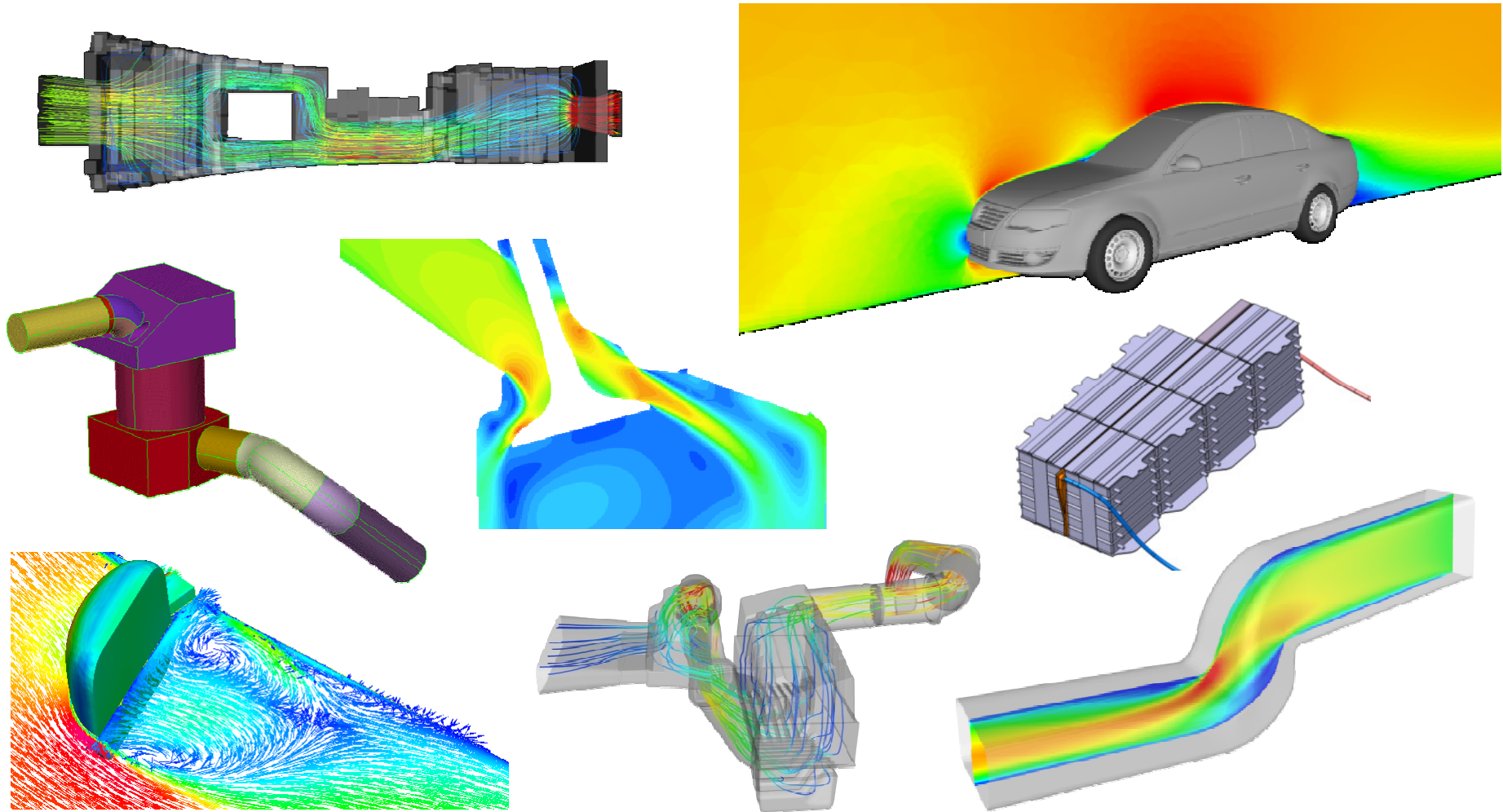




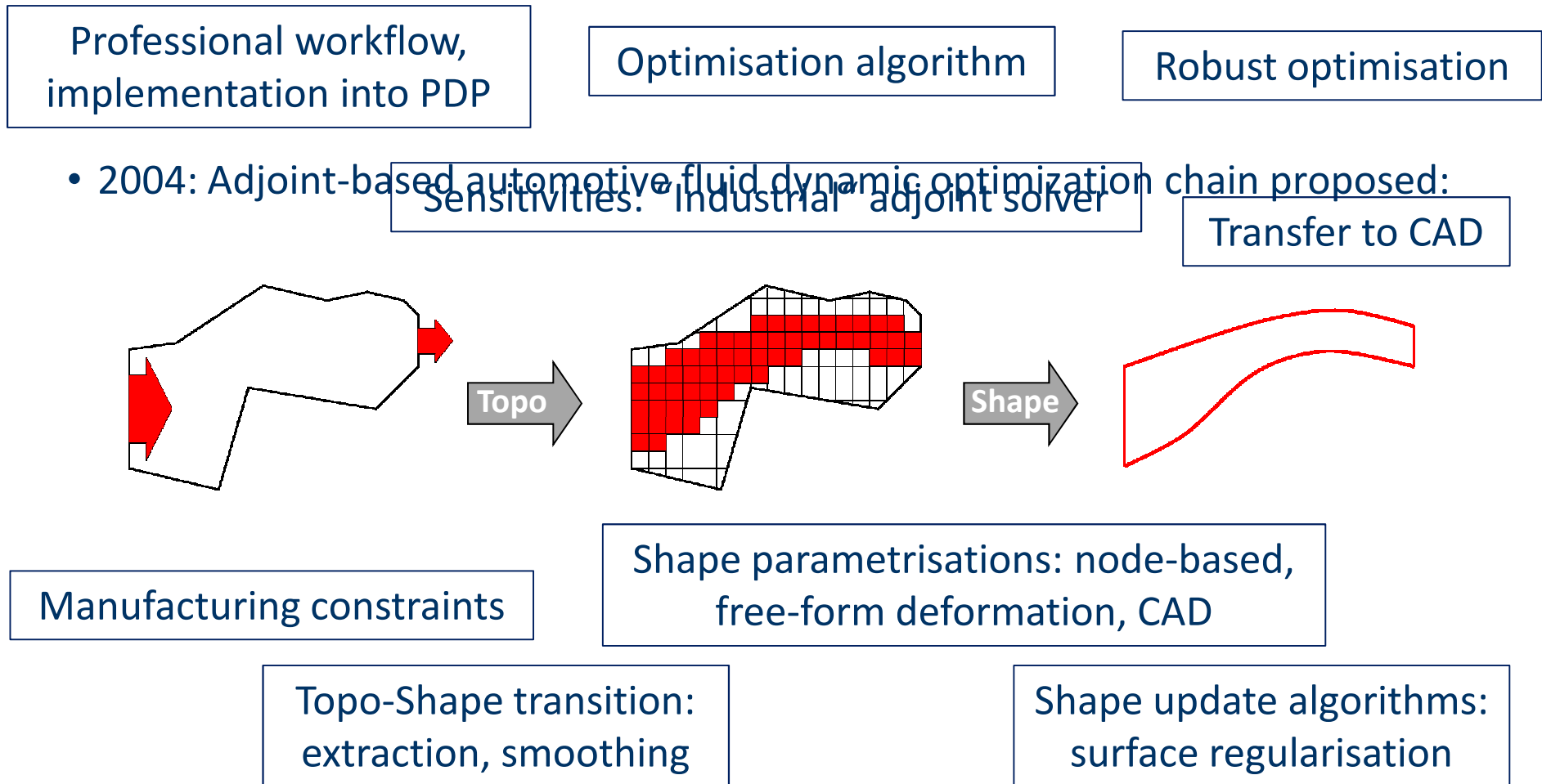
FLOWHEAD: Industrial Requirements and Test Cases

