Discovering the aerodynamic potential of Eurobulk‘s trucks

aeco.green GmbH

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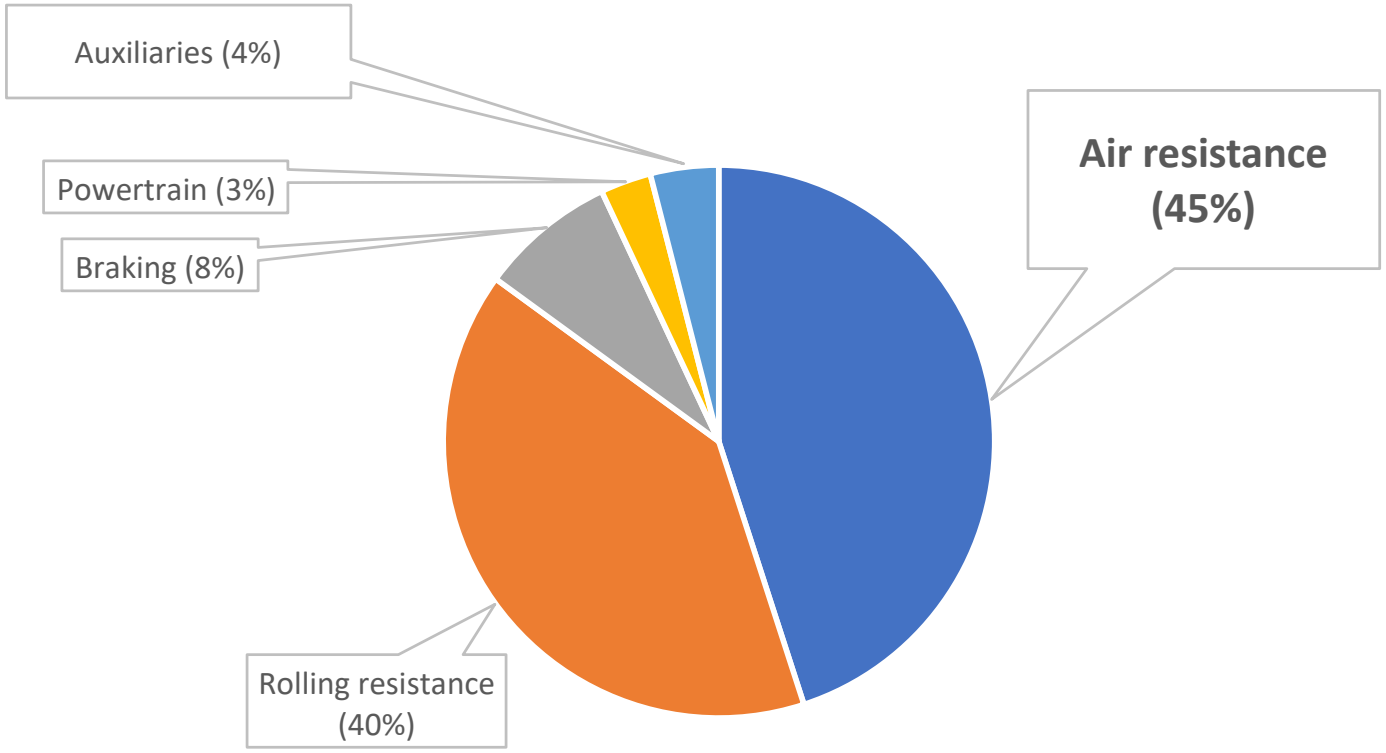
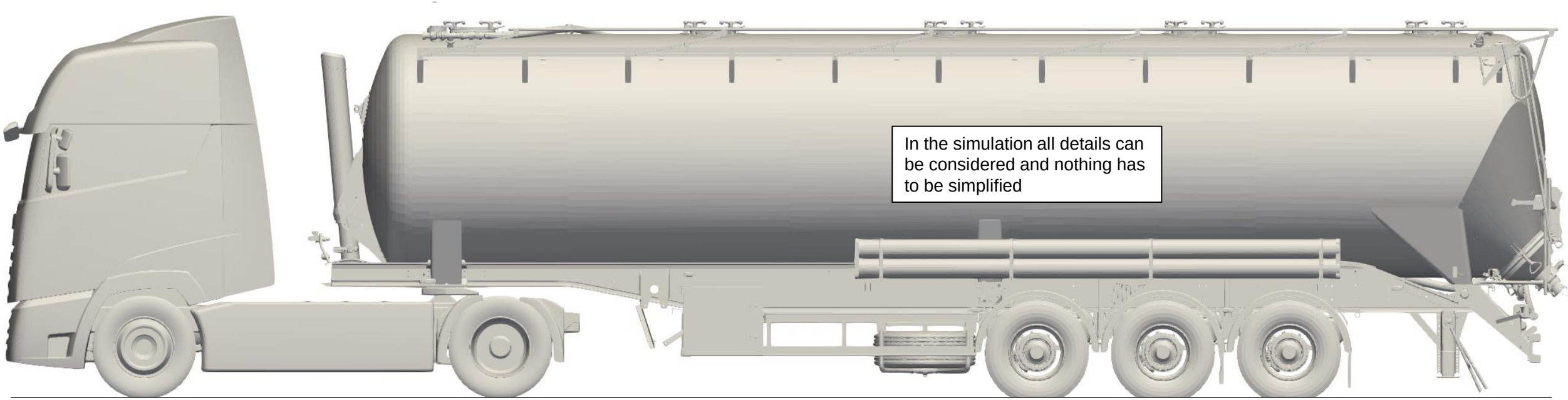
Outline

- Importance of Aerodynamics
- Information on vehicle modeling and flow simulation (CFD)
- Aerodynamic concepts & analyses
  - Reference Truck
  - Optimization 1
  - Optimization 2
  - Optimization 3
- PACE analysis with Optimization 3
- Further Potential for aerodynamic improvements

Aerodynamics is important



Information on vehicle modeling



In the simulation all details can be considered and nothing has to be simplified

EU Standard Tractor according to VECTO procedure

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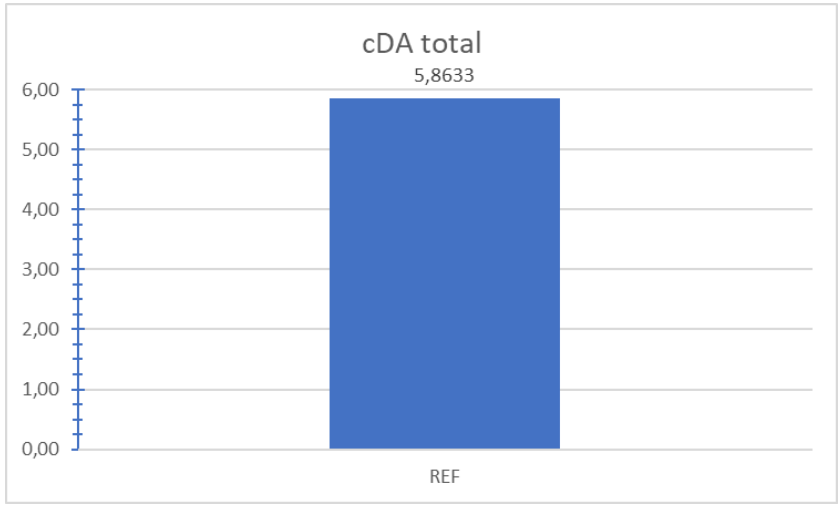
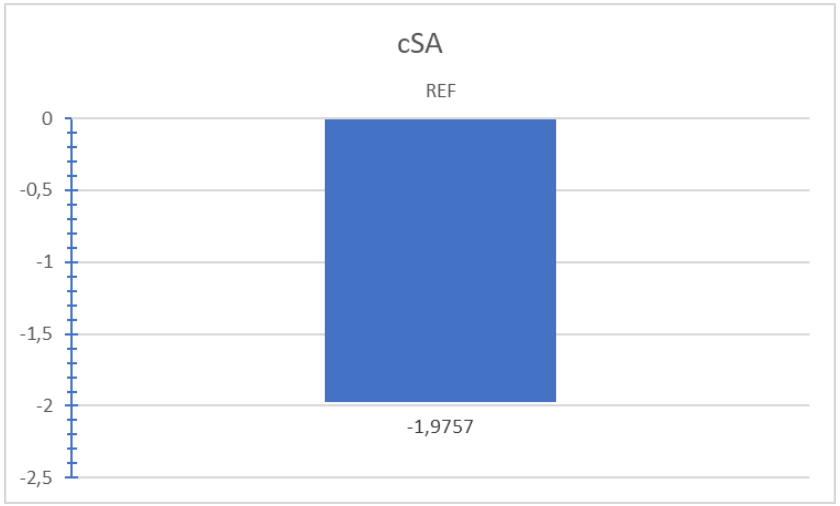
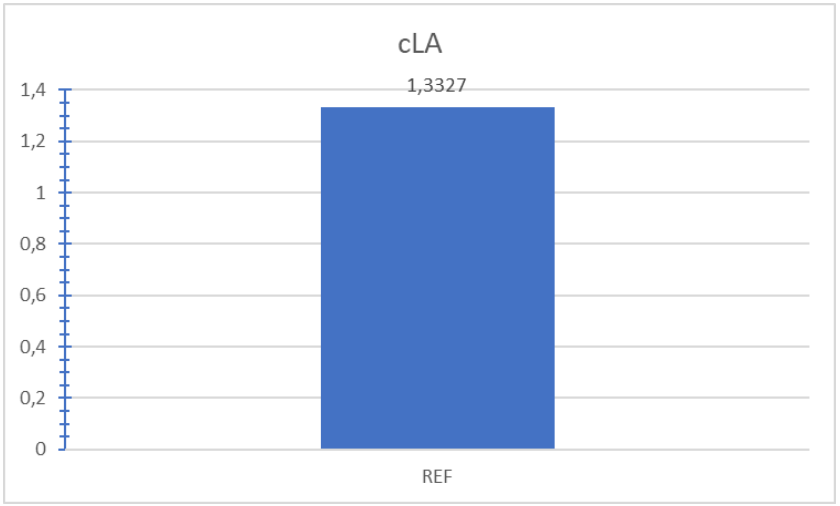
Information on flow simulation (CFD)

- 89 million cells. Local resolution is tuned according to flow gradients: High resolution where there is high flow activity. Maximum resolution near the wall is 11 mm.
- Moving road and rotating wheels
- Average wind from the right hand side results in 3° angle of inflow
- Losses in the radiator of the engine are also simulated
- All velocity data in m/s: 1 m/s = 3.6 km/h
- All pressure data in Pascal: 1 Pa = 1 N/m2

Overview aerodynamic results:
Aerodynamic forces for reference truck







Aerodynamic drag force
(for efficiency)

Side force
(for crosswind sensitivity)

Lift force
(indicator for the aerodynamic quality)

Compare typical standard box trailer configuration:
cDA = 5,56

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Aerodynamic analysis reference truck

