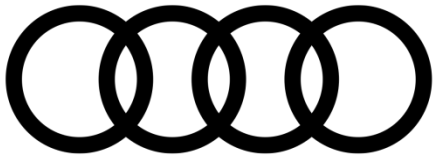


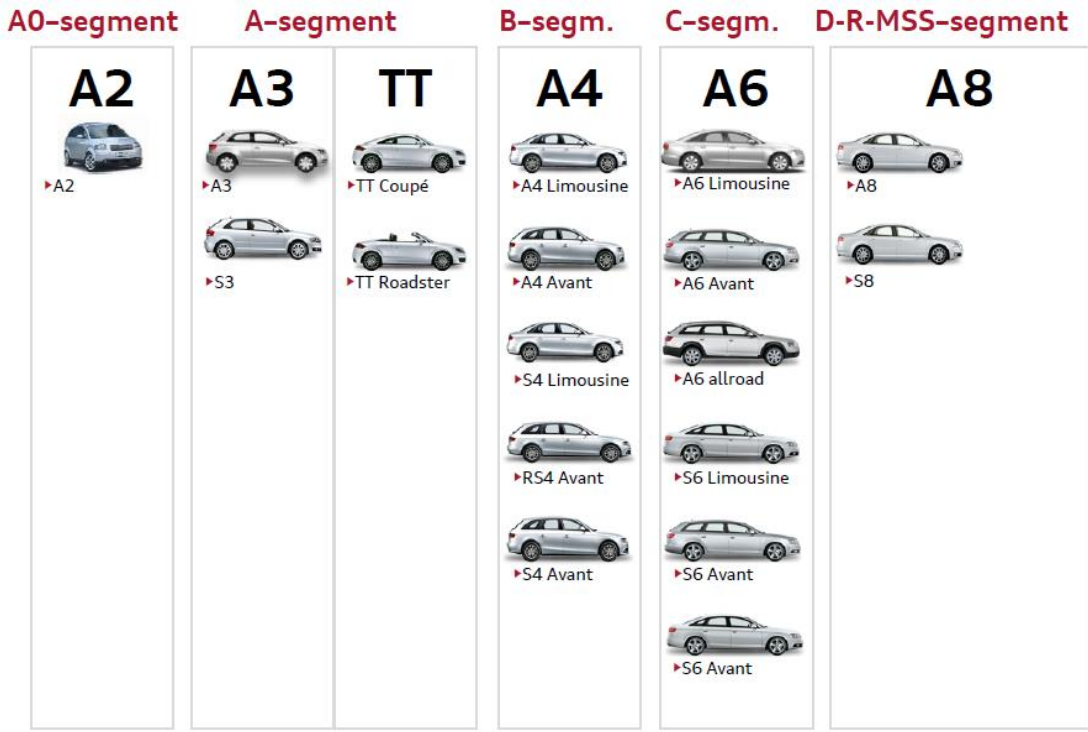
CFD Simulation of Water Management of a Vehicle under Realistic Driving Conditions