Carsten Othmer (Volkswagen AG) and Pierre Froment (Renault SA)

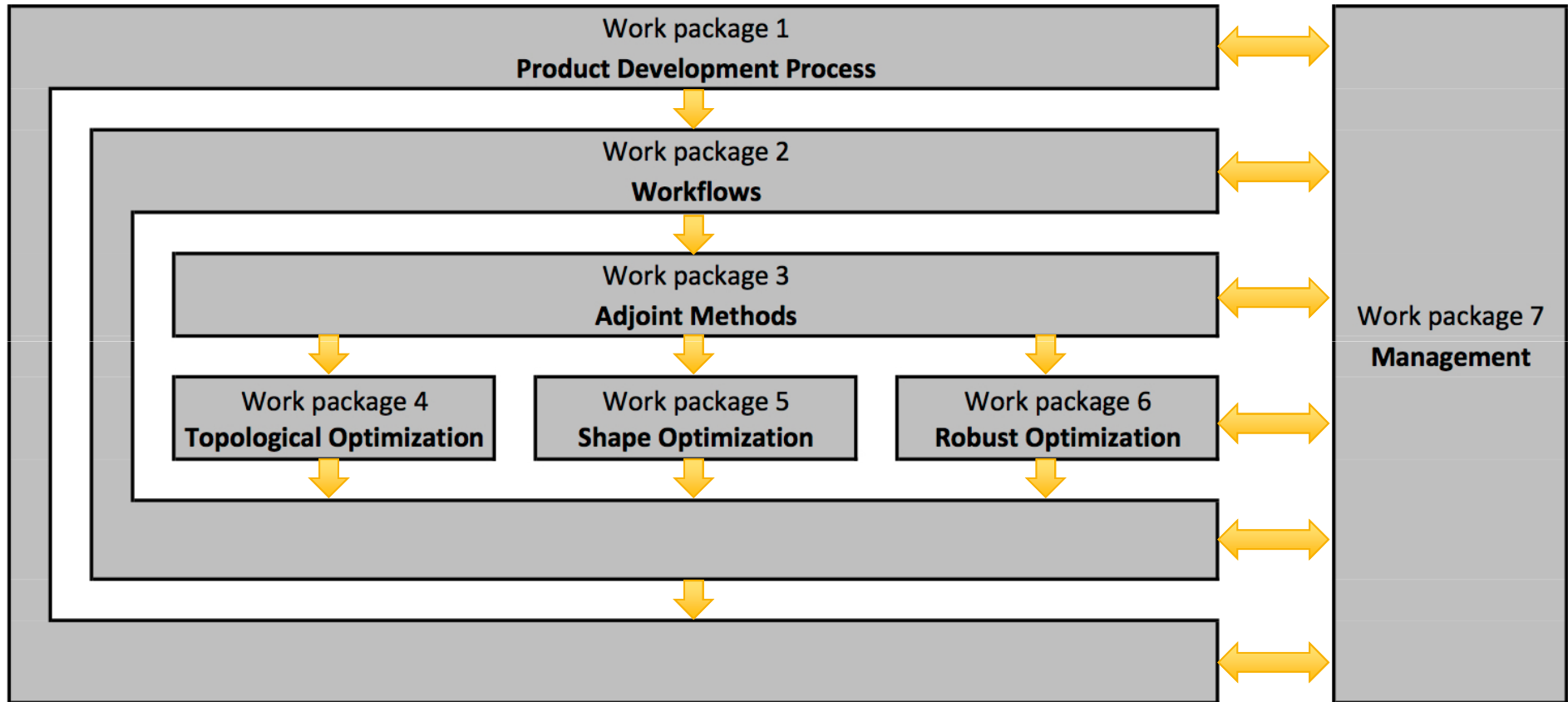
Ubiquity of CFD in Automotive Development



Elements of an Adjoint-based Process Chain



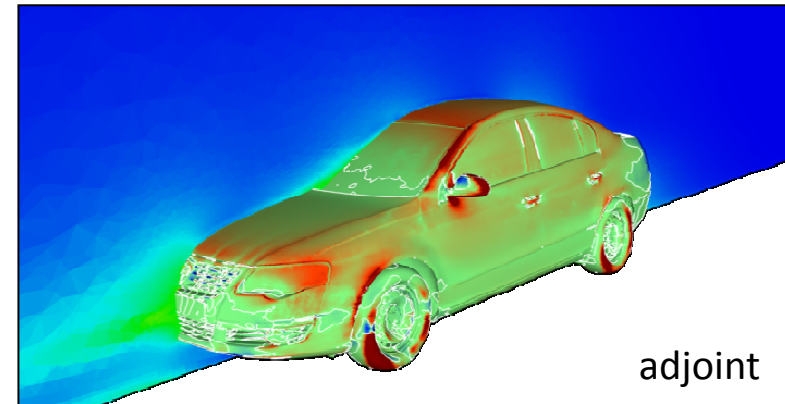
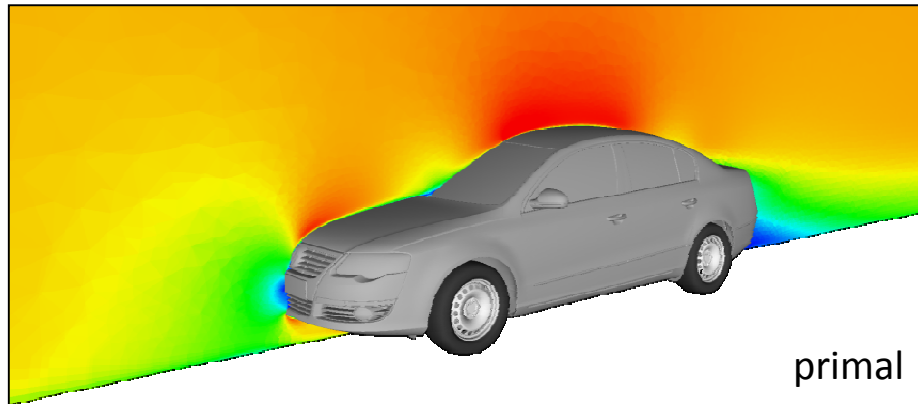
FLOWHEAD Workpackage Structure



