USAGE OF SIMCENTER STAR-CCM+ FOR SIMULATION DRIVEN PRODUCT DEVELOPMENT AT VOLVO CARS

## TORBJÖRN VIRDUNG, TECHNICAL EXPERT, COMPLETE VEHICLE CFD

VOLVO CAR CORPORATION

- Number of employees: ~38000 (21000 in Sweden)
- Sweden's second largest company (212 billion SEK sales)

Objectives 2020

- Sell over 800 000 vehicles globally
- Have a top tier luxury auto brand perception
- Deliver a top car industry ROIC
- Be the employer of choice
- No one should be killed or seriously injured in a new Volvo car

HISTORY OF CFD AT VOLVO CAR CORPORATION

1990   **2D computations**

1991   **1st 3D external flow computation**

100 000 cells, 3 to 4 months Baseline lead time

1993   **CFD used in the early stages of car development**

6 weeks Baseline lead time

2000   **Focus on model complexity**

8 weeks Baseline lead time

2010   **Detailed floor**

60 million cells, 4 weeks Baseline lead time 2 days / configuration

2015   **Fully detailed car**

120-250M cells, 2 weeks Baseline lead time

2018-   **Focus on accuracy, detail, physical models and automation**

150-250M cells for Aerodynamics, 3 days lead time for baseline (goal <24h)

Advanced physical modeling of materials, physics, contamination, moving parts etc
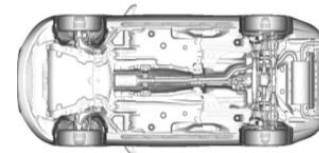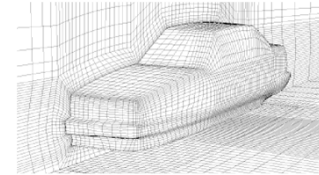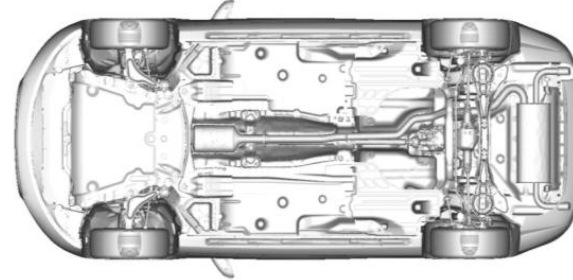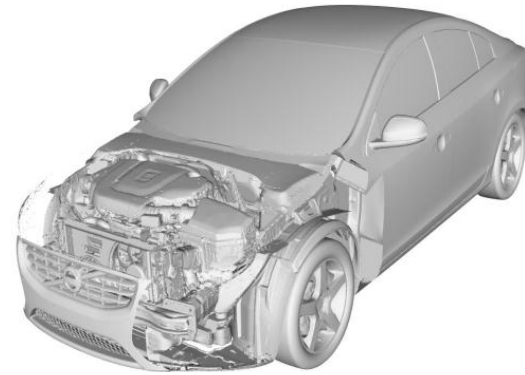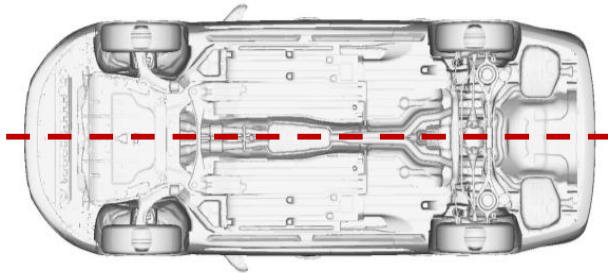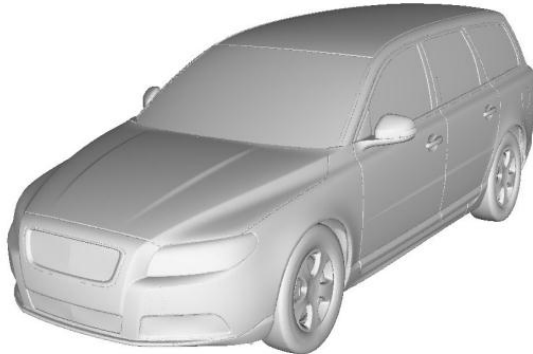
ATTRIBUTES OVERVIEW