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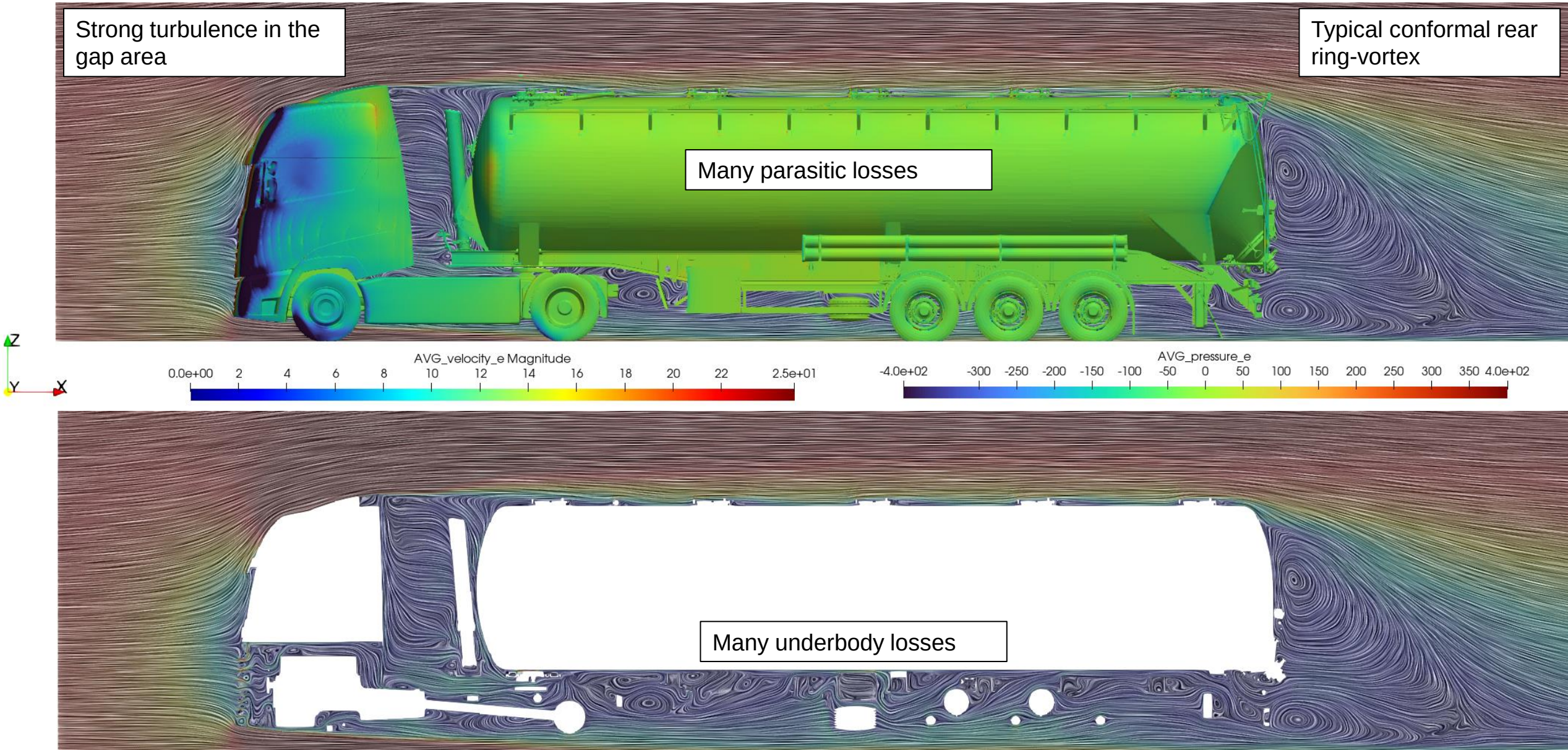
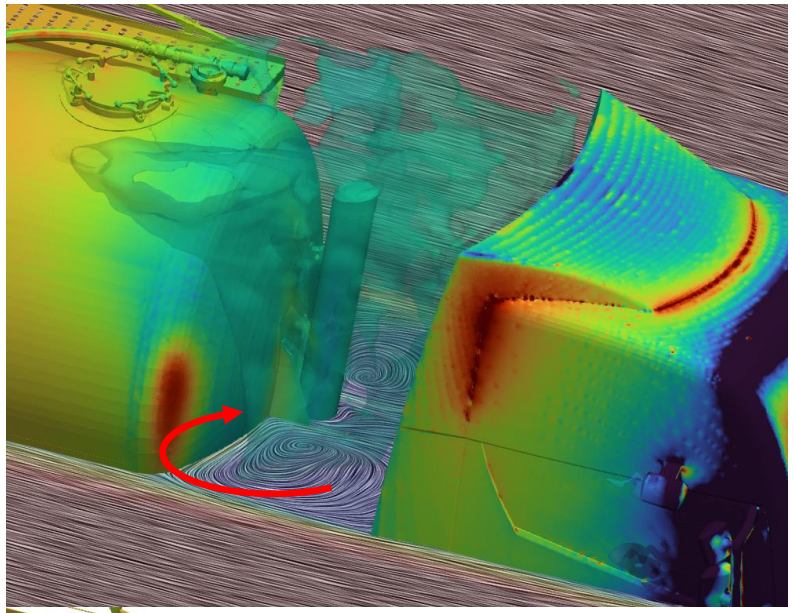
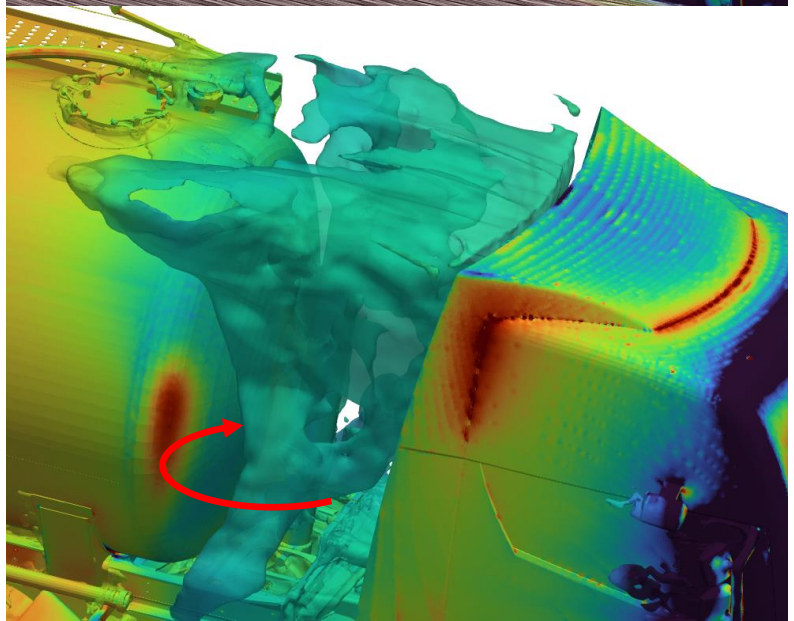
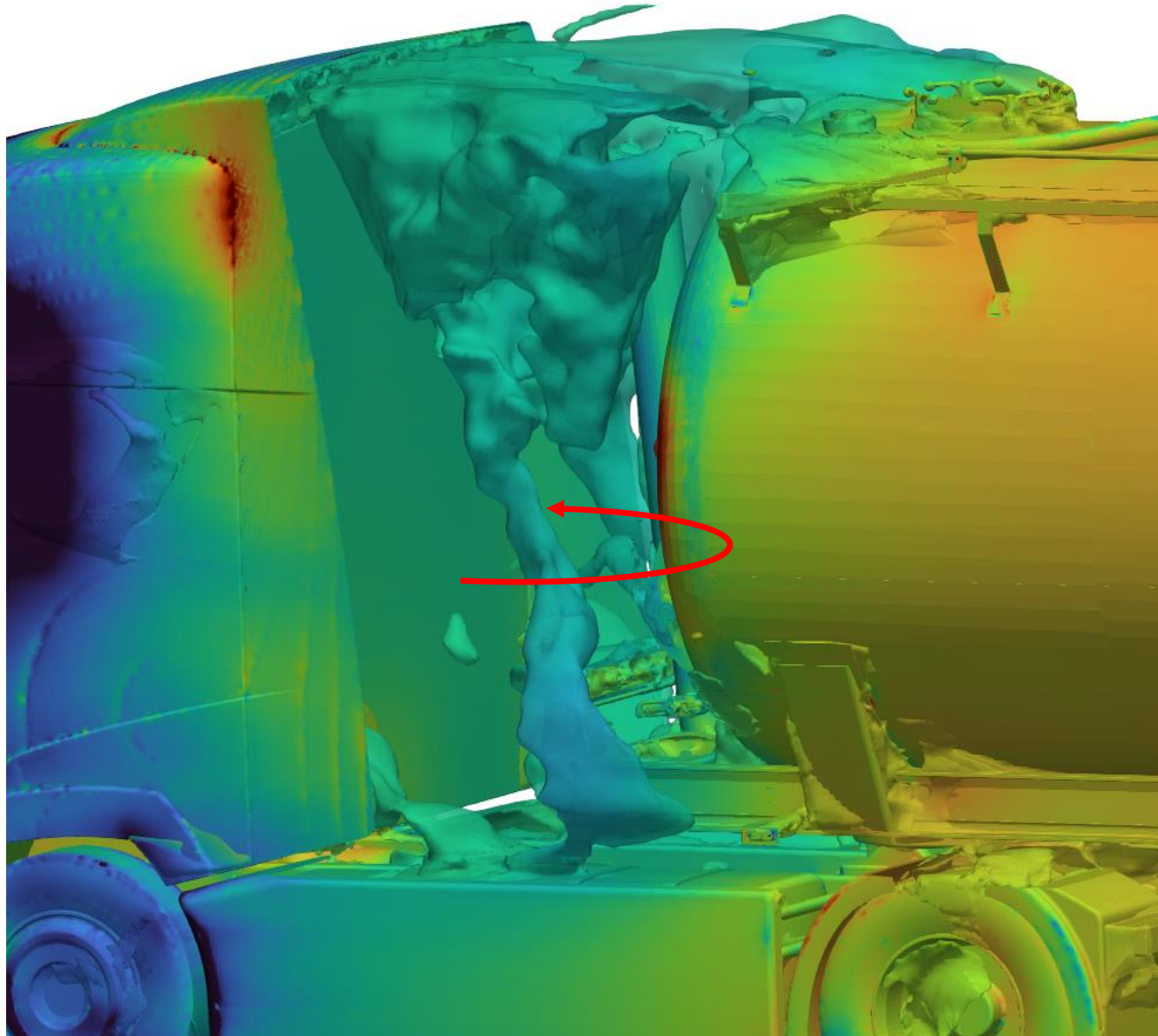
First overview: flow topology (middle section)



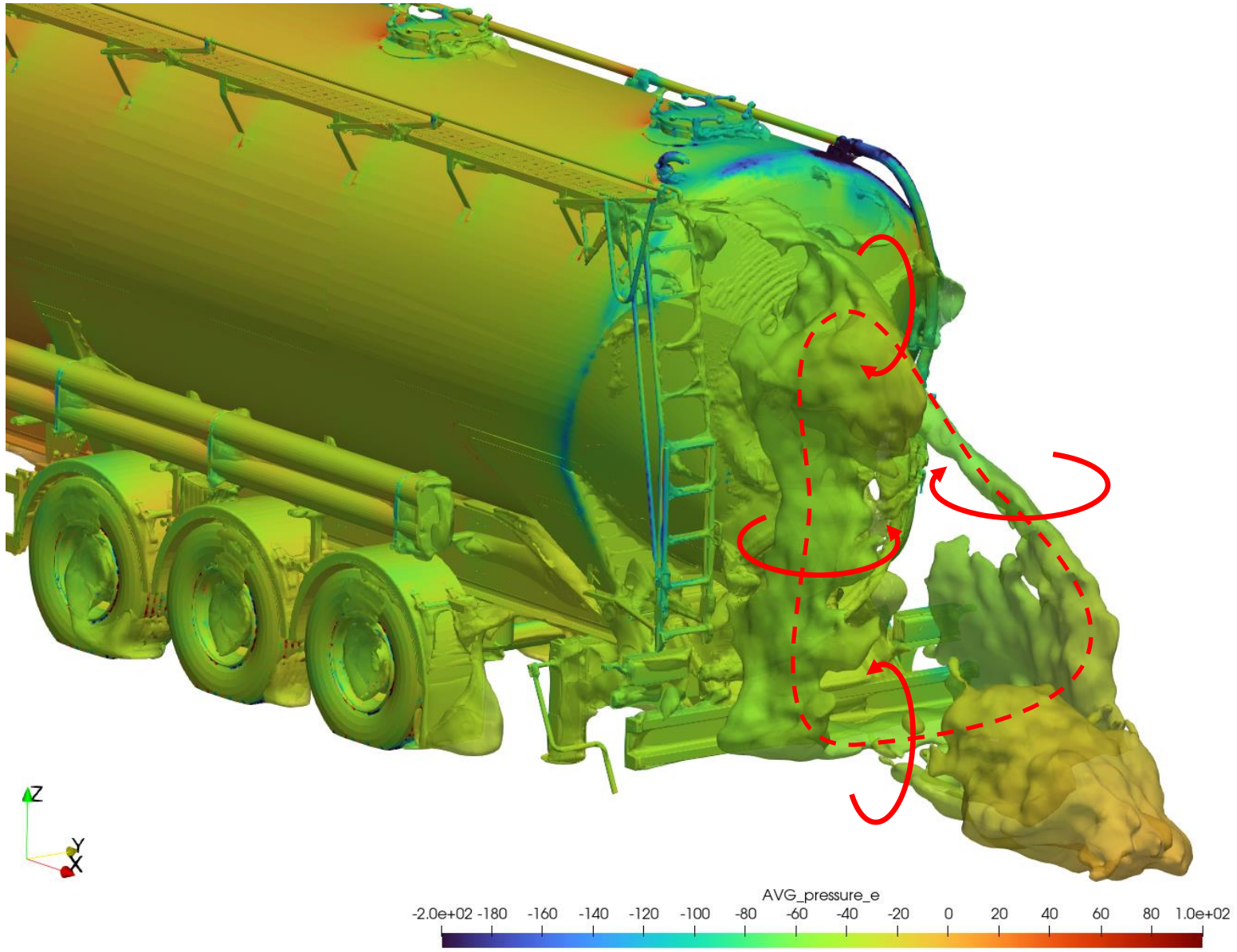
Recirculation area in tractor-trailer-gap



