cavity

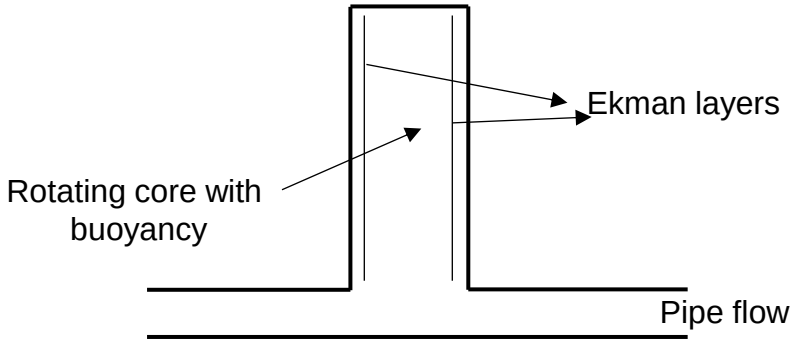
- Heated shroud, cooling secondary air: instability due to buoyancy forces
- Interaction with pseudo-forces: Inertial wave-like structures



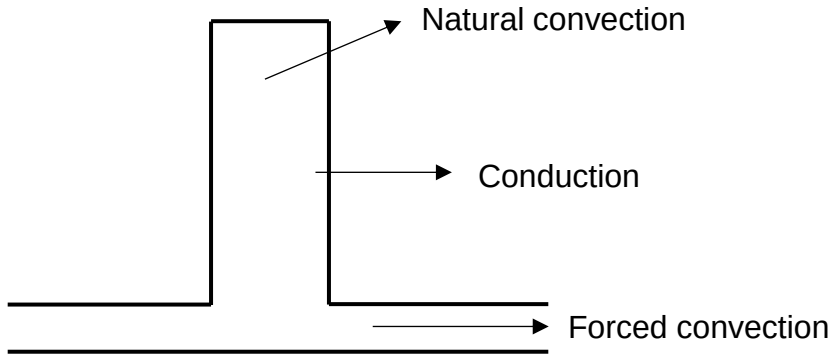
Taken from Gao, 2022



Compressor Drum Cavity



Aerodynamics

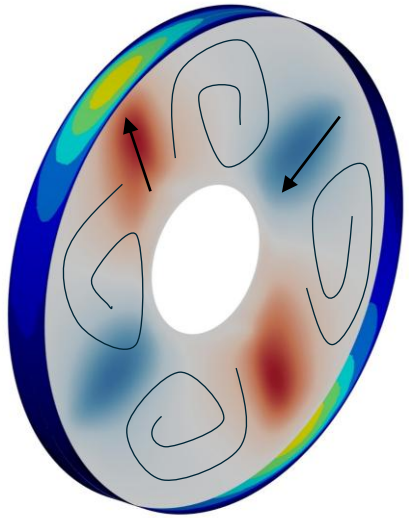


Heat Transfer

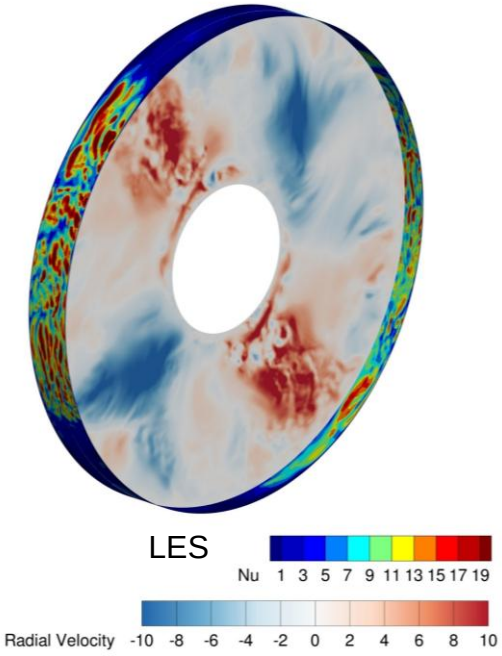
Axial Reynolds number $Re_x = 3000$