- Aerodynamics
- Thermodynamics
- Contamination
- Climate Comfort
- Aeroacoustics
- Powertrain
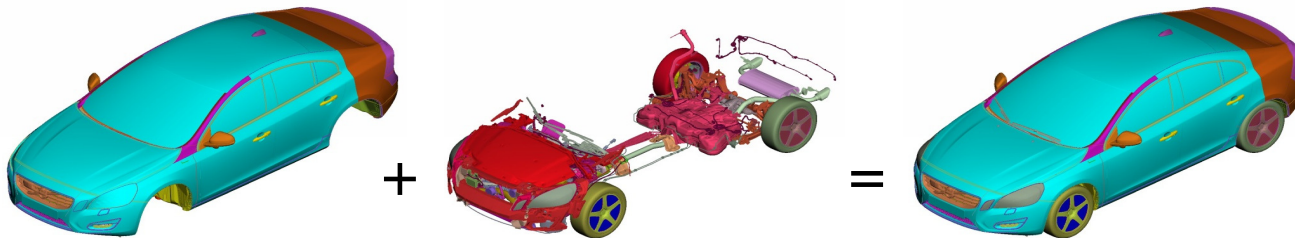- Air Intake System
- Headlights
- Misc
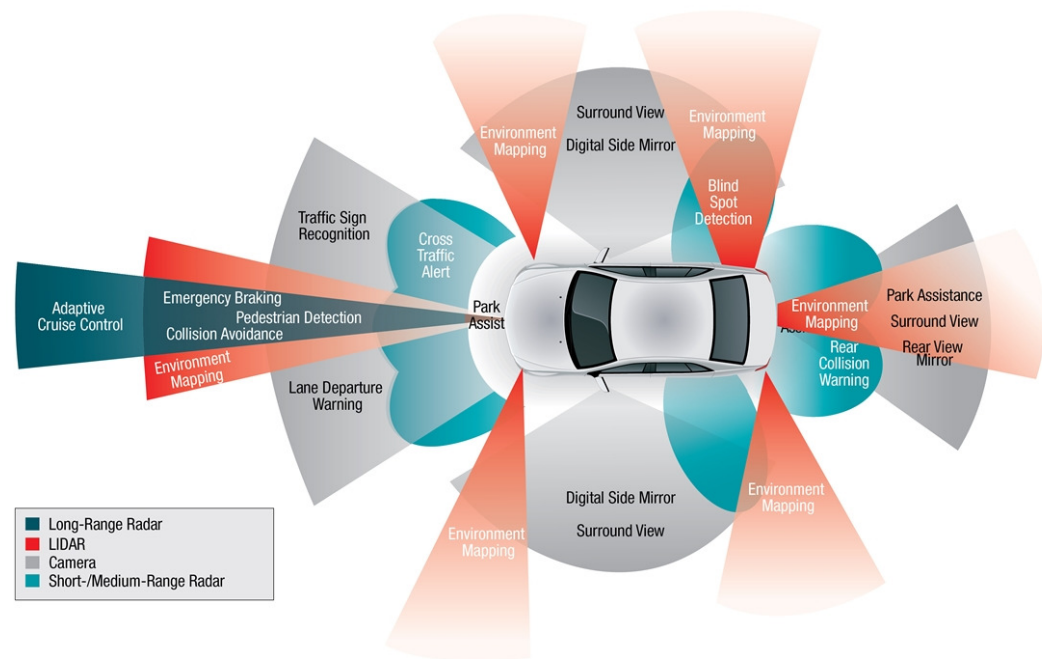
AERODYNAMICS CFD METHODS

- Closed front / semi-detailed
  - Symmetry condition (half car)
  - No engine bay