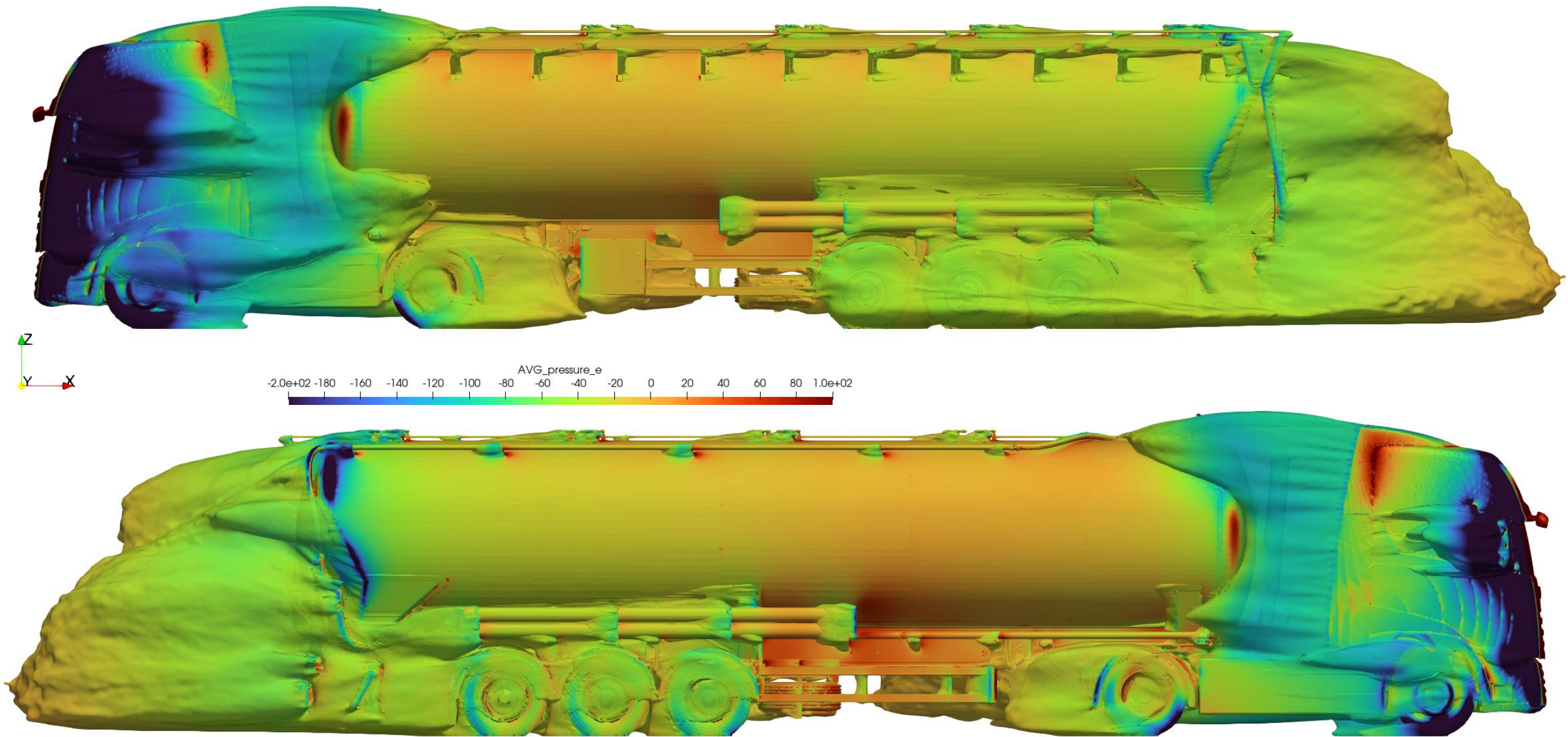




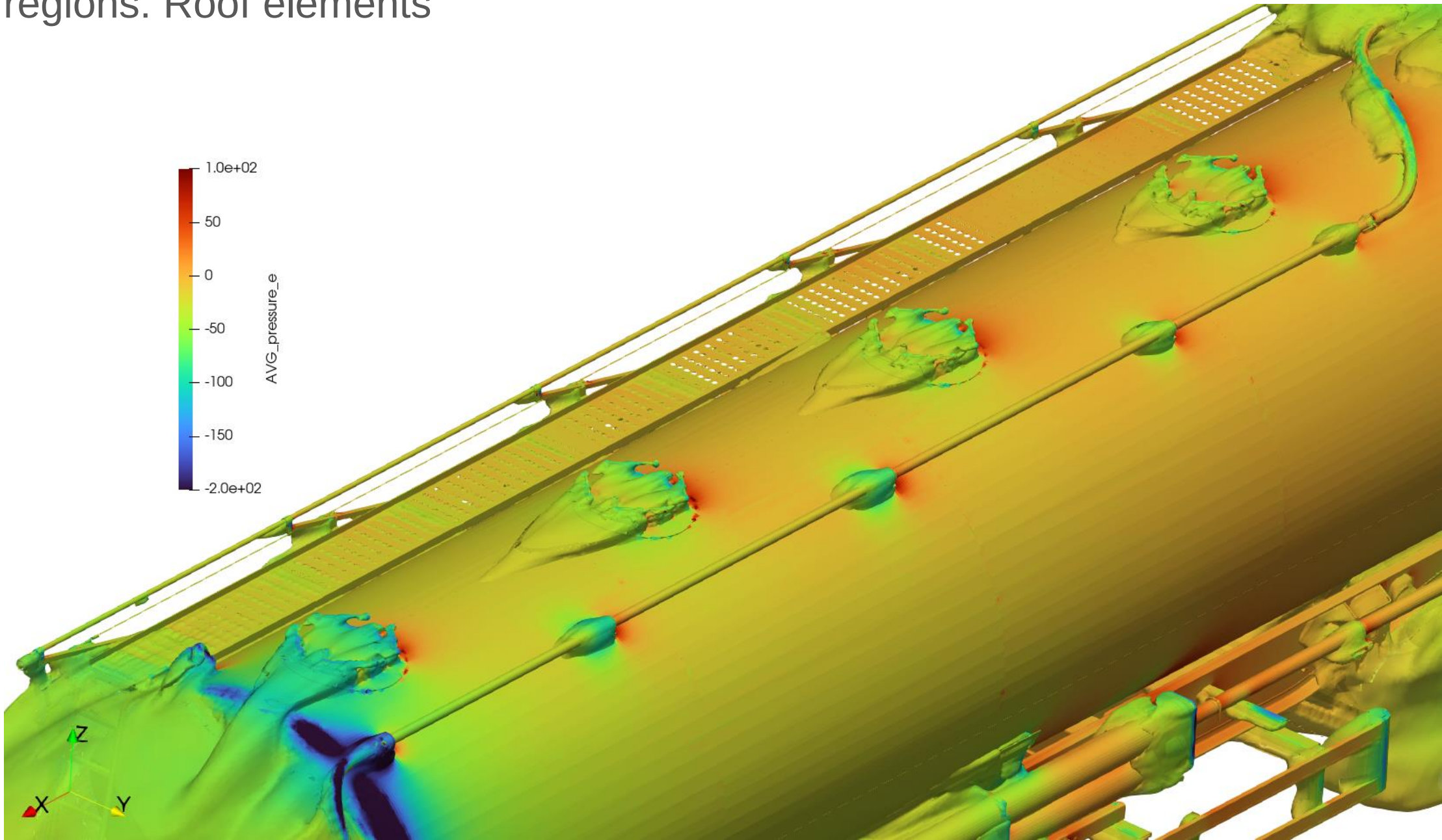
Recirculation area behind the trailer



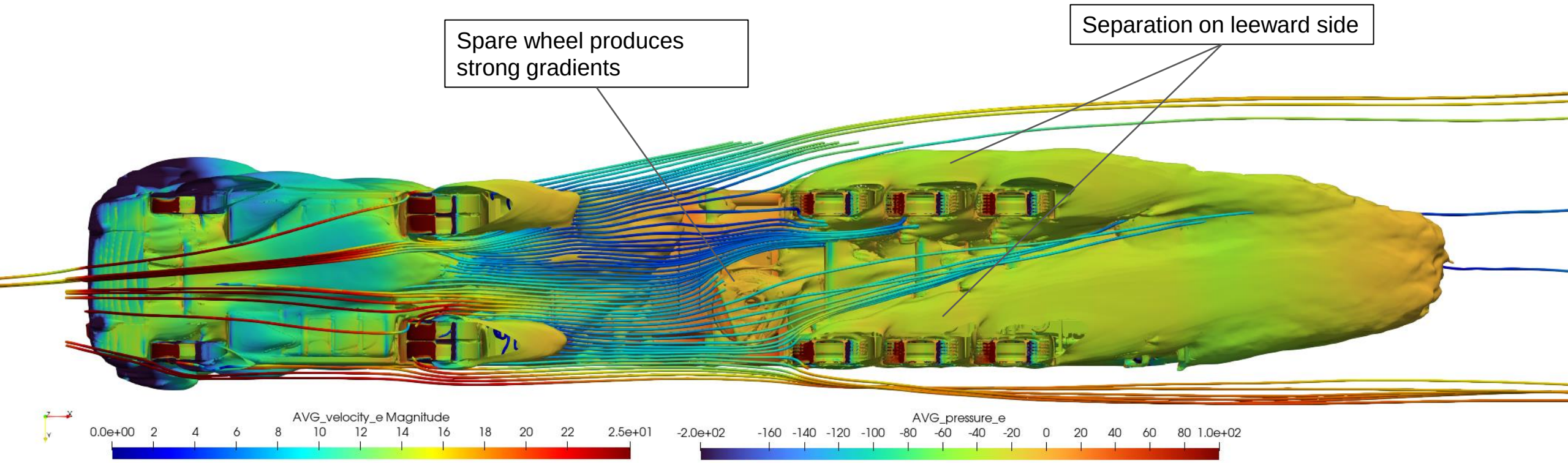
Loss regions



Loss regions: Roof elements



Loss regions: Underbody