Rotational Reynolds number $Re_\omega = 2 \times 10^5$

Grashof number $Gr = 3.03 \times 10^9$



RANS

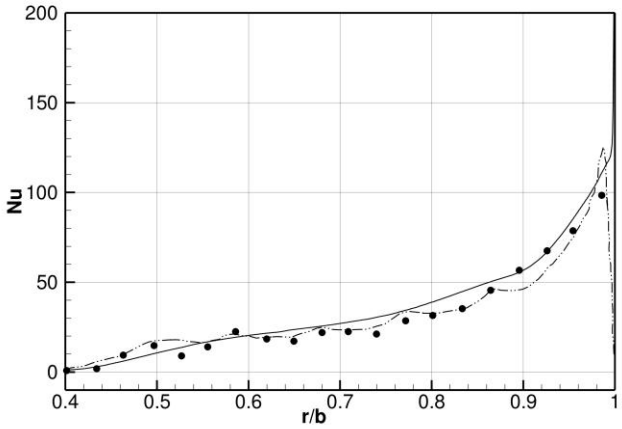


LES

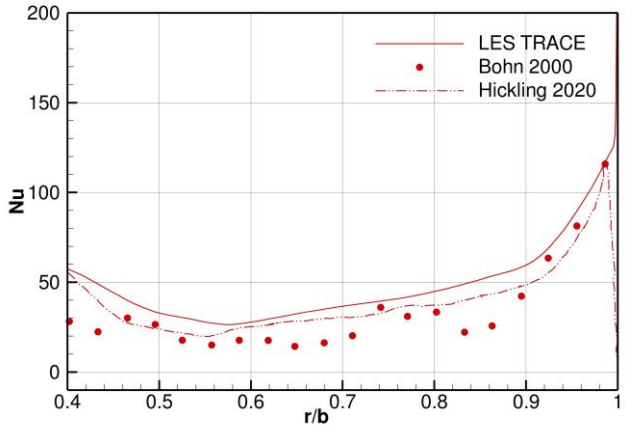
Radial flow impinging on the shroud

Compressor Drum Cavity

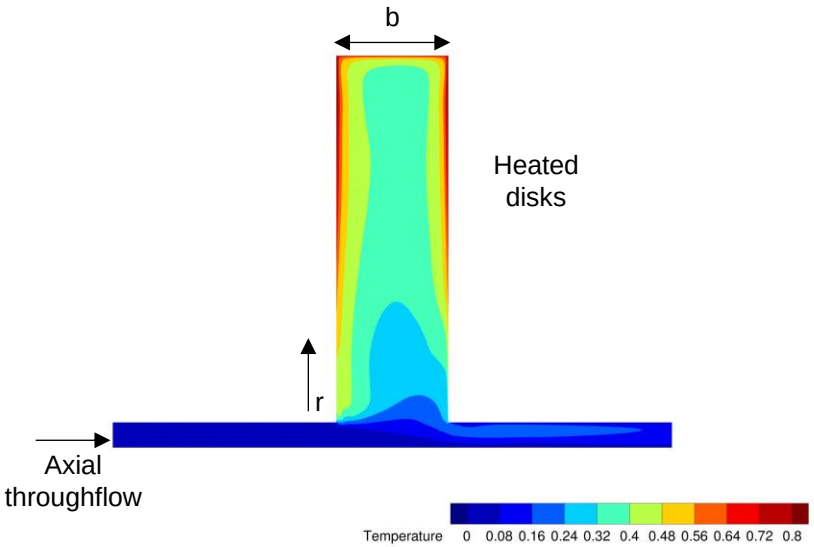
- Secondary air ingestion in the cavity – cooling of the disks
- Validation of LES through literature data