Dr. Dirk Bäder, Audi AG

Agenda

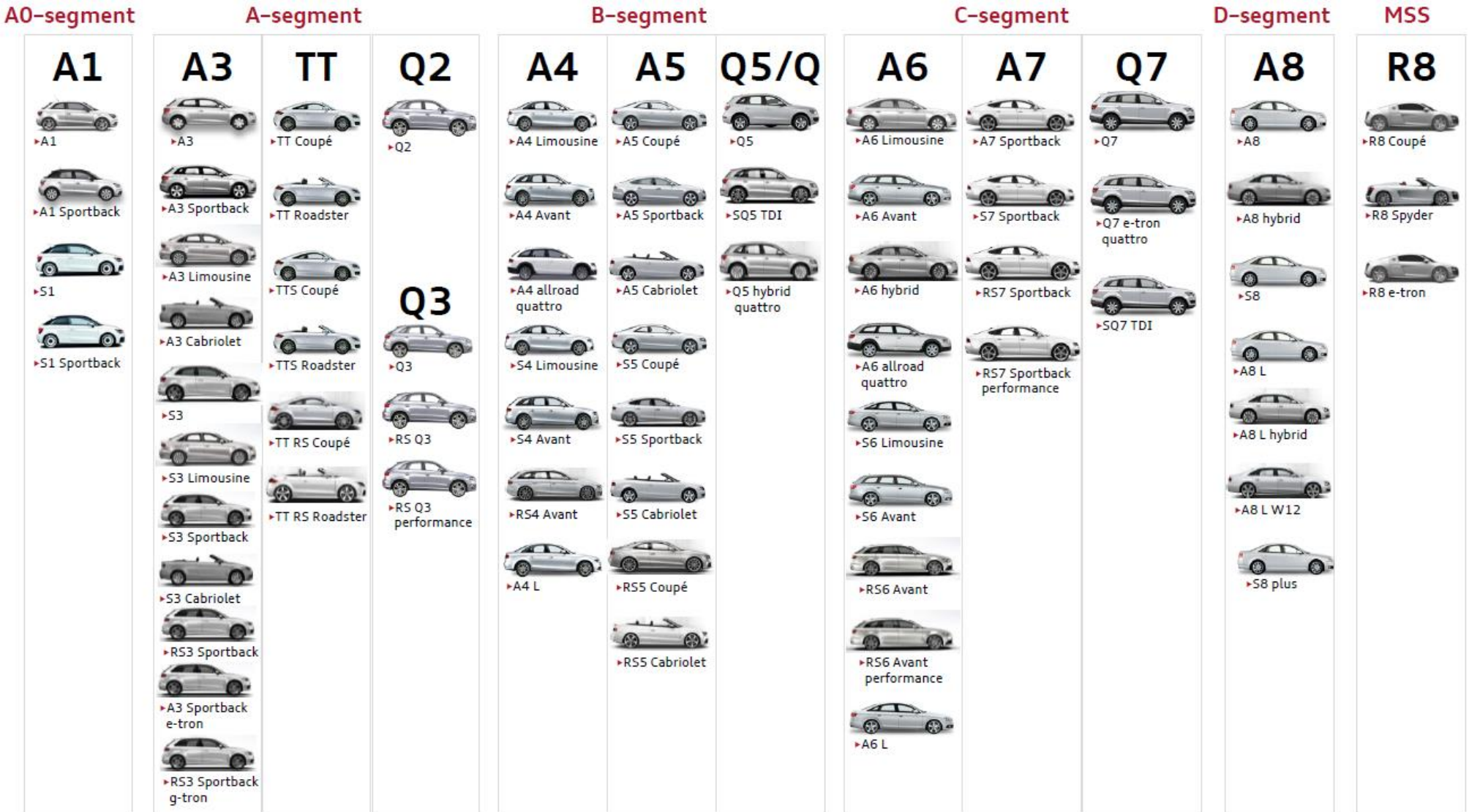
- Challenge
- Investigation of the Influence of the Windscreen Wiper Movement
- Investigation of the Influence of the Airflow Field
- Investigation of the Influence of Acceleration Forces
- Summary and Outlook

Overview over vehicles of the Audi AG in the year 2000



Bildquelle: Vortrag D. Bäder: Berechnung der Lufttemperaturen im Motorraum eines Fahrzeugs, NAFEMS-Konferenz, November 2017
sowie R. Borris: Customized developments for AUDI´s OpenFOAM process, October 11, 2016, OpenFOAM-Conference 2016