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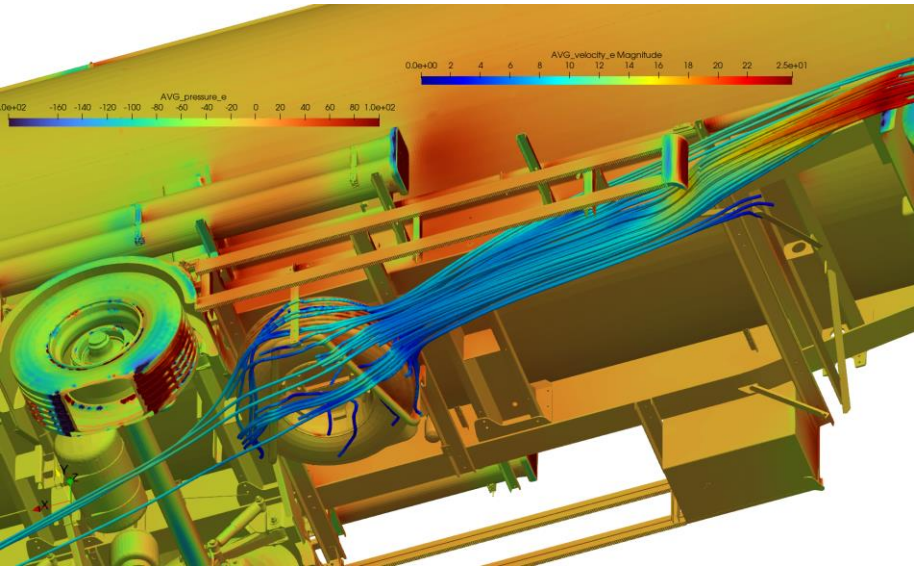
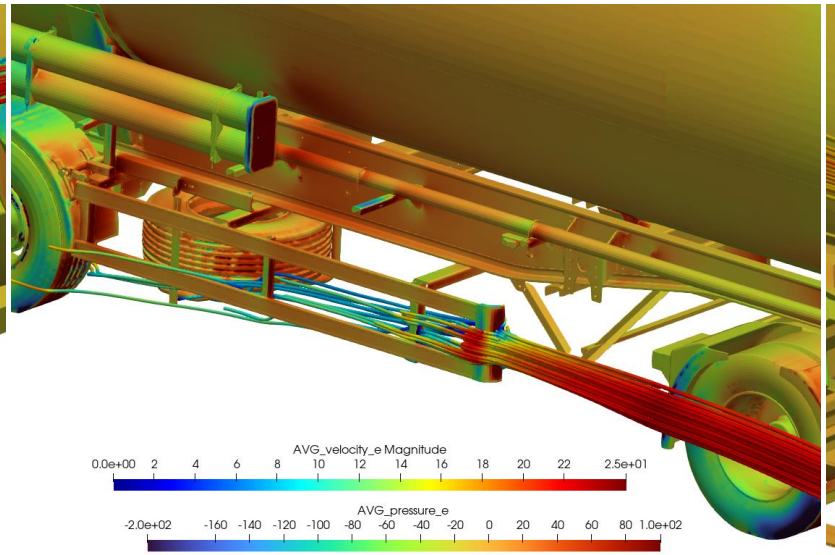
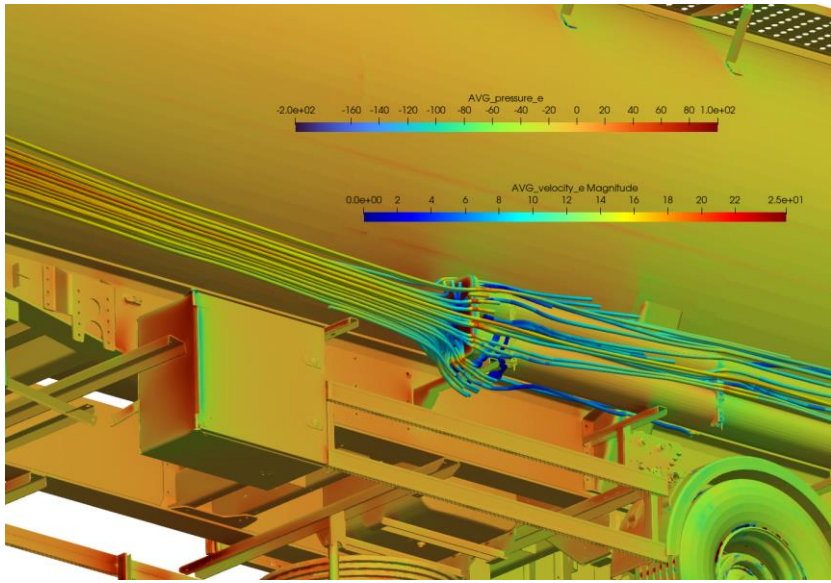
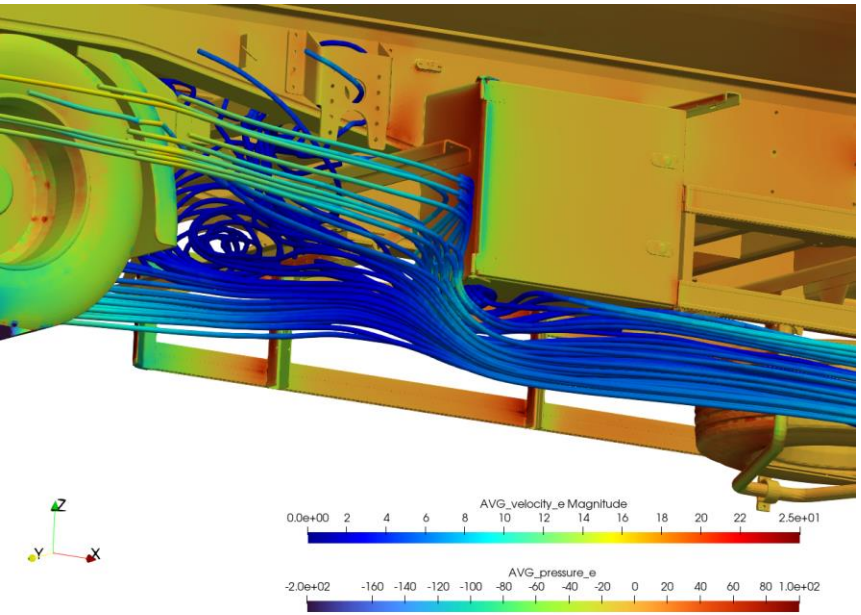
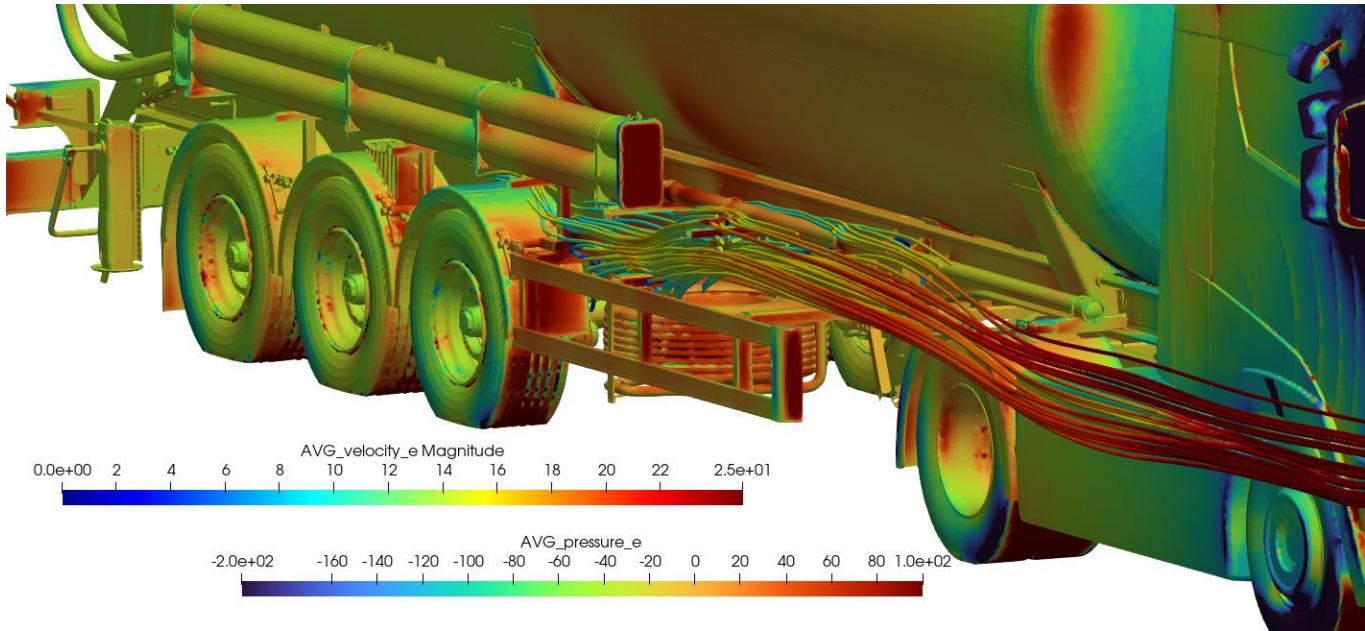
Local pressure effects