- Open front / fully detailed
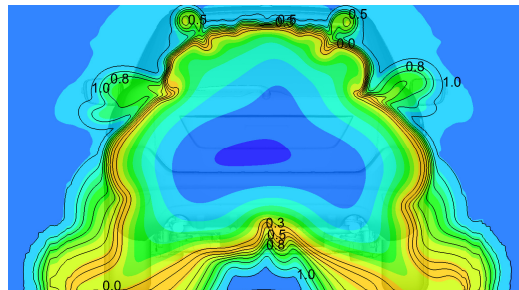 - Asymmetric underbody
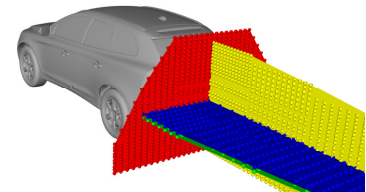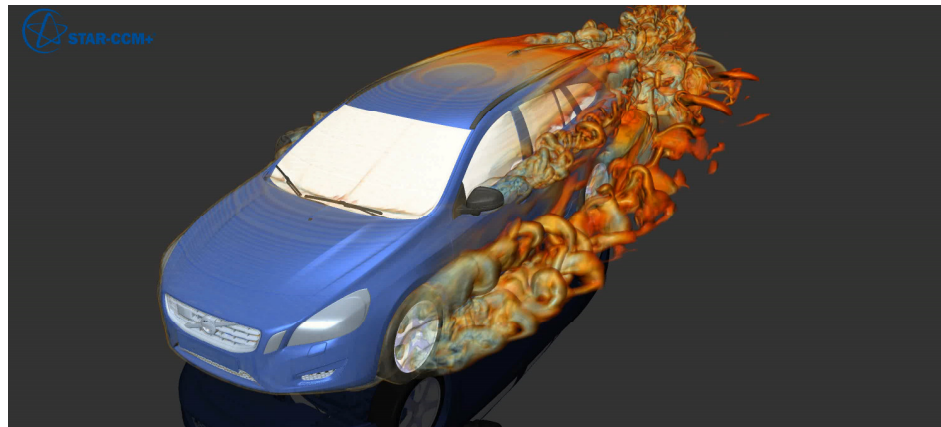 - Detailed engine bay

CFD WORKFLOW

- Teamcenter (Automated)
  - Extracting CAD model

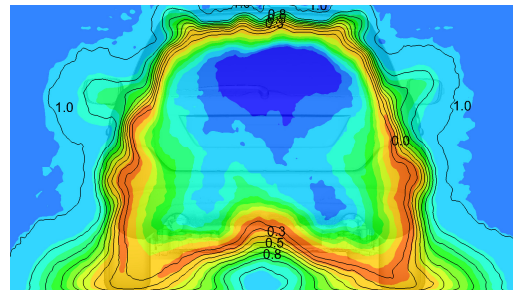- ANSA (Semi-Automated)

- Star-CCM+ or other solver (Automated)
  - VSIM or Template based setup
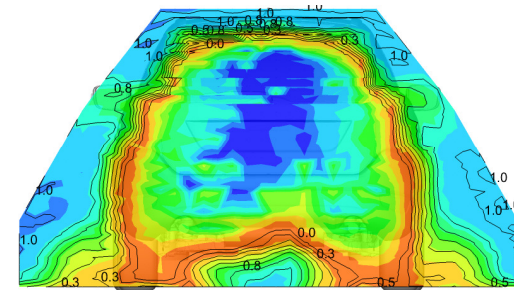 - Meshing, Solving and Post Processing

AERODYNAMICS RESULTS
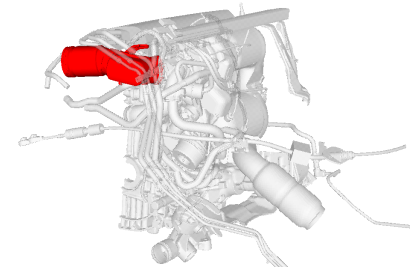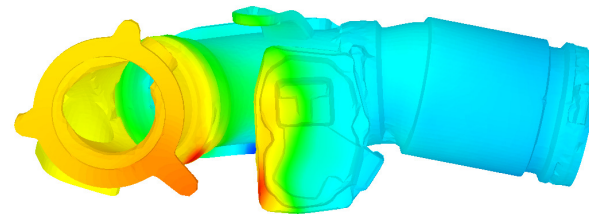