Overview over vehicles of the Audi AG in the year 2015



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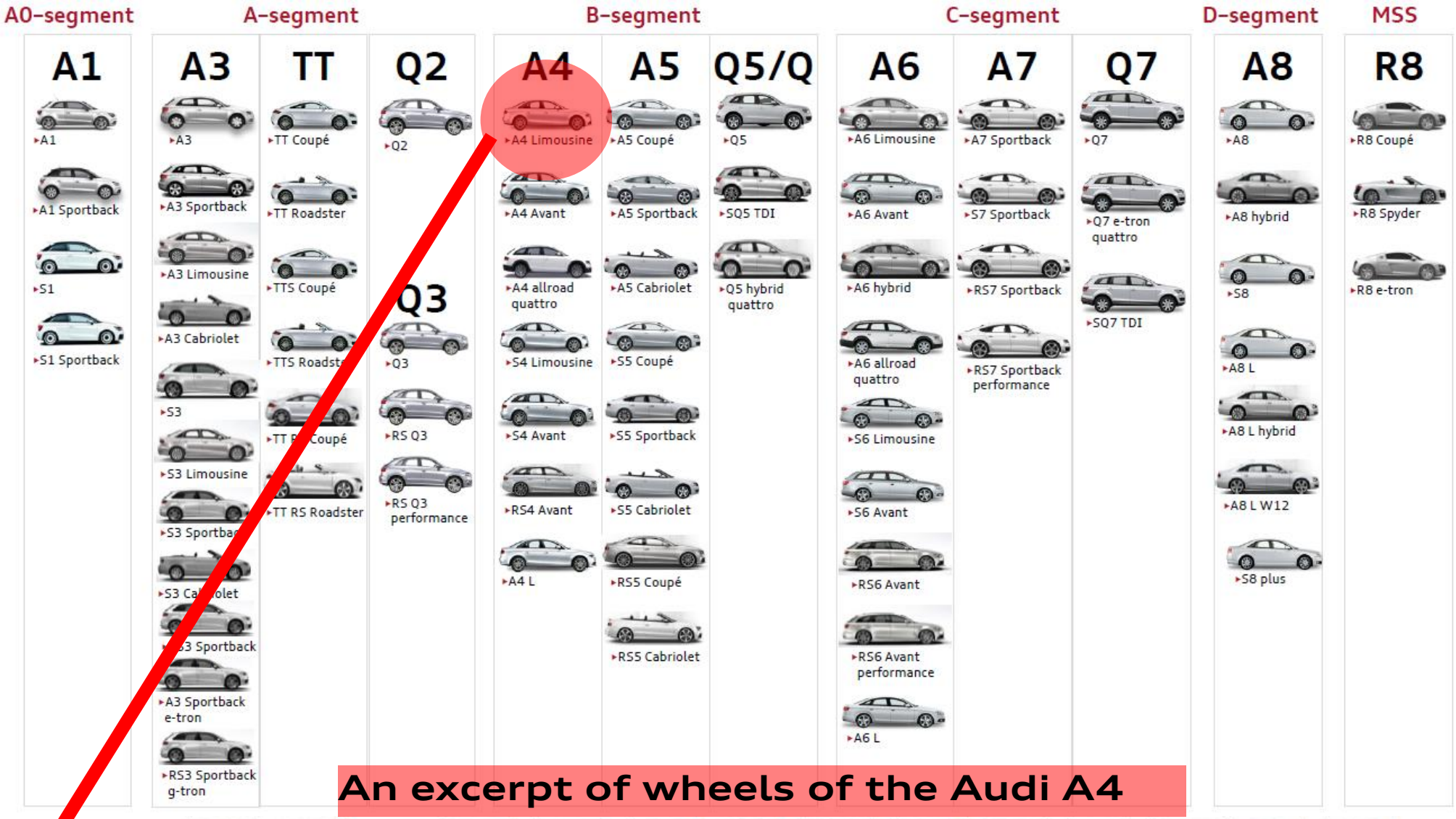