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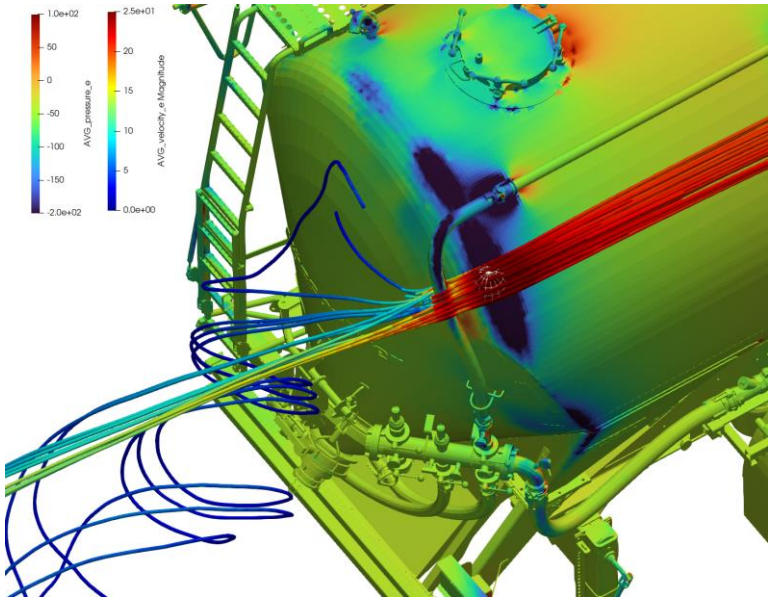
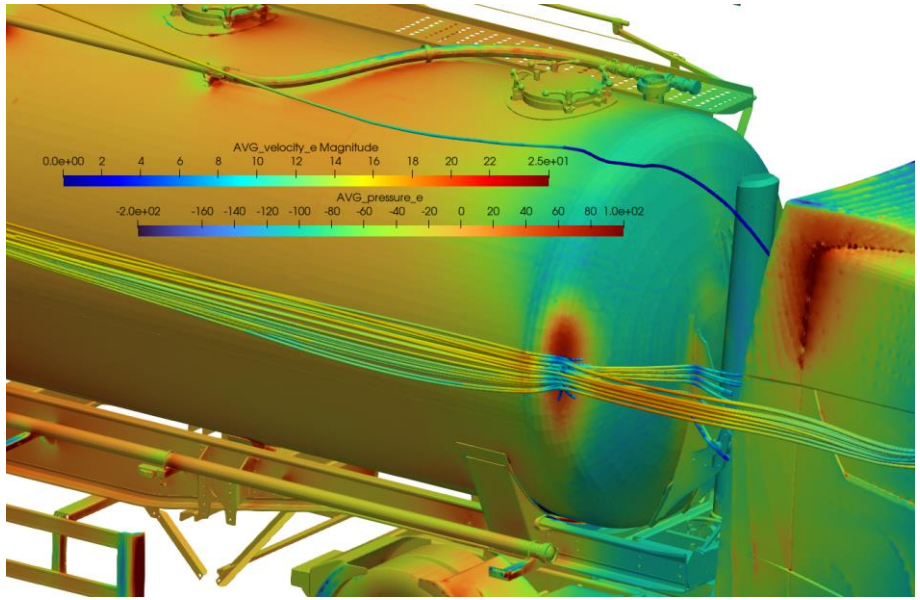
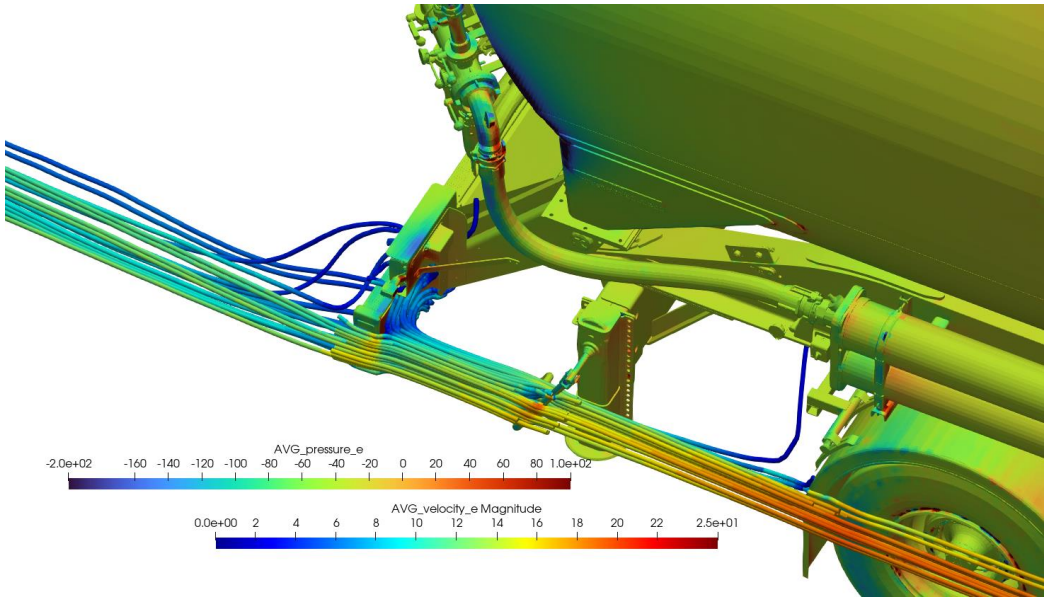
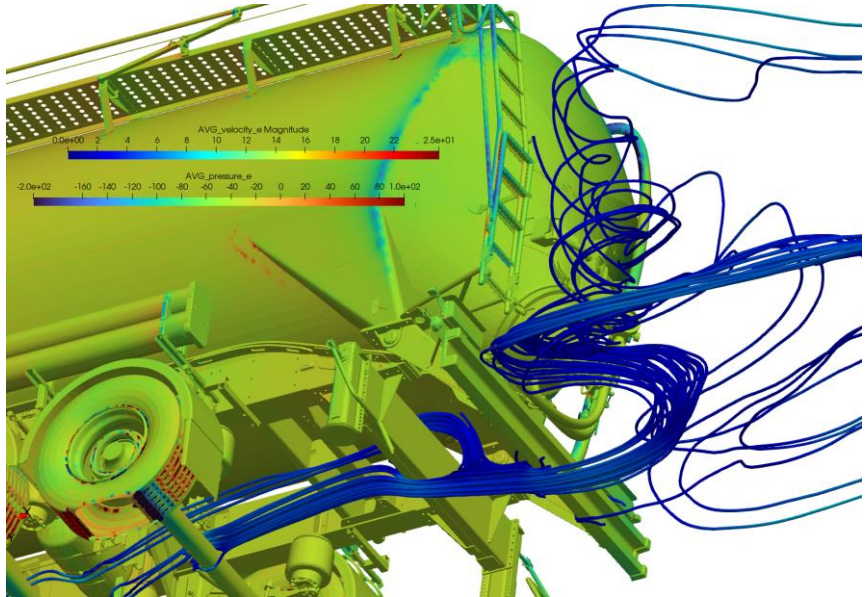
Local pressure effects



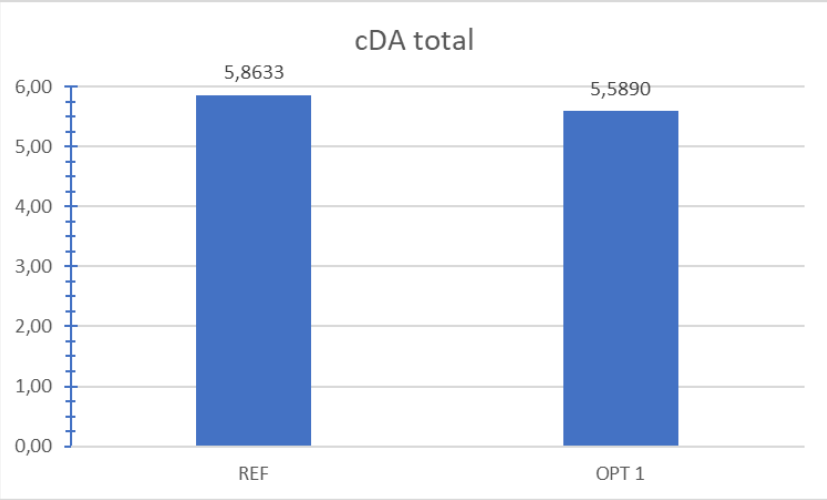


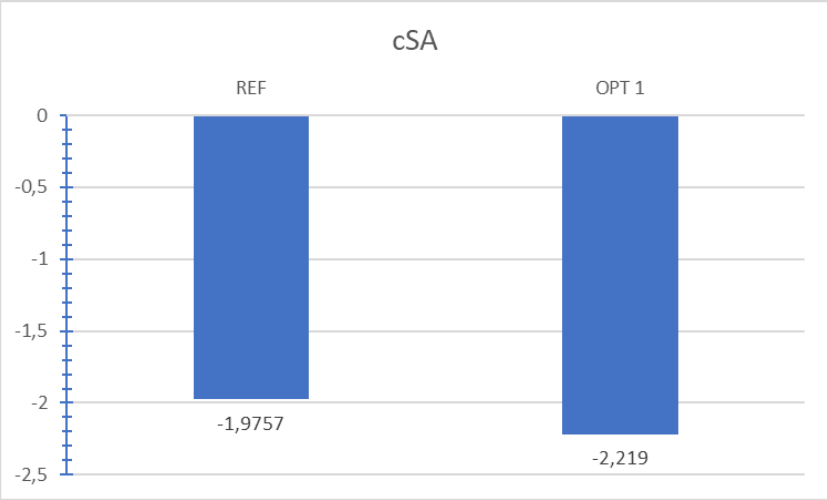


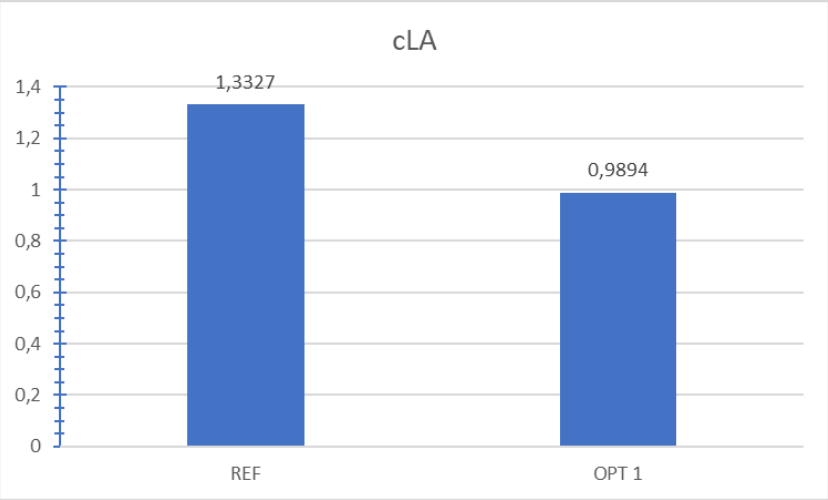


Aerodynamic concept & analysis of Optimization 1

Overview aerodynamic results:
Aerodynamic forces for Reference and Optimization 1