External Aerodynamics: Full Vehicle



- Full car model of the previous Volkswagen Passat

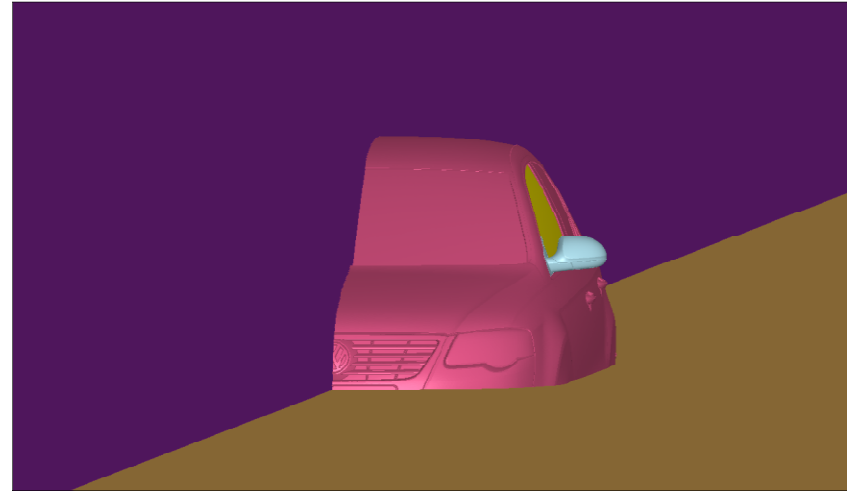
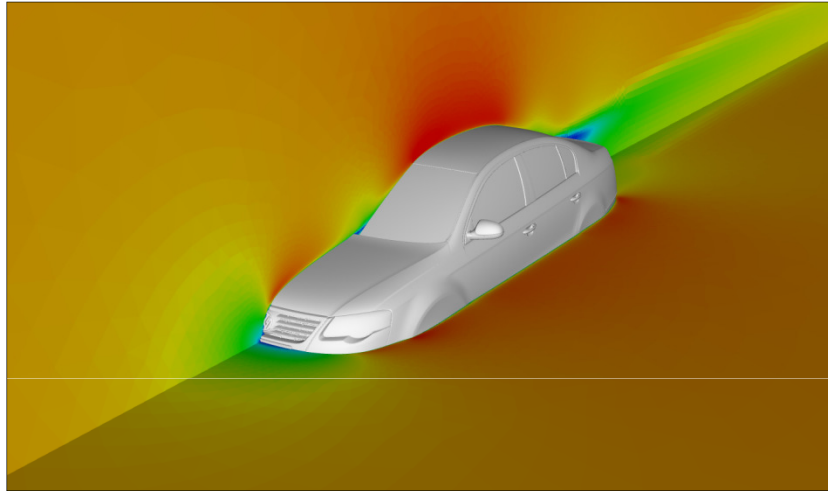


- Objectives:
 - drag reduction
 - rear lift reduction
- 17 Mio. volume cells, surface resolution 5-15mm, Reynolds number $\sim 10^6$

External Aerodynamics: Side Mirror Aeroacoustics



- One quarter of the previous Volkswagen Passat

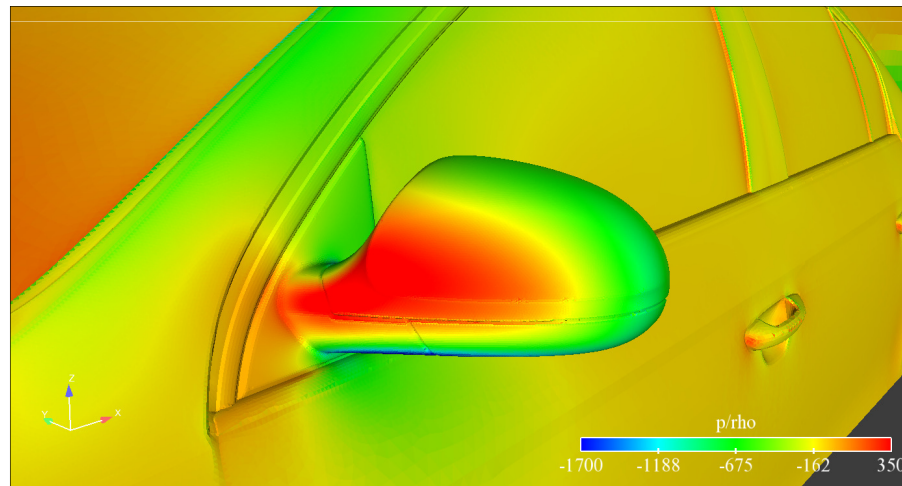


- Objective:
 - Reduction of RANS-based aeroacoustic cost function (nu_t , wall shear stress on the side window)
- adjoint turbulence model required