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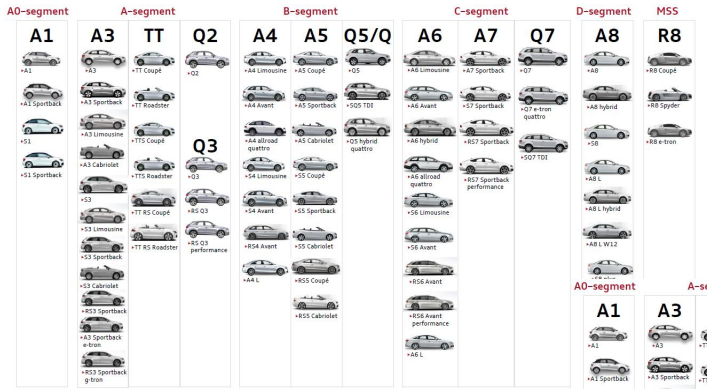
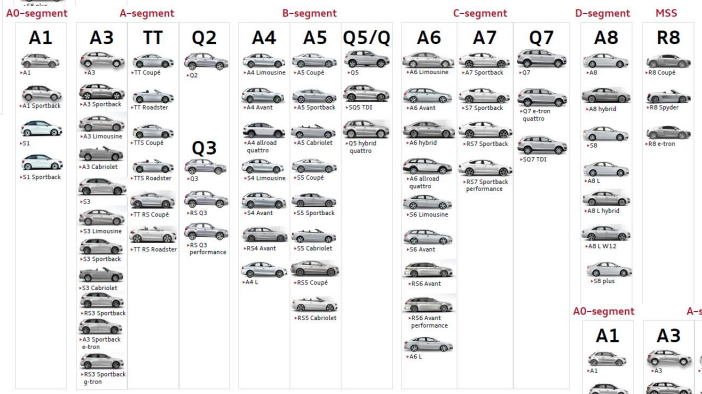
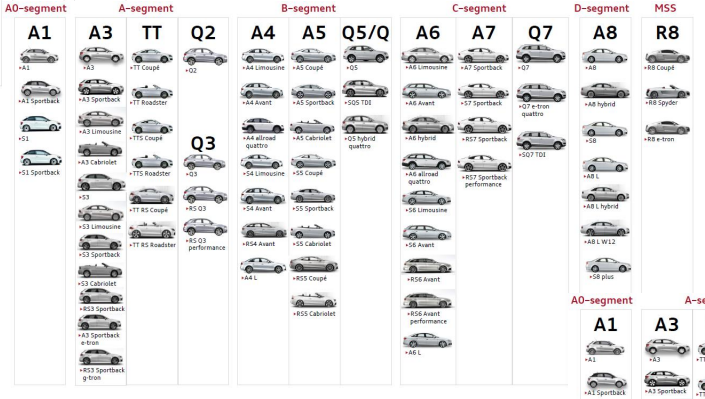
What does the future bring?



Conventional drive units (Otto + Diesel) with conventional and e-fuels



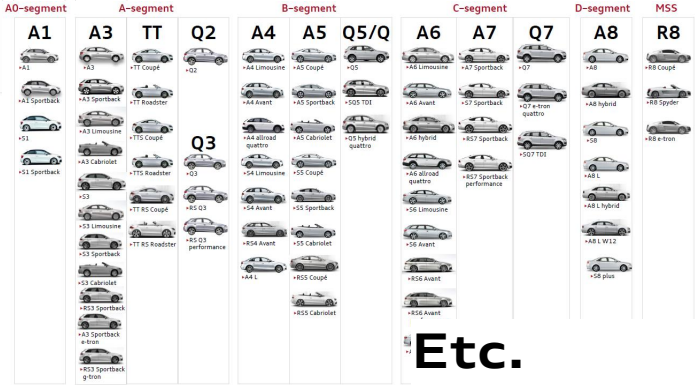
Electrical drive units (BEV, HEV, etc.)



Fuel Cell

New concepts of mobility?

Individual mobility in megacities?



Etc.

Bildquelle: Vortrag D. Bäder: Berechnung der Lufttemperaturen im Motorraum eines Fahrzeugs, NAFEMS-Konferenz, November 2017
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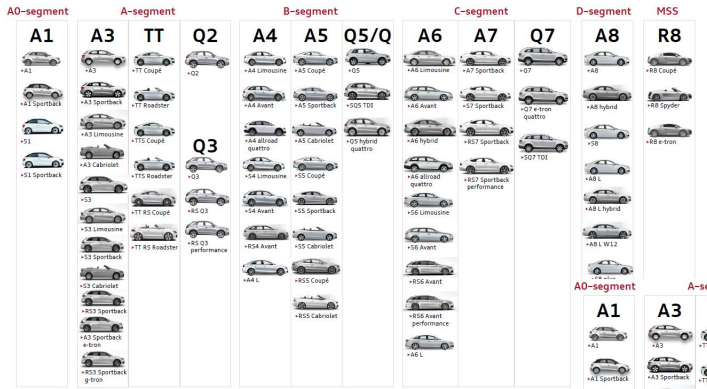