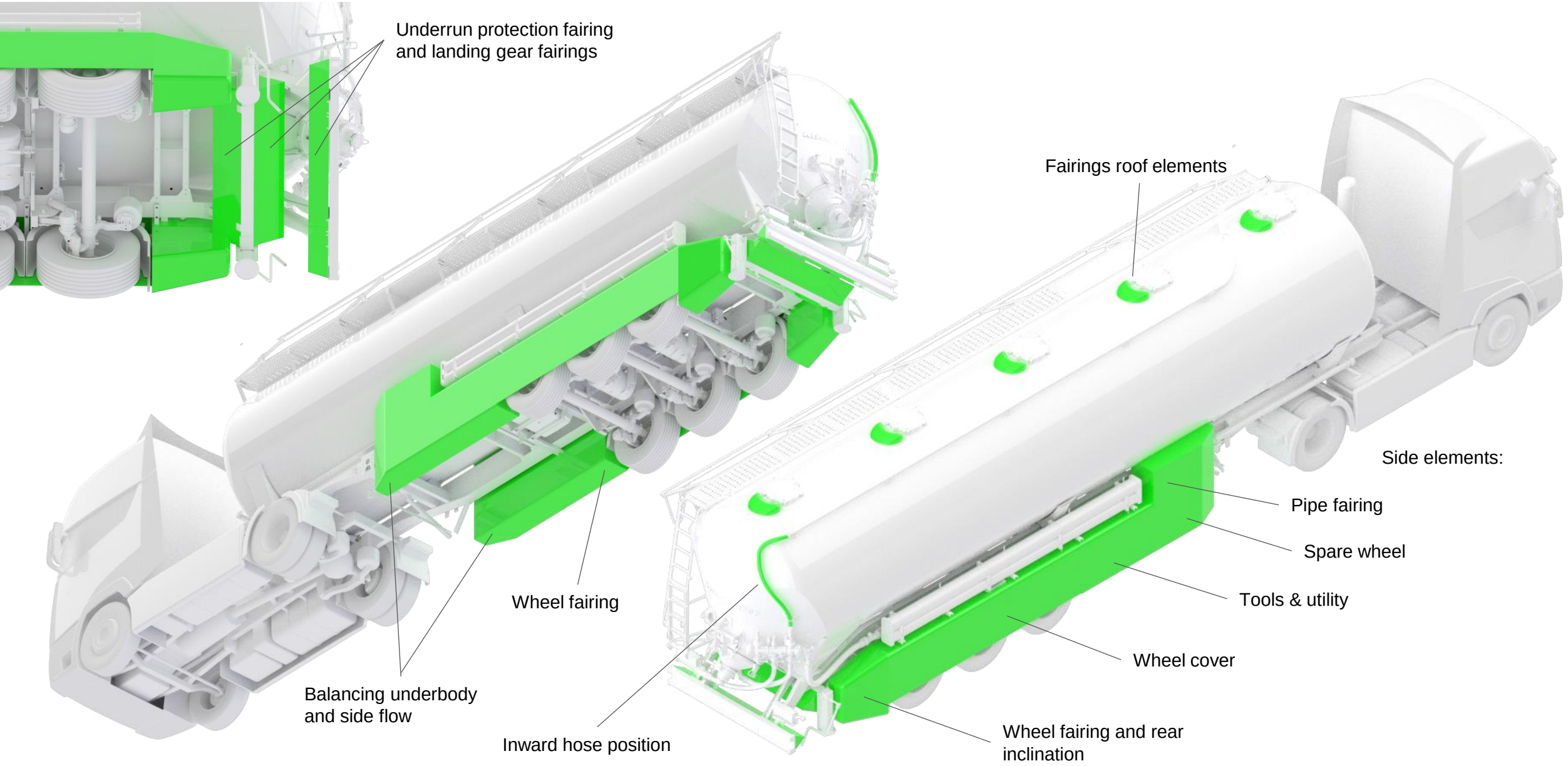


Aerodynamic drag force
(for efficiency)
Result: -5%

Side force
(for crosswind sensitivity)
Change: +12%

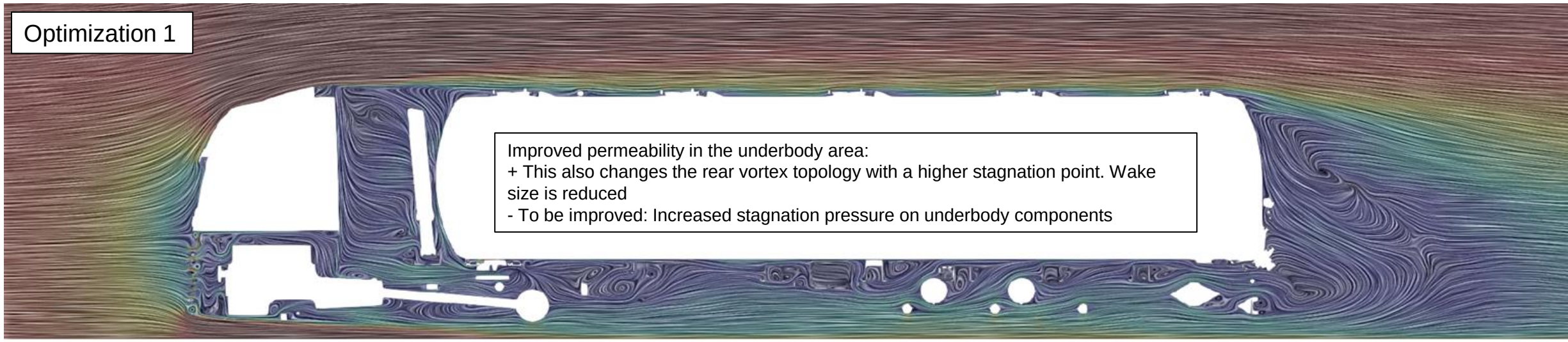
Lift force
(indicator for the aerodynamic quality)
Change: -26%

Actions for Optimization 1

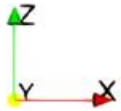


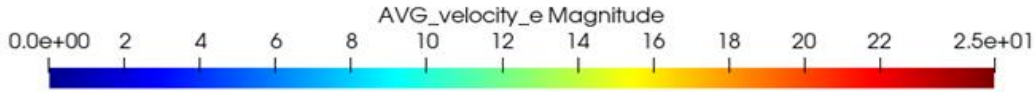
Flow topology (middle section) in comparison

Optimization 1

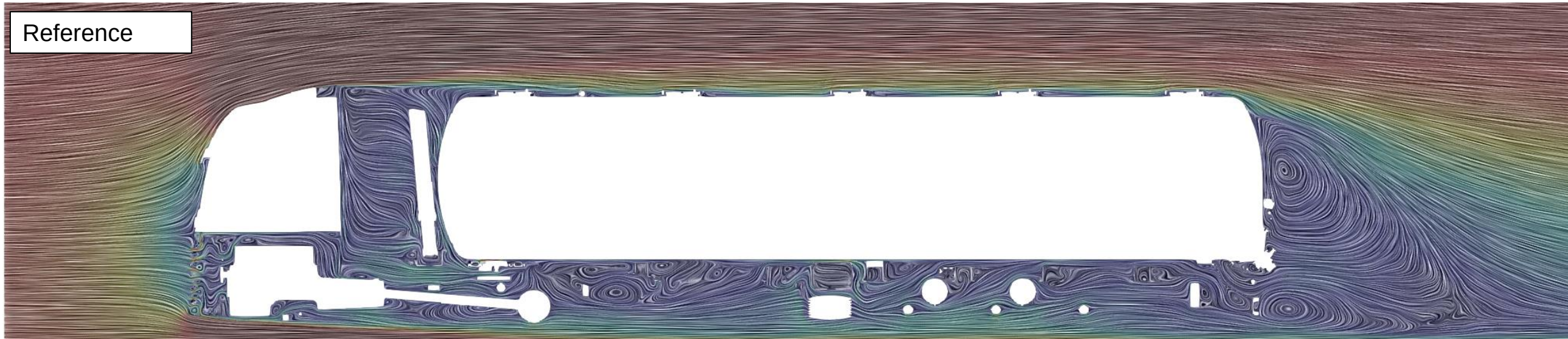


Improved permeability in the underbody area:
+ This also changes the rear vortex topology with a higher stagnation point. Wake size is reduced
- To be improved: Increased stagnation pressure on underbody components

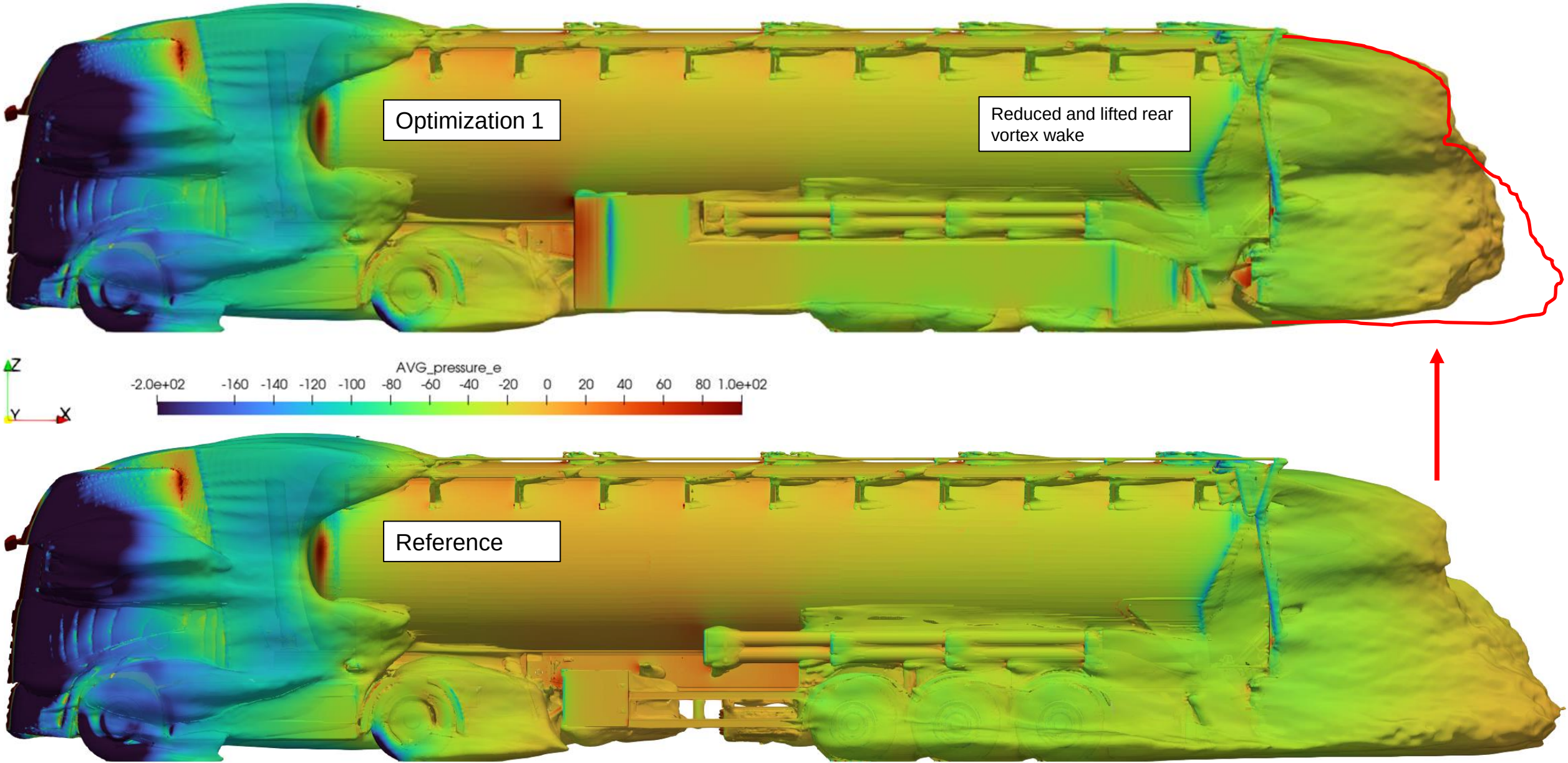




Reference



Loss regions in comparison



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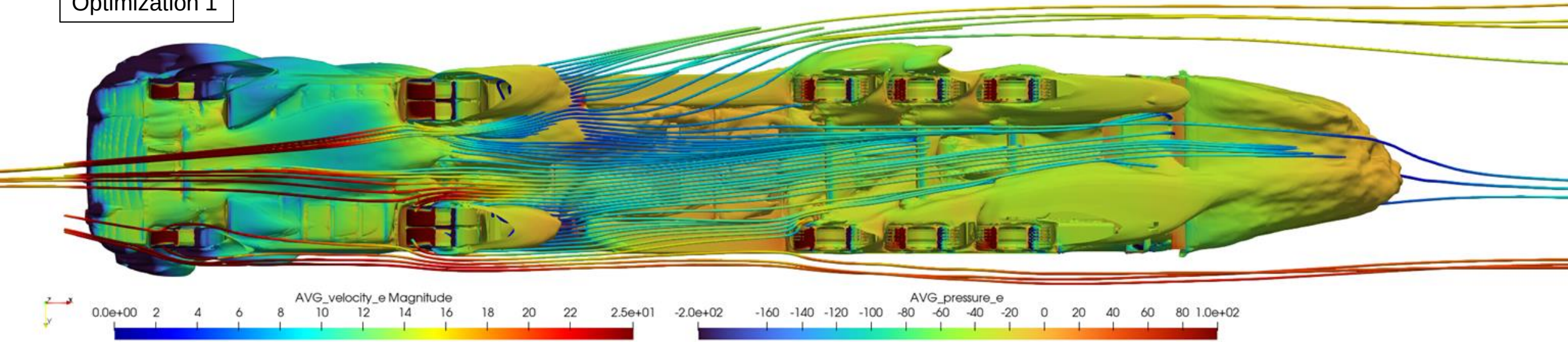
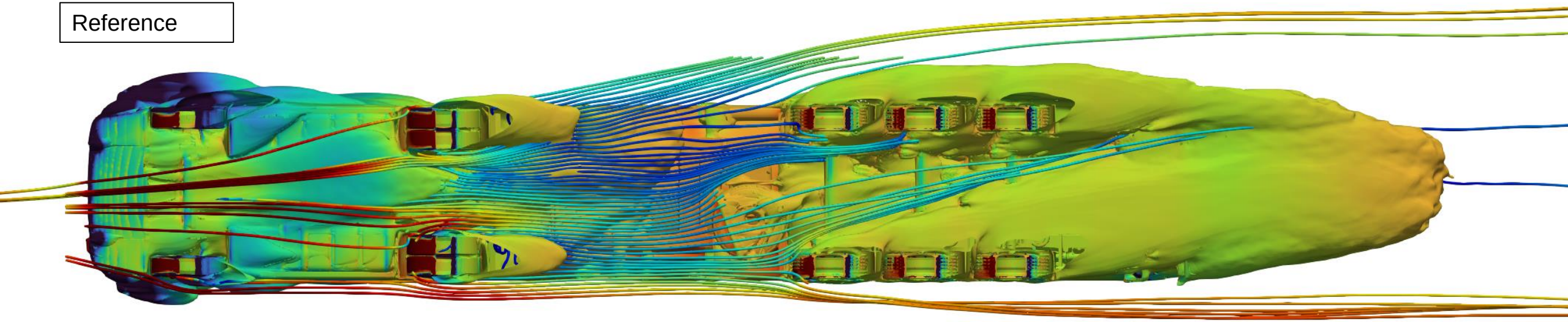
Loss regions underbody in comparison