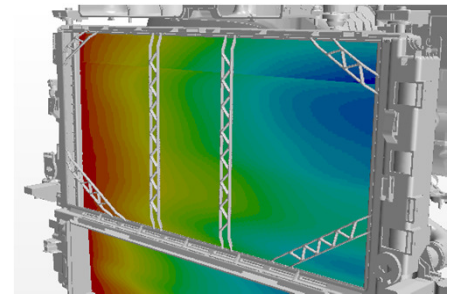Steady-state CFD | Transient CFD | PVT

THERMODYNAMICS METHODS
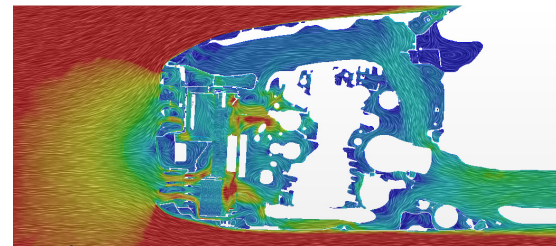
- Component Analysis
  - Determine if heat shield is needed
  - Determine if the material specifications needs to be changed
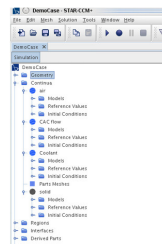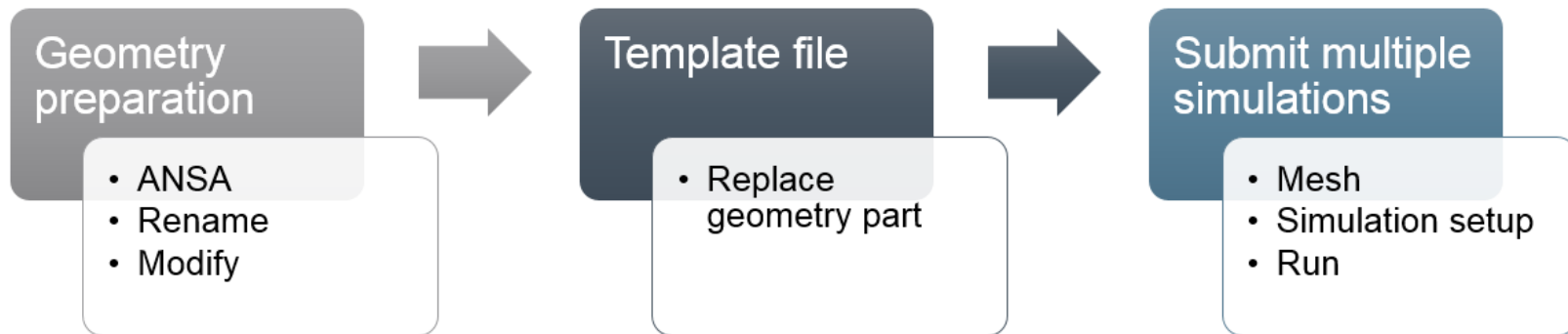

- Cooling performance
  - Determine if the cooling package installation fulfills the required cooling performance
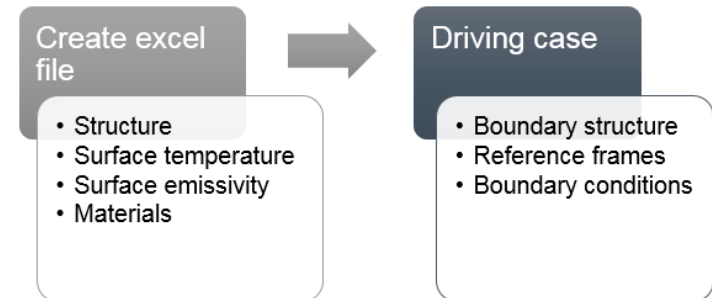 - Dimensioning front openings and towing weight

THERMODYNAMICS WORKFLOW IN CCM+

Geometry preparation
- ANSA
- Rename
- Modify

→

Template file
- Replace geometry part

→

Submit multiple simulations
- Mesh
- Simulation setup
- Run

- Generic geometry parts
- Region structure
- Physics
- Solver settings
- Reports, monitors and plots
- Wrapper settings
- Mesh settings