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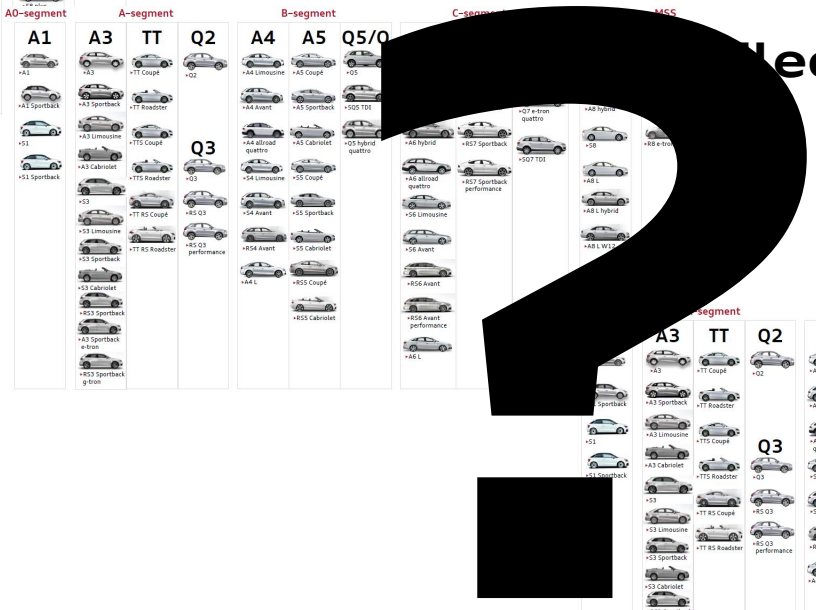
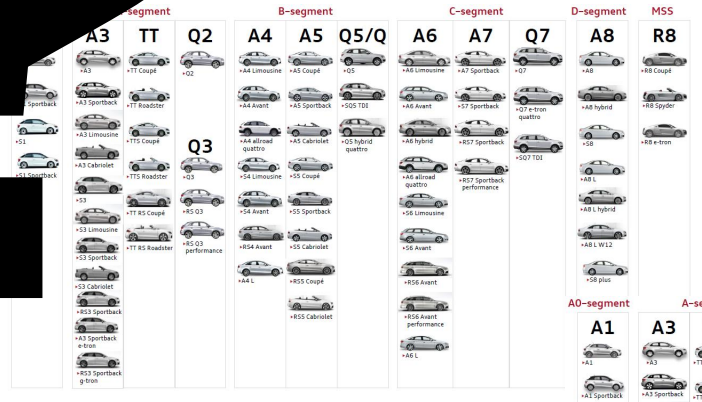
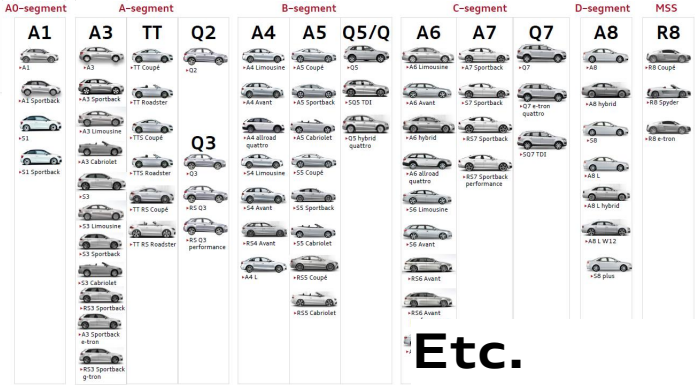


Electrical drive units (BEV, PHEV, etc.)