+ Underbody flow straighter, better permeability
+ Improved wheel flow and open potentials for wheel flow

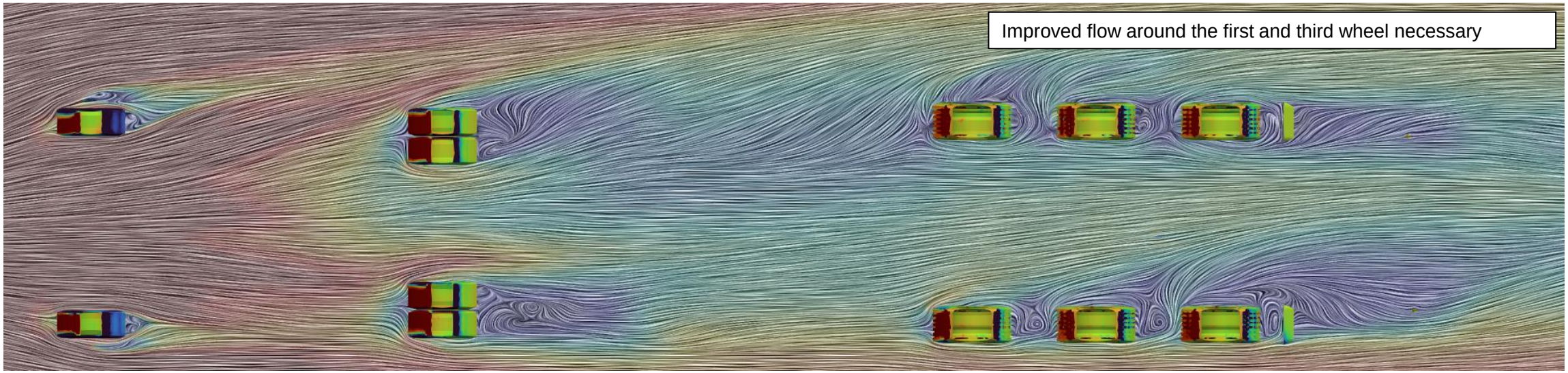
Optimization 1

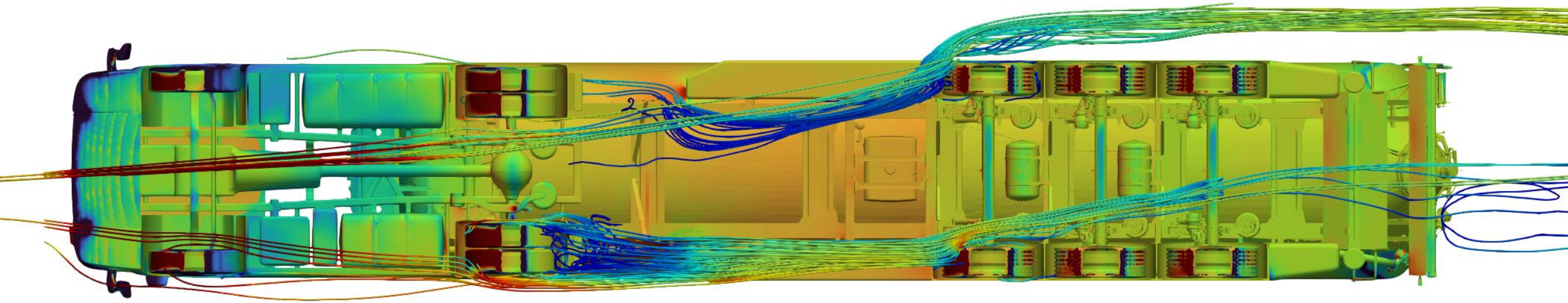


Reference

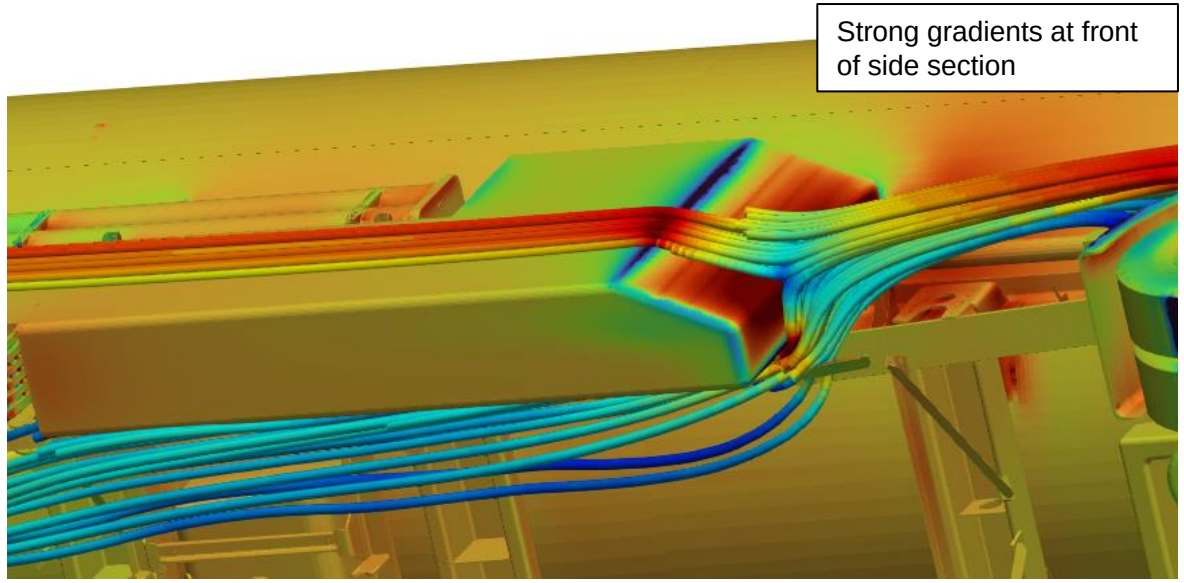


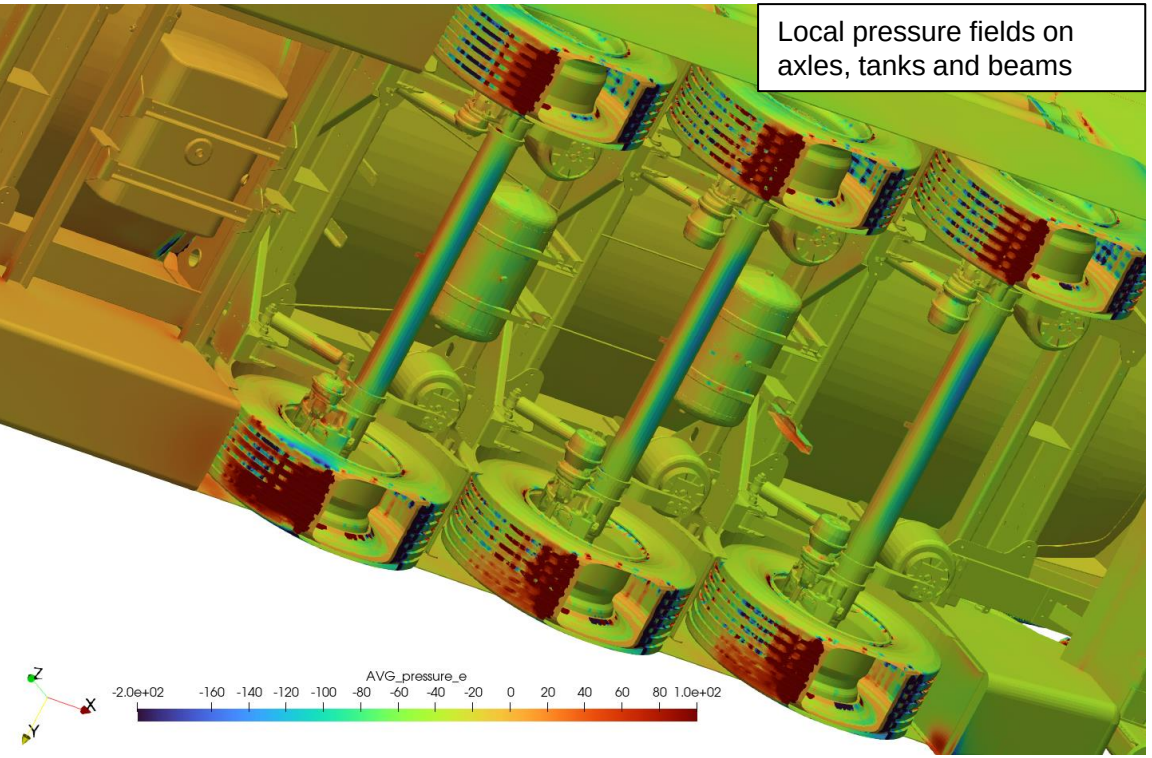
Loss regions underbody for Optimization 1

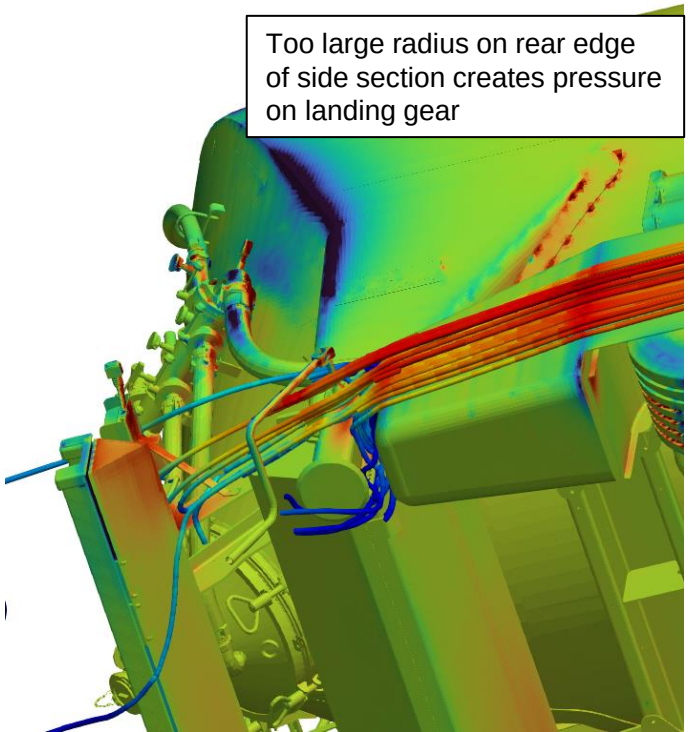


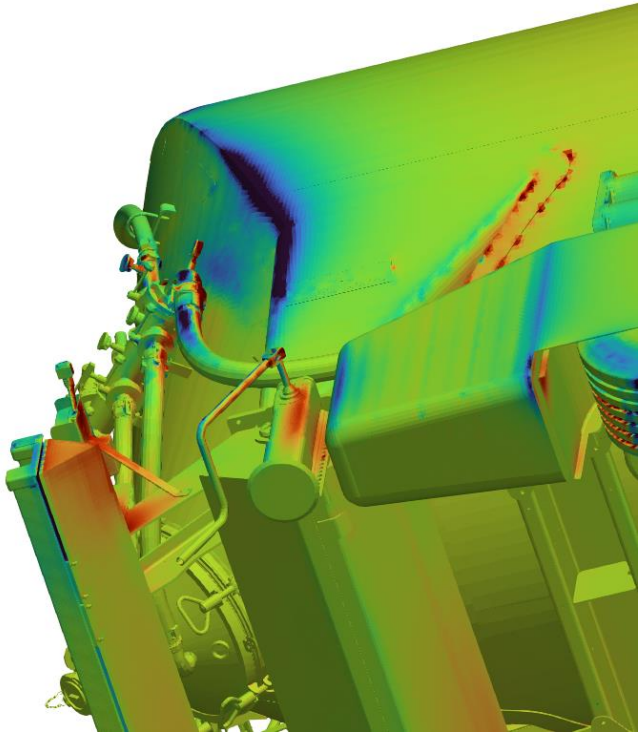


Local pressure effects









PACE analysis (driving simulation) with Optimization 3

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About the PACE functionality