External Aerodynamics: Side Mirror Aeroacoustics



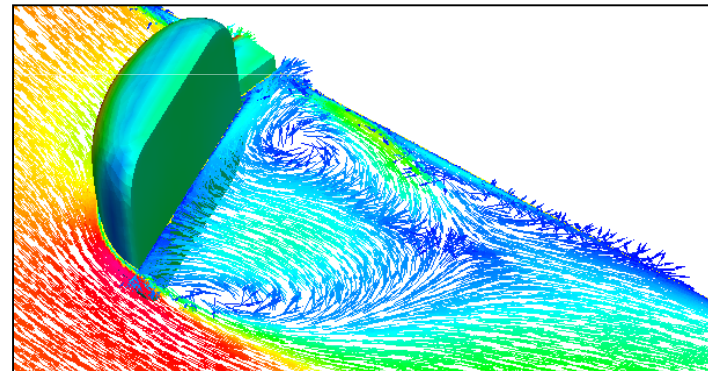
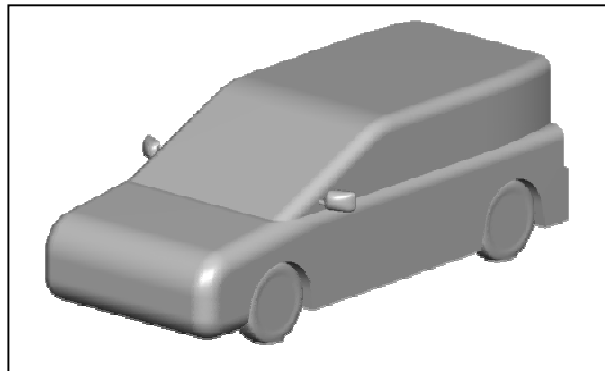
- Model characteristics:
 - Prism layers all over the car (first height $\sim 0.01\text{mm}$, $y^+ \sim 1$)
 - 23 Mio. volume cells, surface resolution: 2-15mm
 - Reynolds number $\sim 10^6$



External Aerodynamics: Parametric Mirror



- Side mirror mounted on a simplified car model, fully CAD-parametric
- Objectives:
 - Reduction of local (mirror) drag and overall drag
 - Reduction of mirror noise

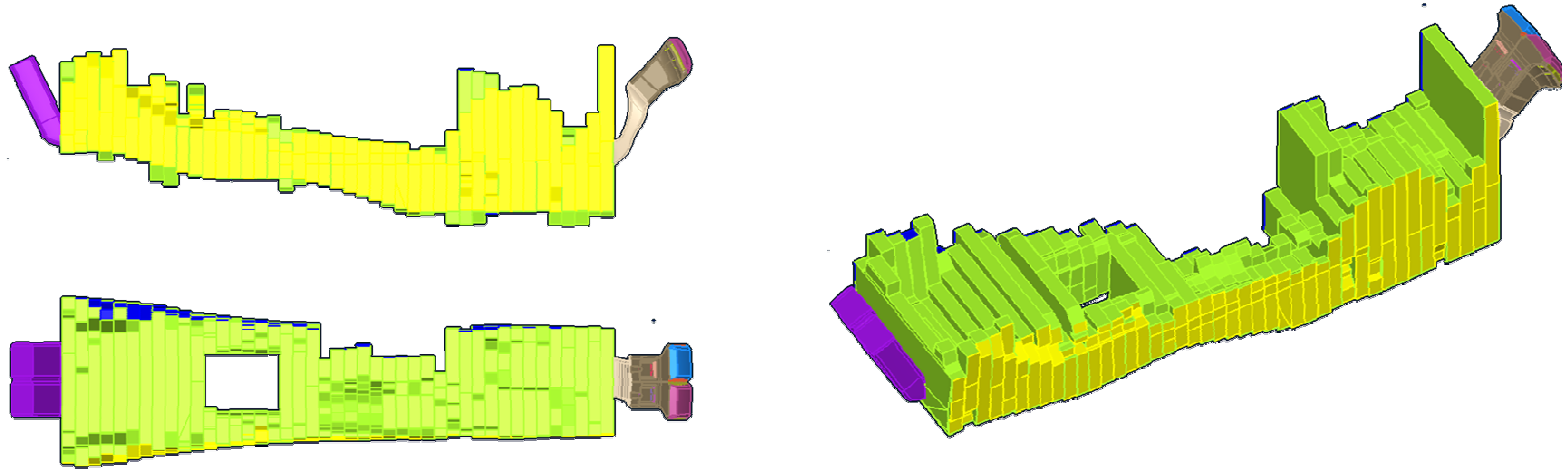


- Geometric variations restricted to the mirror itself
- 15 Mio. volume cells, Reynolds number $\sim 10^6$

Air duct: Design Domain



- Packaging space for a centre console duct of the current VW Golf Plus

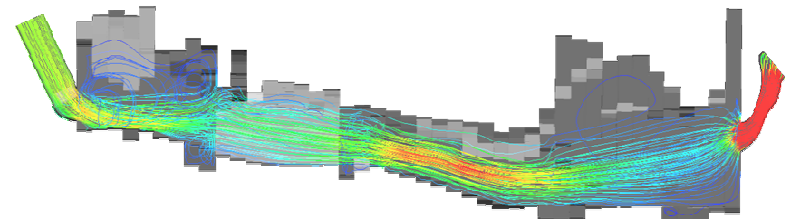
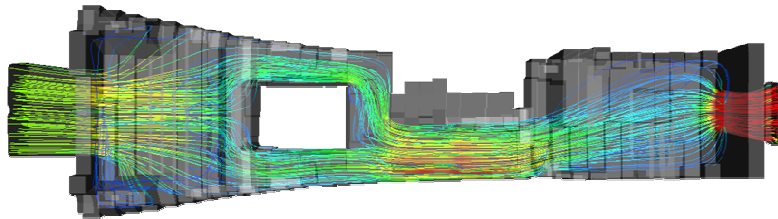