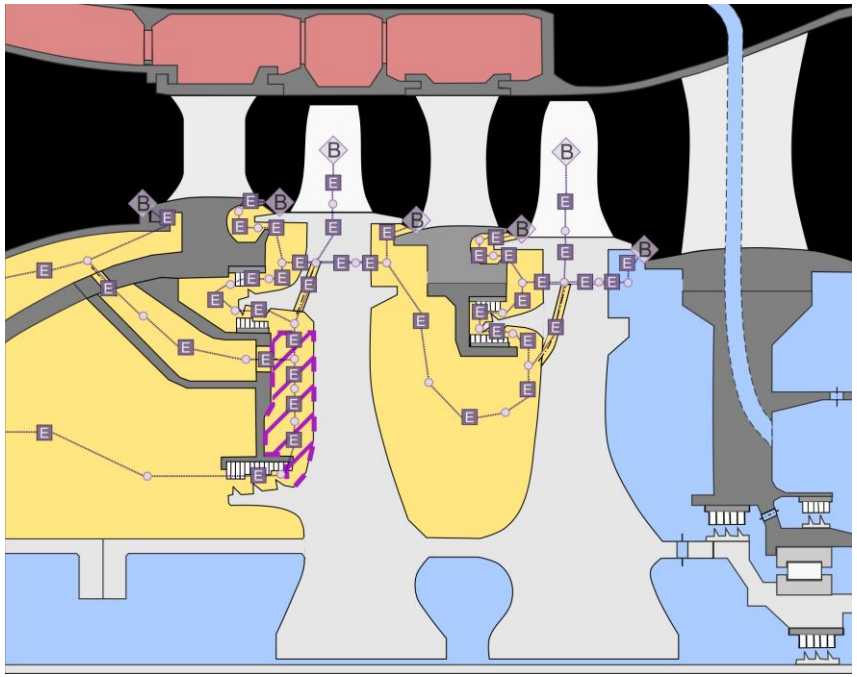
Upstream disk



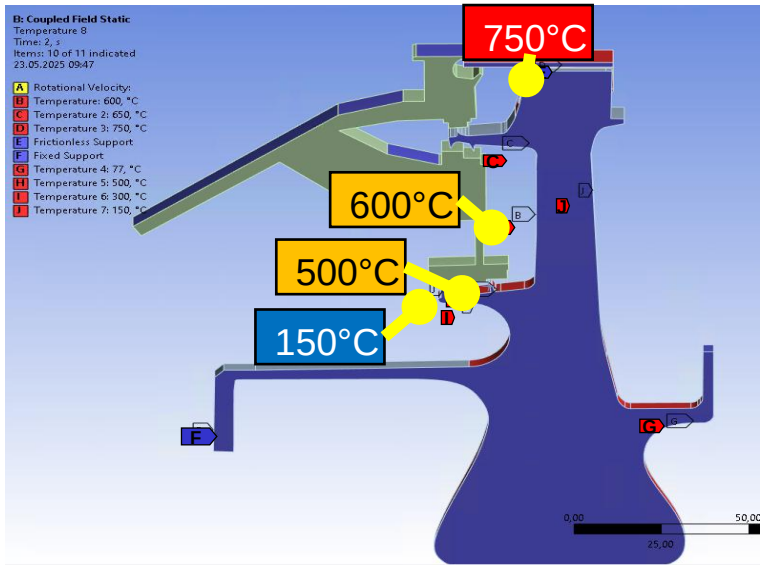
Downstream disk



Interfaces and coupling methodologies



Coupling of CFD with 1D SAS network model

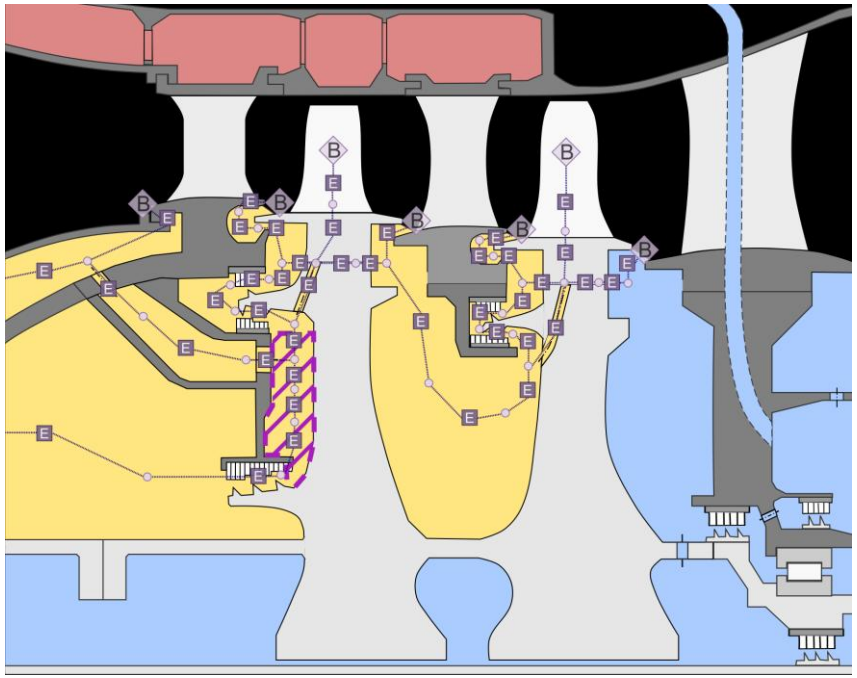


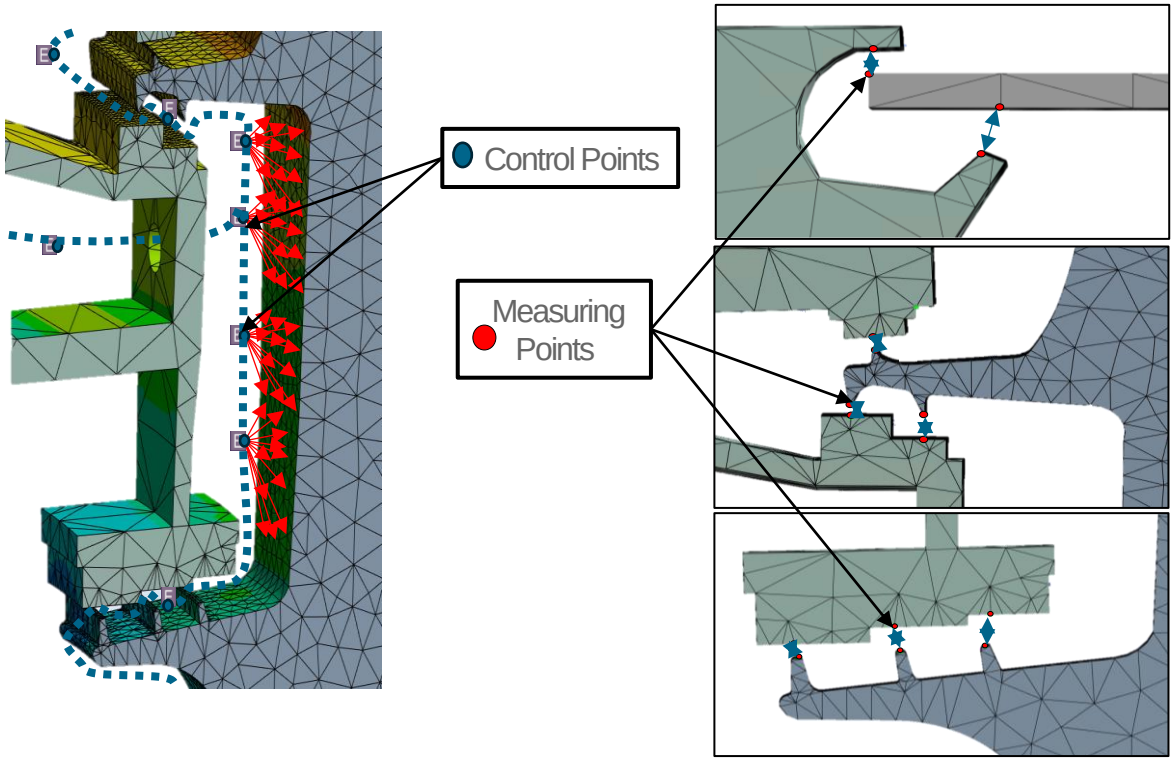
Fluid-structure interaction: 1D SAS to 3D-FEM