**The goal is to have everything except the case specific information, e.g. velocity, in the template file**

Create excel file
- Structure
- Surface temperature
- Surface emissivity
- Materials

→

Driving case
- Boundary structure
- Reference frames
- Boundary conditions

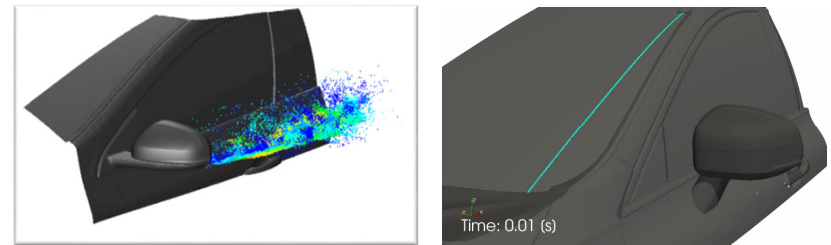# CONTAMINATION METHODS (1)

- Wading, Splash (+ FSI)
  - Protective panels and other critical components should sustain the impact force from splashing water
  - Water should not enter the air intake which can cause an engine brake down.
  - Water should not enter components under the car such as transmission, AWD-system and electrical components.


Time: 0.1 (s)

Time: 0.1 (s)
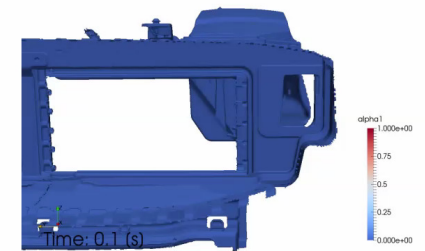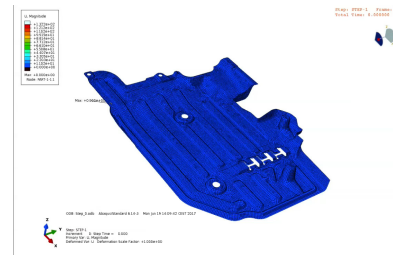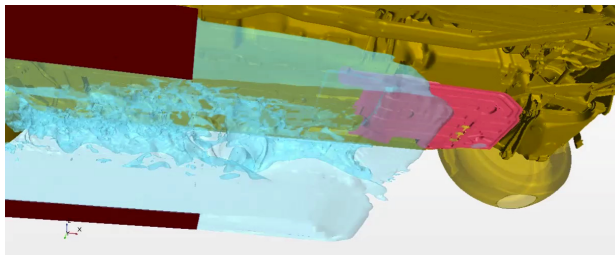
CONTAMINATION METHODS (2)

- Water/Dirt Management on A-pillar/Side Mirror
  - Minimum degradation of visibility through side window and mirror during driving