- Objectives and constraints:
 - Reduction of pressure drop
 - Volume constraint

Air duct: Design Domain



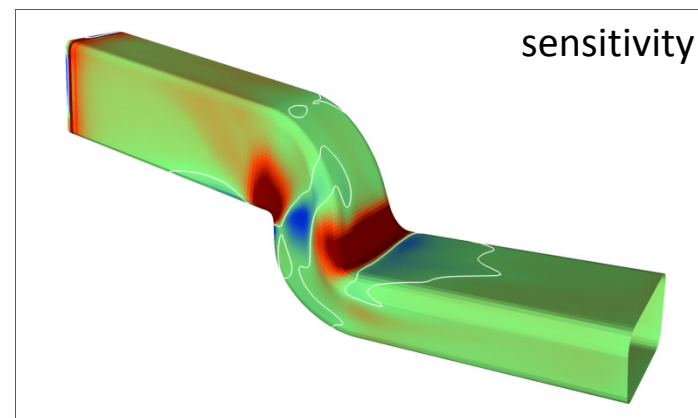
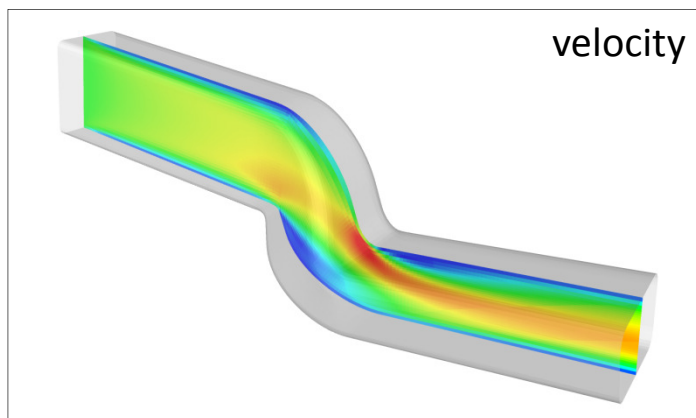
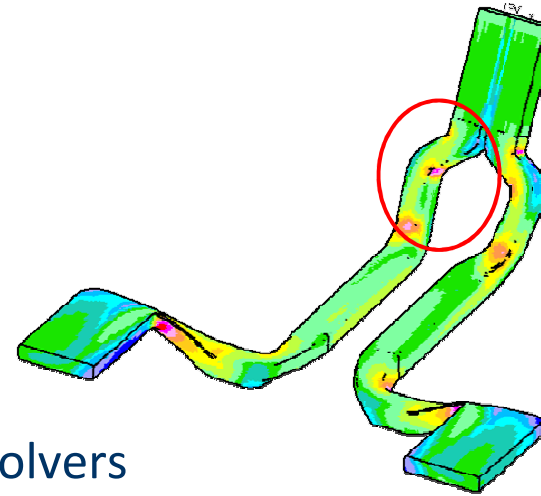
- Model characteristics:
 - 5 Mio. volume cells
 - Reynolds number $\sim 10^4$
- One or two pipes possible: **Topology** optimisation



Air duct: S-Bend Testcase



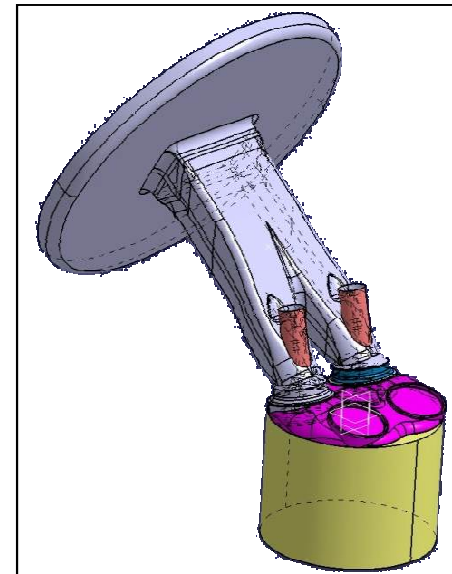
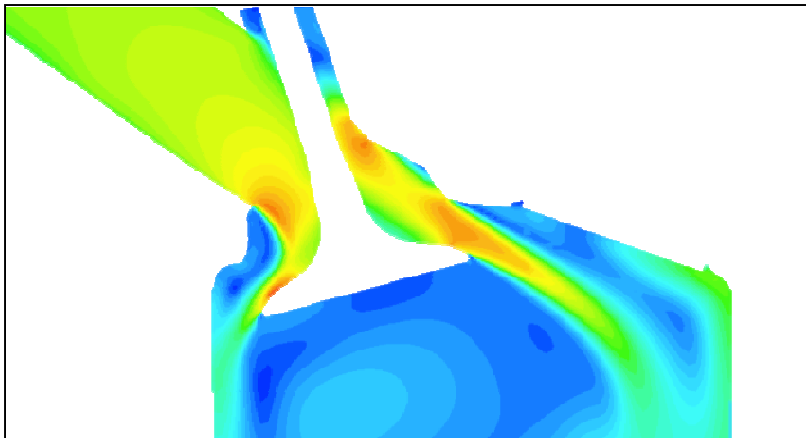
- Segment of an air duct
- Objective function: pressure drop
- Topo and shape optimisation test case
- both laminar and turbulent ($Re \sim 10^4$) set-up
- Benchmark case for the different FlowHead solvers



Engine CFD: Intake Port



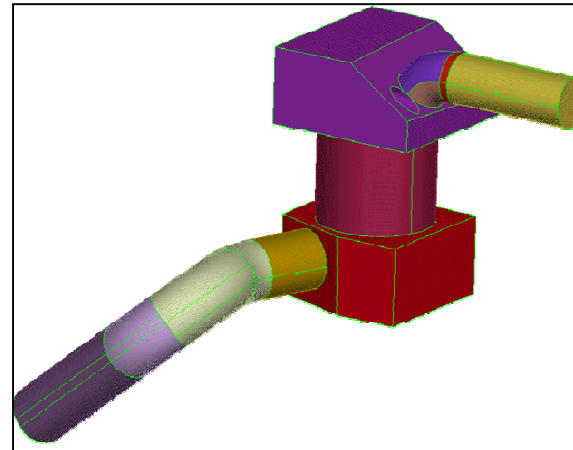
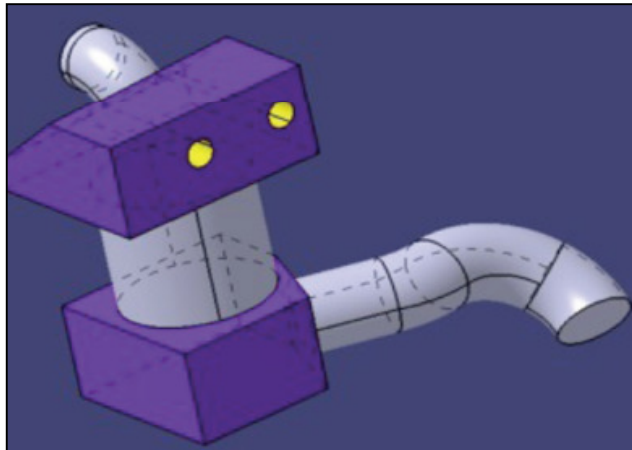
- Intake port optimisation
- Objective function: Tumble motion (angular momentum of the flow) inside the combustion chamber
- Geometric variations restricted to duct itself