Gap Estimation of Seals

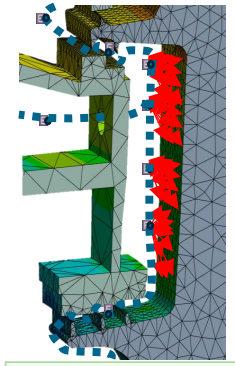
Fluid-Structure Coupling

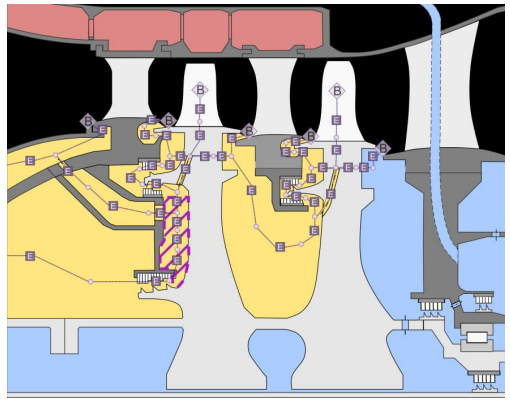
- 1D-SAS to 3D Caclulix coupling for BCs - temperature, pressure, heat transfer
- Thermo-mechancial simulation of seals and disks in SAS
- Quasi-static simulation to transient simulation
- Parametric workflow