- Particle (Snow/Dust/Stone)
  - Minimizing accumulation of dirt/gravel in the rear rims
  - Control of contamination on car body side
  - Avoid dust entering cabin or other sensitive areas
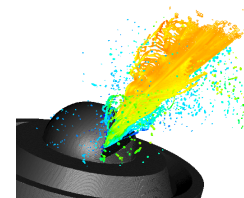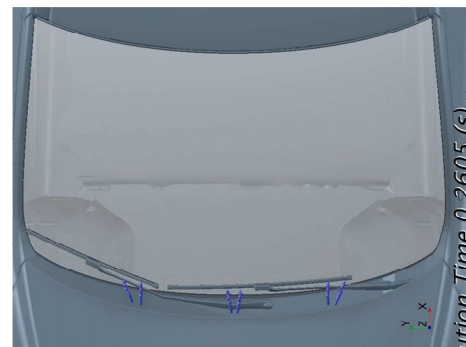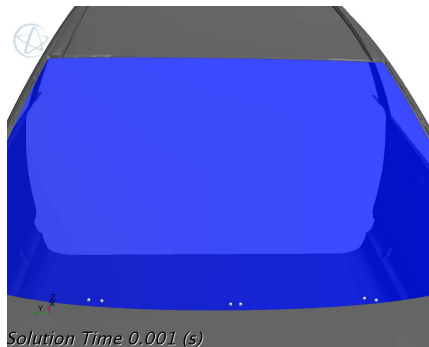 - Snow accumulation in cavities
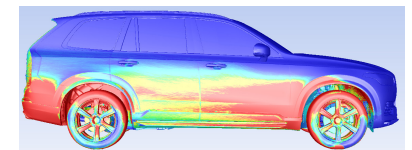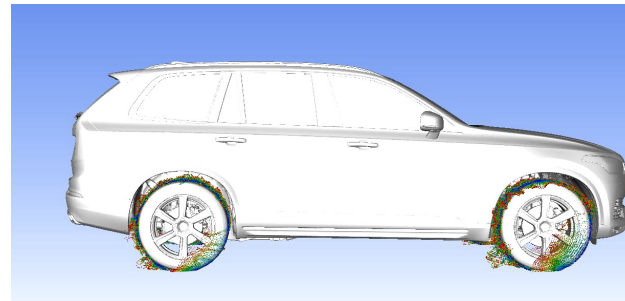
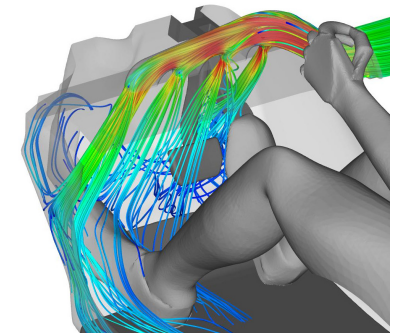*Some methods being transferred to CCM+*

# CONTAMINATION METHODS (3)

- Cleaning
  - Front and rear wind screen wiper cleaning performance
  - AD sensor cleaning
  - FSI (wiper motion)
  - Dirt dissolution
  - Aerodynamic effects on wiper and washer spray

Solution Time 0.001 (s)

Solution Time 0.2605 (s)