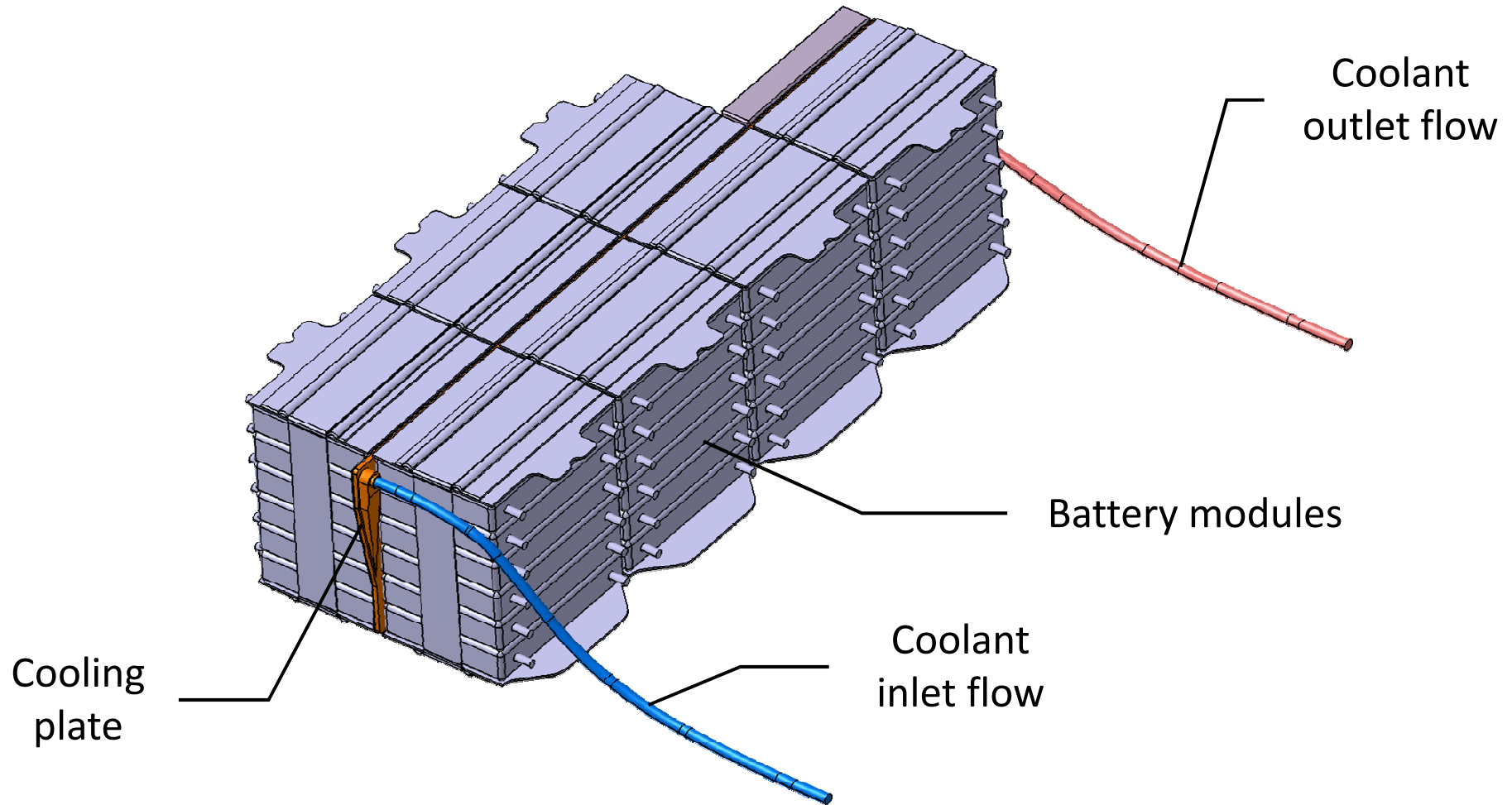
Engine CFD: CAD to CAE Interface Test Case



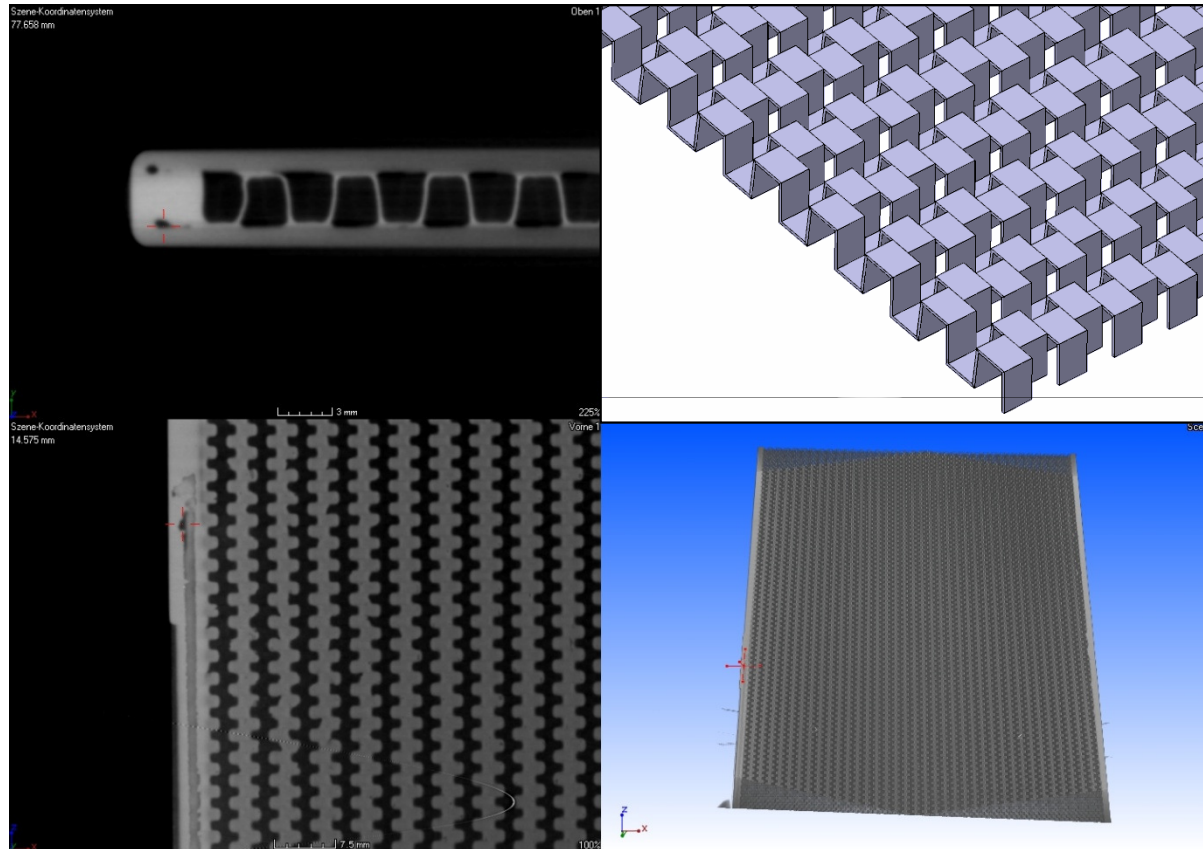
- Catalytic converter
- CAD geometry: design domain + fully designed parts
- Generated to develop CAD/CAE interface with TU Sofia