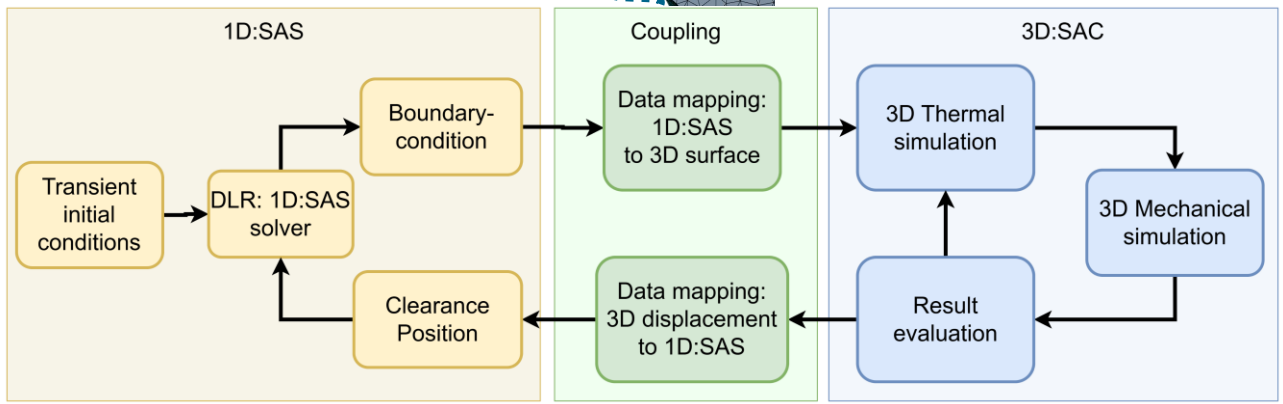


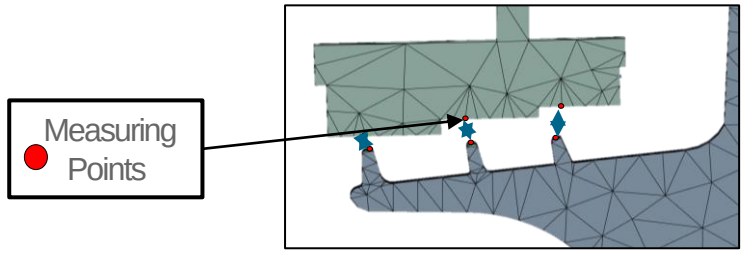


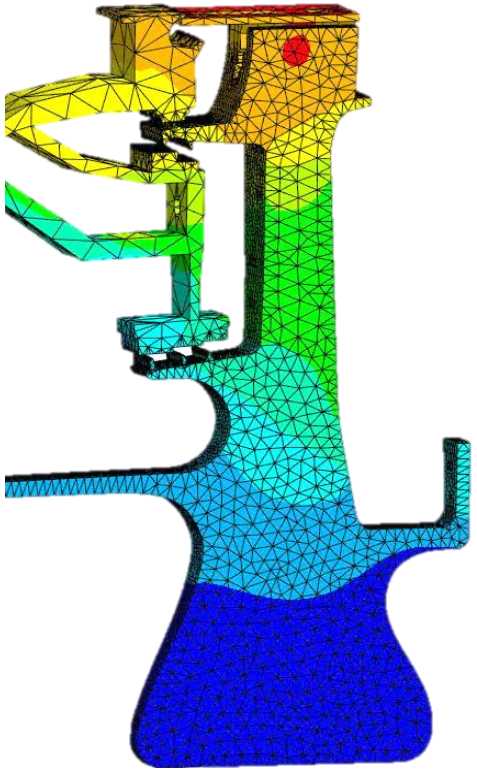
Thermomechanical Simulation Workflow







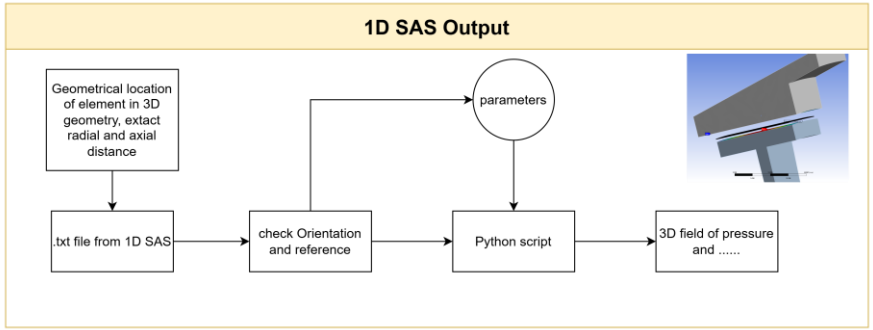


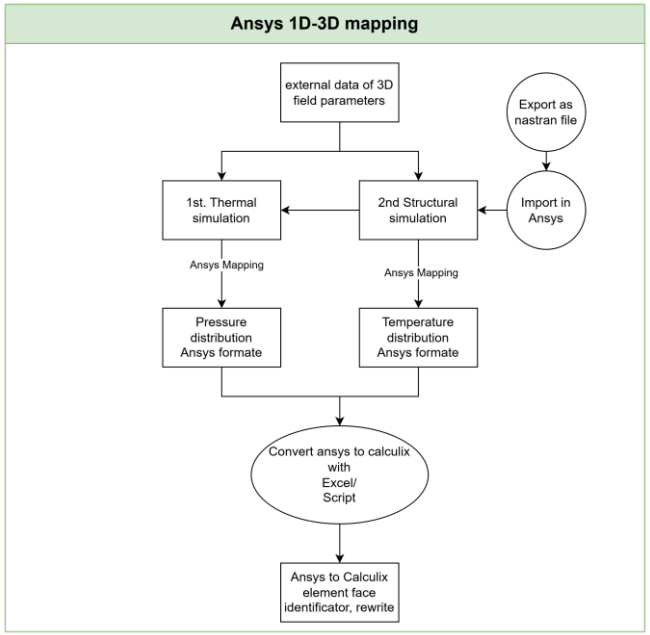


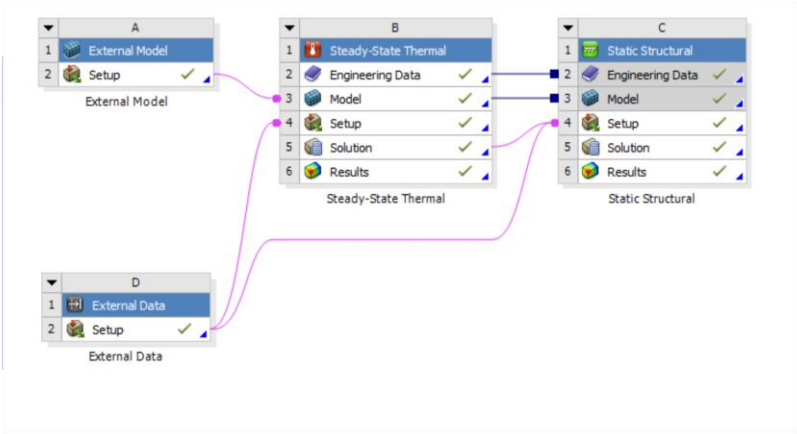
Thermomechanical Simulation Coupling

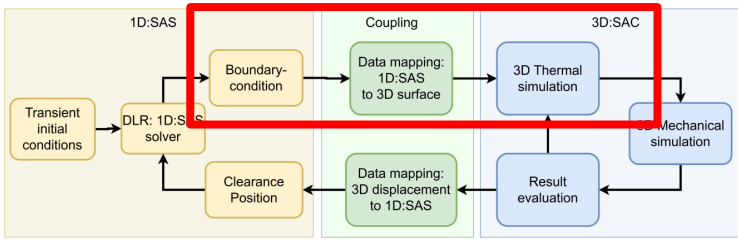
Current approach

- Convert 1D value into 3D field (interpolation, orientation of 1D:SAS and 3D CAD model)
- Mapping with Ansys
- Simulation in Calculix (steady-state simulation, elasto-plastic simulation)
  - submodeling
  - honeycomb structure