Vehicle Parameters

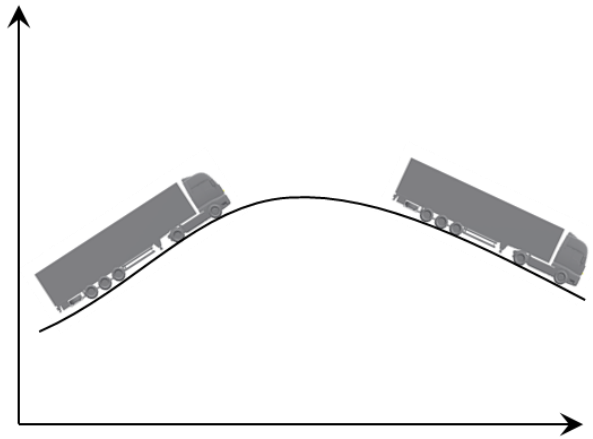
Mass	Empty Masses	Loading	Fuel mass over time	Ad-Blue masses over time	Mass of aero-equipment	Drivers
Tire Rolling Resistance	c_R (Tire Label)	Tire Pressure	Temperature	Speed	Load	Rain
Aerodynamic resistance	c_D (Drag coefficient)	Frontal area	Wind direction	Wind speed		
Drive train	No. of gears	η gear	Gear ratios	Axle transmission ratio	η axle transmission	Wheel diameter
Engine Mechanics	specific consumption	η engine	Max Power	EUR Norm		

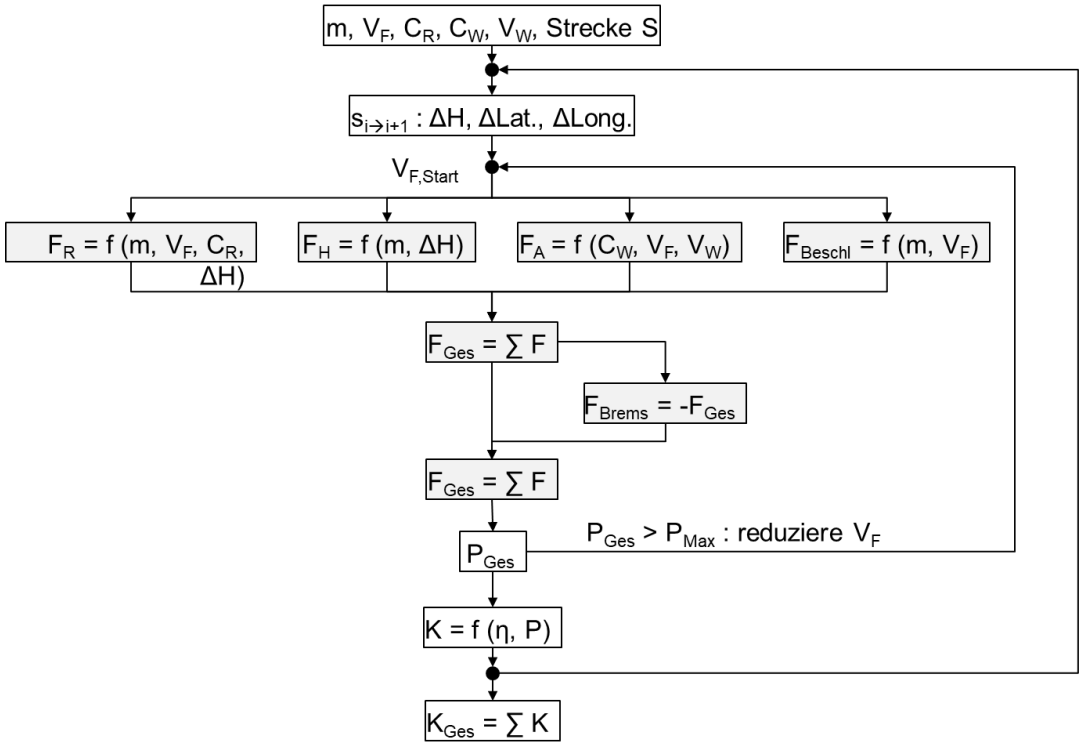
Mission Parameters

Traffic	Effic.-density-correlation	
Topography on route	Height profile	Lat.-long. wind profile

Environmental Parameters

Wind	Direction	Speed	
Air data	Temperature	Humidity	Pressure





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Input data for PACE consumption and savings simulation

- Tires:
  - Quality all tires: C level
  - All tire pressures: 9 bar
- Masses:
  - Reference-vehicle empty SSK60: 6250 kg
  - Mean weight load, 3 cases:
    - Denmark full (50%): 42.750 kg (@ 56 t total)
    - International full (70%): 26.750 kg (@ 40 t total)
    - Denmark / International: empty: 0 kg
  - Fuel-weight reduces during mission according to consumption
  - Extra mass due to current optimization parts is estimated to 405 kg
- Engine:
  - 430 PS = 316 kW
  - Efficiency and fuel consumption are calculated based on gearbox- and engine-map
  - Mission data:
  - Maximum driving speed: 85 km/h
  - Route profile toughness: Medium
- Mean air data:
  - Air pressure: 1013 hPa
  - Temperature: 15°C

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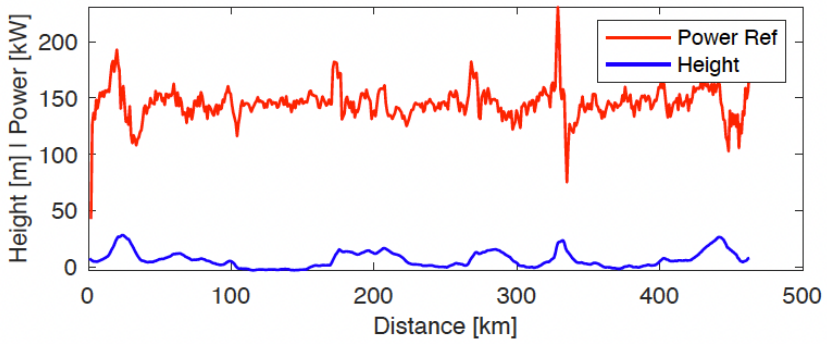
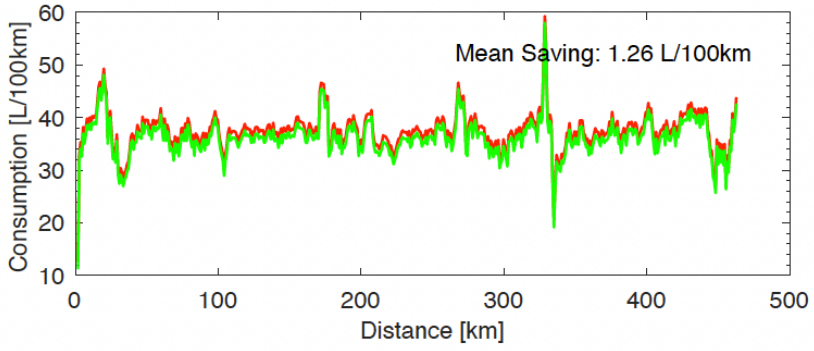
Results of the PACE consumption and saving simulation based on Optimization 3

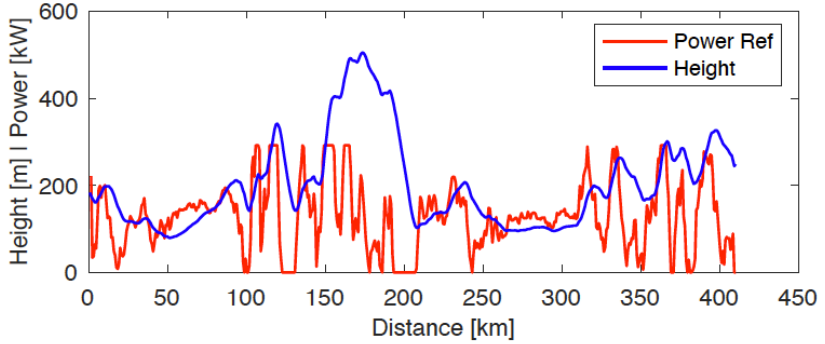
Figures in L/100km (REF / AERO / SAVING)	Full according to load given			Empty			Combined saving according to ratio given
Denmark (56 t and 0 t @ 50/50)	37,23	35,97	-1,26 (-3,4%)	21,53	20,38	-1,15 (-5,3%)	-1,20
International (40 t and 0 t @ 70/30)	32,28	31,25	-1,03 (-3,2%)	21,53	20,36	-1,17 (-5,4%)	-1,07

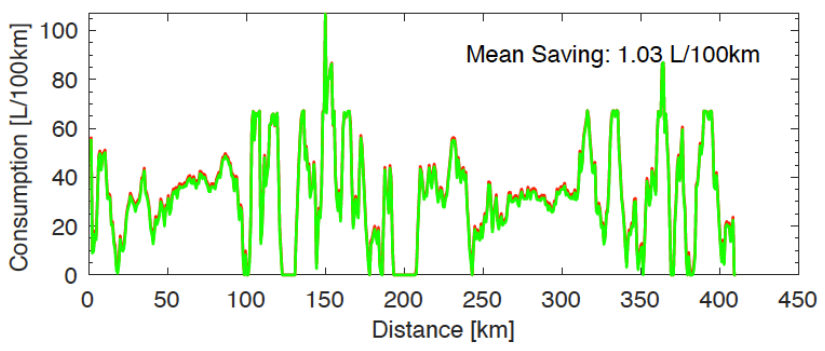
Denmark Full (easy profile)



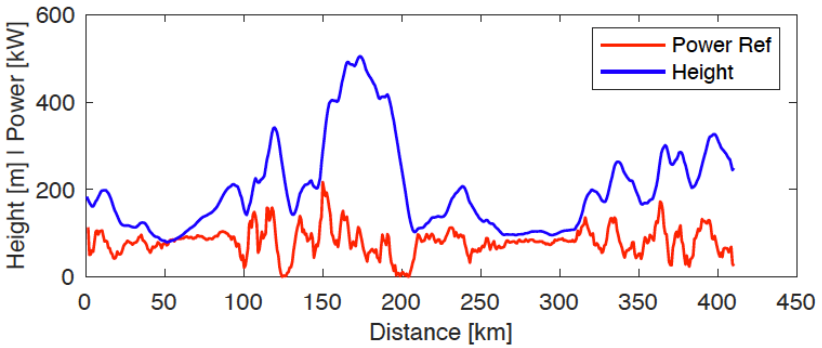


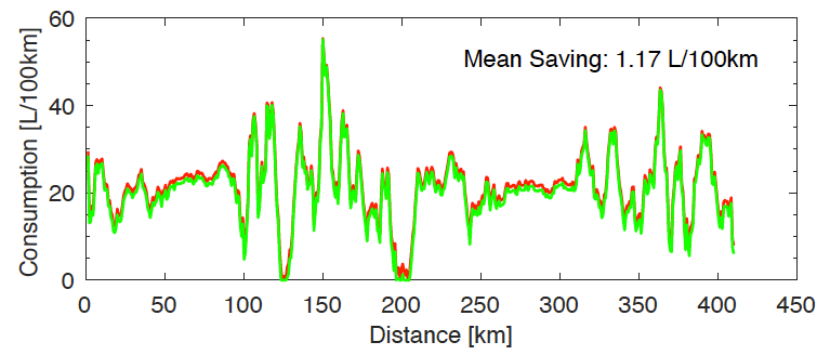
International Full (medium profile)





Empty (medium profile)





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Further potential for aerodynamic improvements

- Optimization3 with camera mirrors and optimized spoilers of tractor: estimated 16% aerodynamics, saving about 1.7 L/100km
- With significant optimization of the trailer: estimated 20-25% aerodynamics, saving about 2.1-2.6 L/100km
- Global TCO optimization for minimum extra-mass, minimum effort for parts, best TCO


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