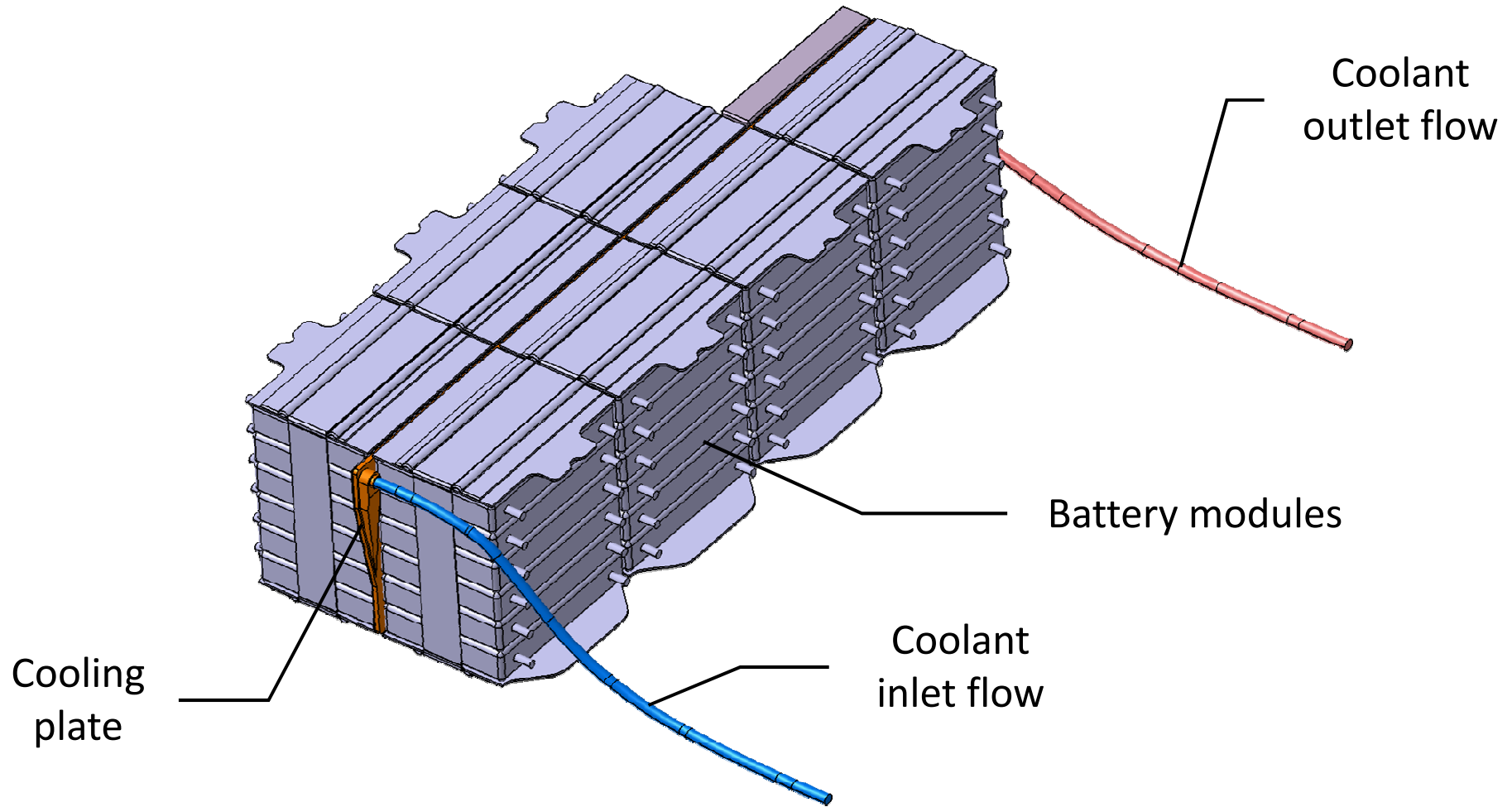
Heat Transfer Test Case: Battery Cooling