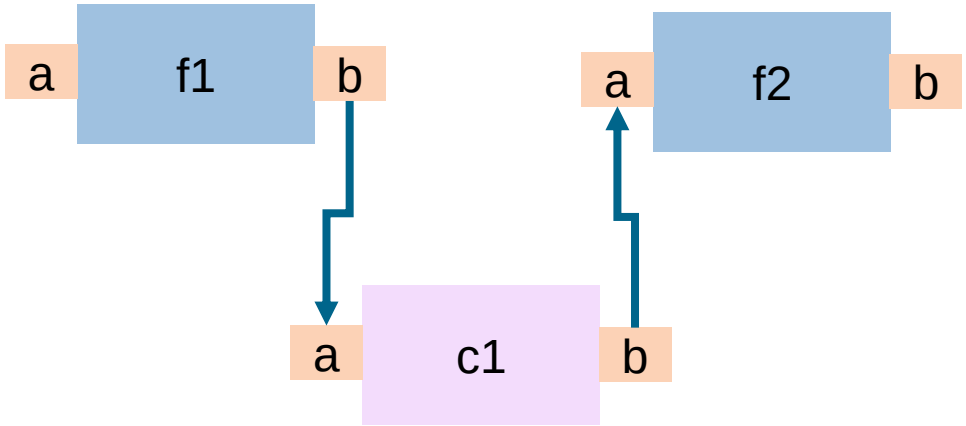


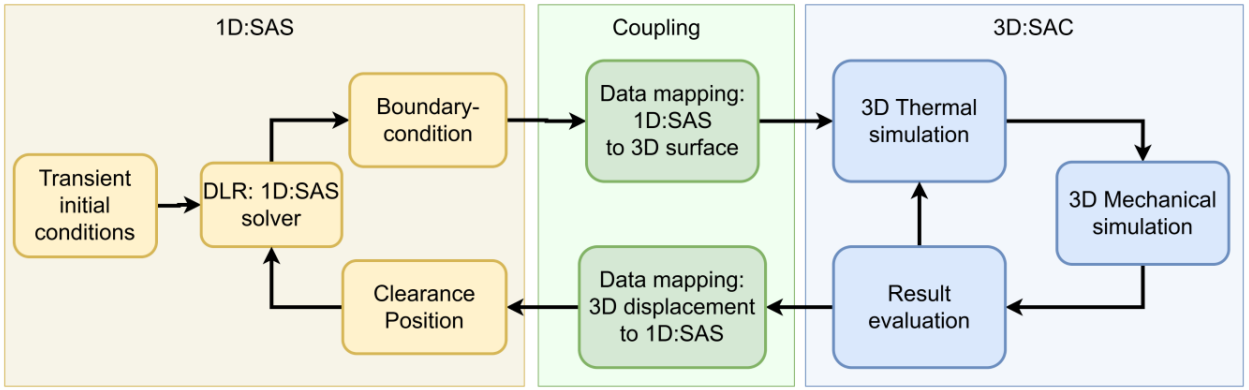


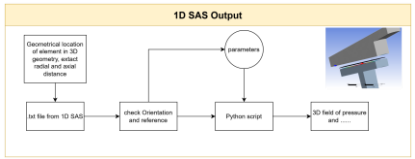
Thermomechanical Simulation

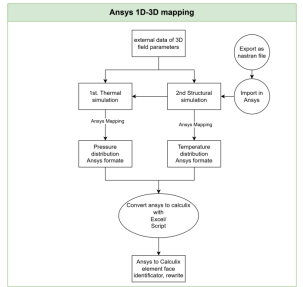
New approach: implementing phase

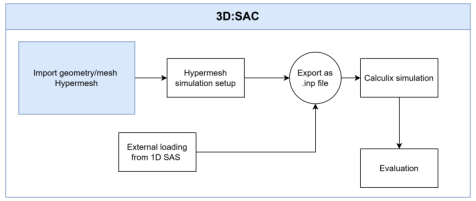
- Simulation topology with hypergate
- Mapping and coupling concept using PreCICE
- Transient simulation and fracture mechanics











Outlook

- Coupled 3D high-fidelity simulations
- Characterization of SAS components
- Enhanced heat transfer and pressure loss correlations for the network model
- Semi-automated simulation
- AI based evaluation of structural simulation



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