CLIMATE COMFORT METHODS

- Pressure drop calculations
- HVAC air flow distribution
- Directability of air
- Windscreen heat-up
- Rear screen deicing
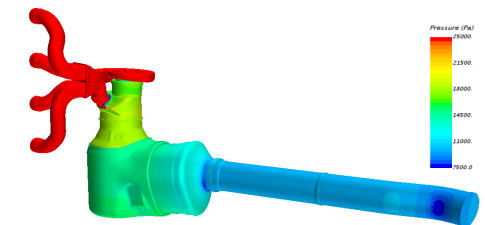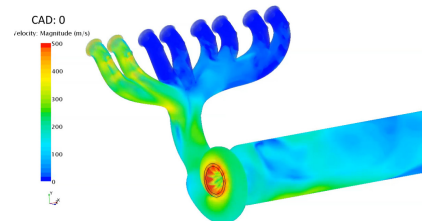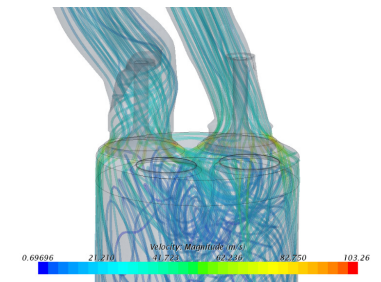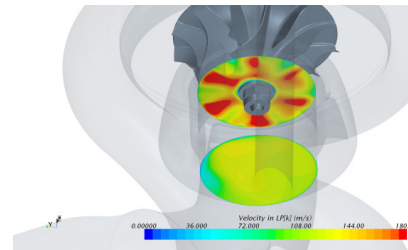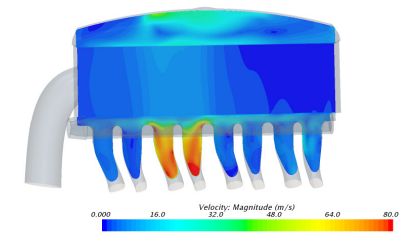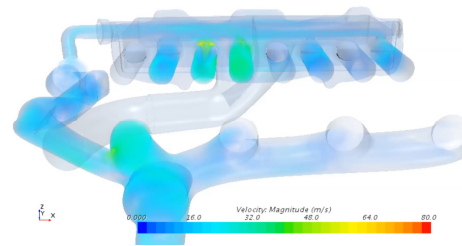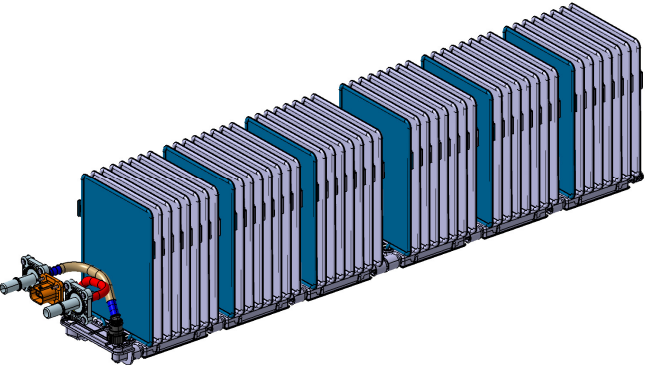- Exhaust gas intrusion
- Heat Pickup
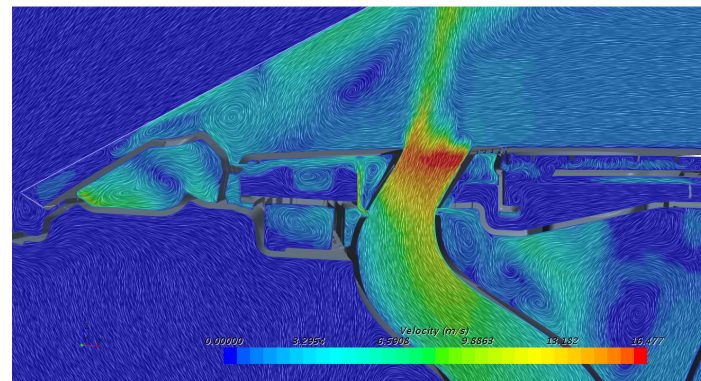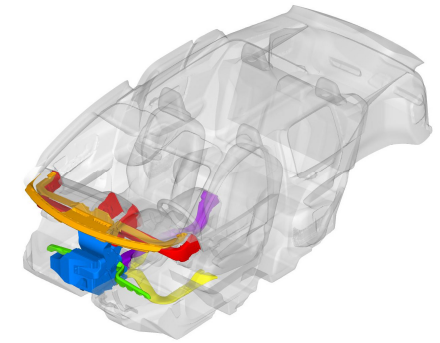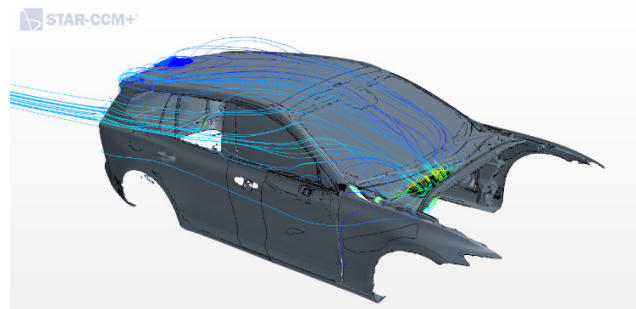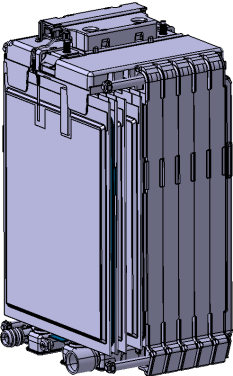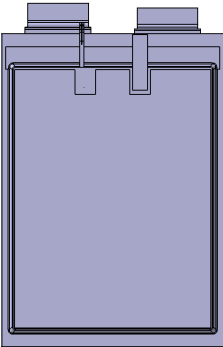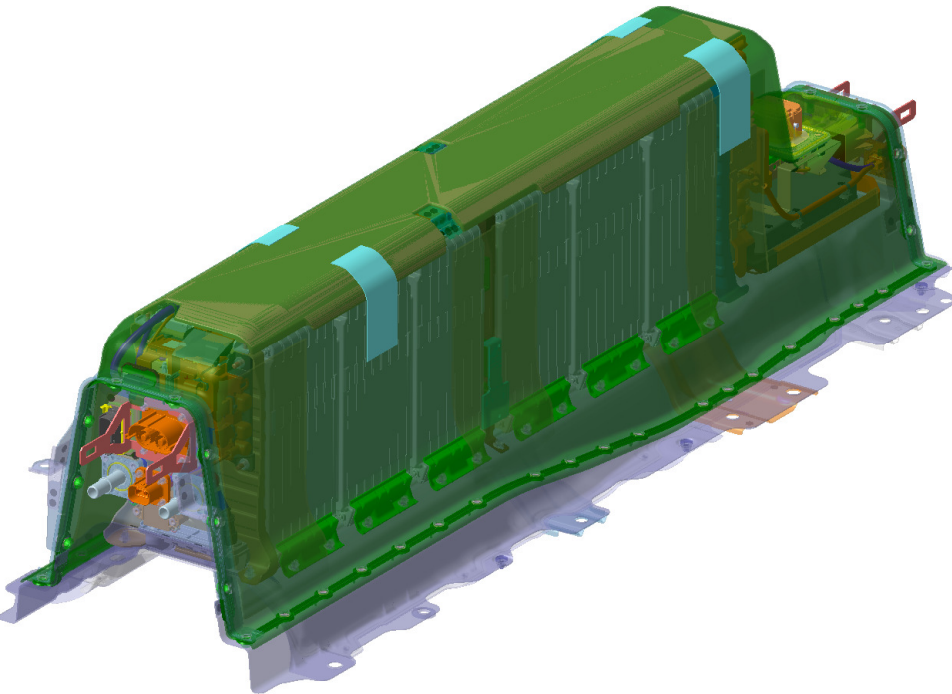