Heat Transfer Test Case: Actual Design

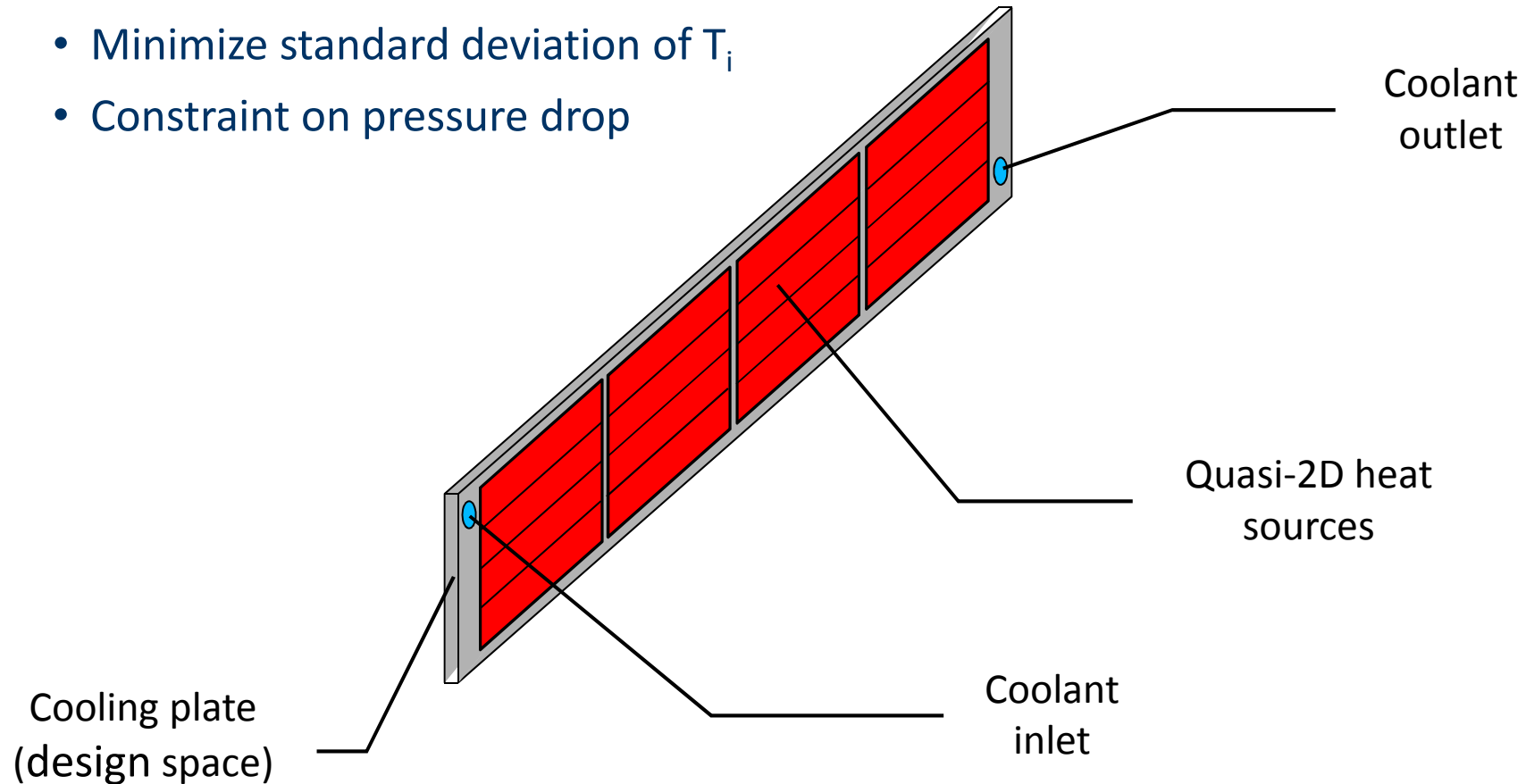


Heat Transfer Test Case: Battery Cooling

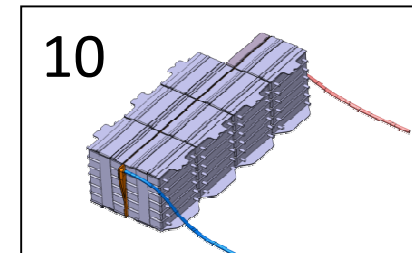
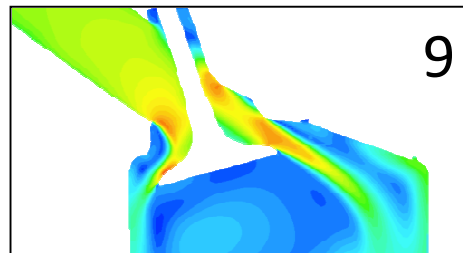
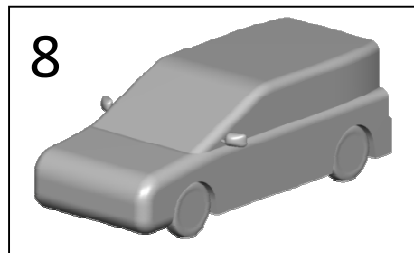
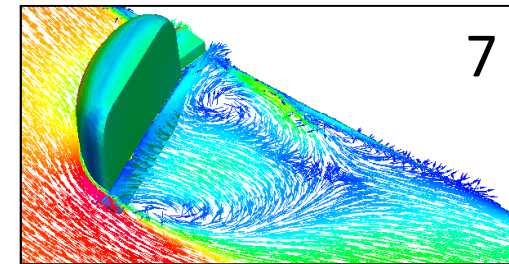
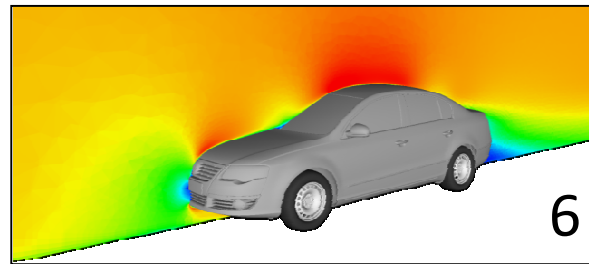
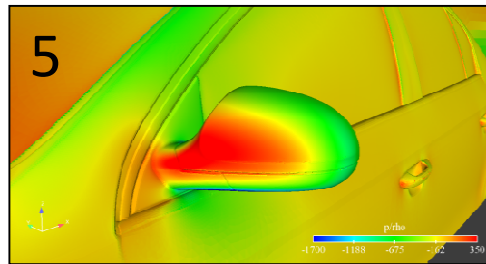
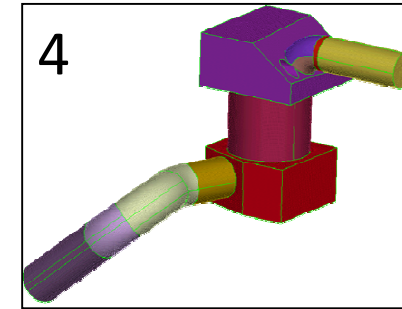
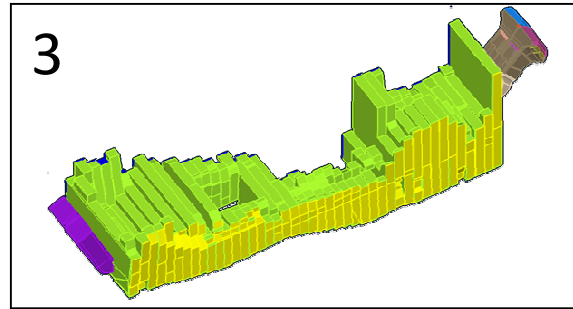
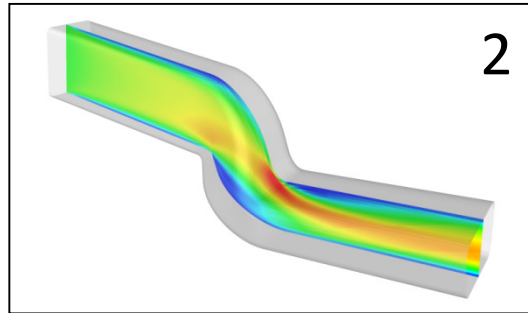


Heat Transfer Test Case: Simplification to 2D

- Minimize average cell temperature T_i
- Minimize standard deviation of T_i
- Constraint on pressure drop



Test cases: Overview



- Steady-state incompressible RANS
-

Elements of an Adjoint-based Process Chain