Some methods being transferred to CCM+
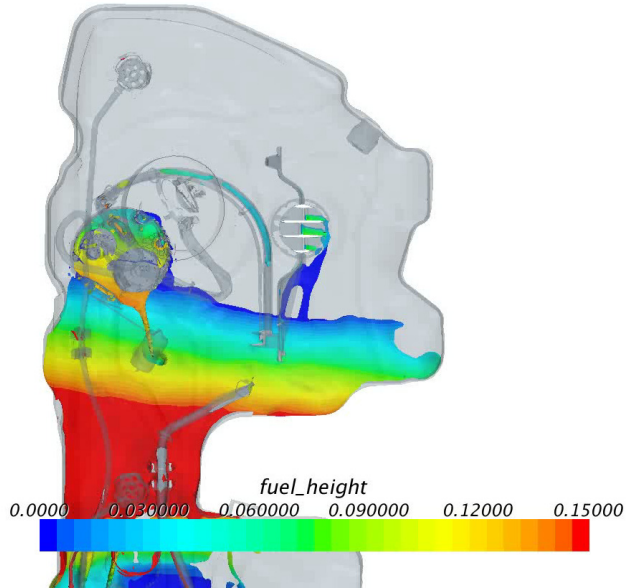
POWERTRAIN METHODS

- EGR distribution
- Intake optimization
- Compressor optimization
- Intake Port Design
- Exhaust Manifold
- Exhaust After treatment
- Noise
- Cooling

ELECTRICAL POWERTRAIN

FUEL SYSTEM

Solution Time 0.1 (s)

Solution Time 0.1 (s)
Bypass V10

fuel_height
0.0000   0.030000   0.060000   0.090000   0.12000   0.15000

FUTURE OF CFD AT VOLVO CAR GROUP

- Corporate decision to increase CAE analyses in projects.
    - An <u>integral part of development work</u>, not just complement to testing.
    - <u>Replace physical verification prototypes</u> with CAE loops in <u>long-term</u>.

- Increased need of CFD related analyses from structural groups.

- Research for improved fluid flow prediction
    - Car model geometry representation
    - Numerical domain
    - Mesh strategy
    - Turbulence modelling
    - ....

- Fully automated CFD process

- Coupled optimization tools for enhanced analyses

Thank you