Fuel Cell

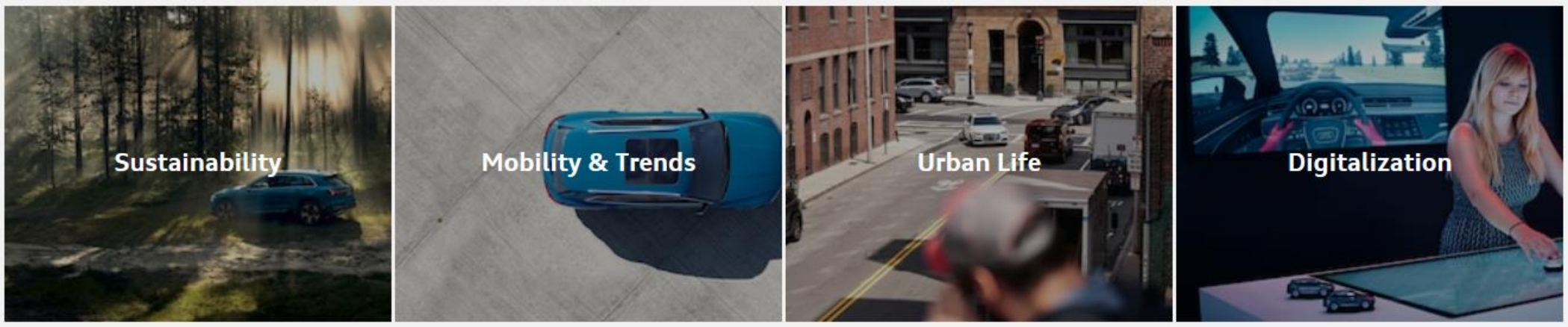


Etc.

New concepts of mobility?

Individual mobility in megacities?

The World Changes – Audi Strategy



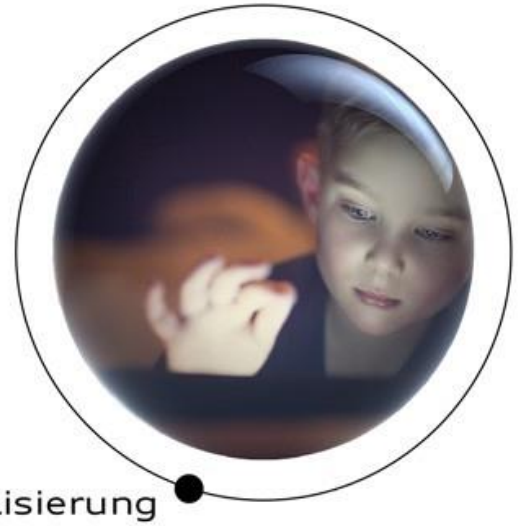
Quelle: www.audi.com/corporate/de/unternehmen/unternehmensstrategie.html

Digitalization – Audi Strategy:

Digitization offers great opportunities for Audi: Vehicles can be personalized and made safer, the driving public protected and the flow of traffic made more efficient. We aim to systematically digitize our processes and use digital services to open up new business models and sales potential — in retail, in the vehicle and for mobility offers beyond the vehicle.

Quelle: www.audi.com/corporate/de/unternehmen/unternehmensstrategie.html

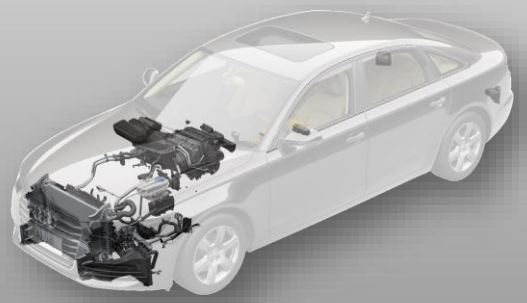
Digitalization – Audi Strategy



Development of new Simulation Methods are necessary

Bildquelle: Vortrag D. Bäder: Berechnung der Lufttemperaturen im Motorraum eines Fahrzeugs, NAFEMS-Konferenz, November 2017
sowie R. Borris: Customized developments for AUDI's OpenFOAM process, October 11, 2016, OpenFOAM-Conference 2016 sowie www.audi.com

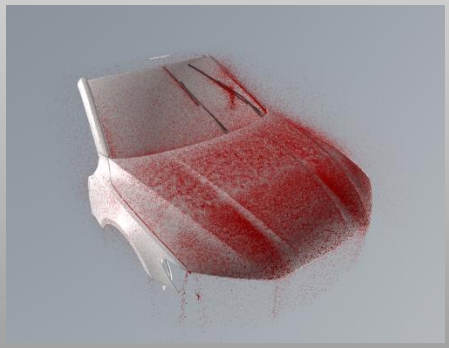
- thermal management



- aerodynamics/aeroacoustics

- cabin HVAC

- water management



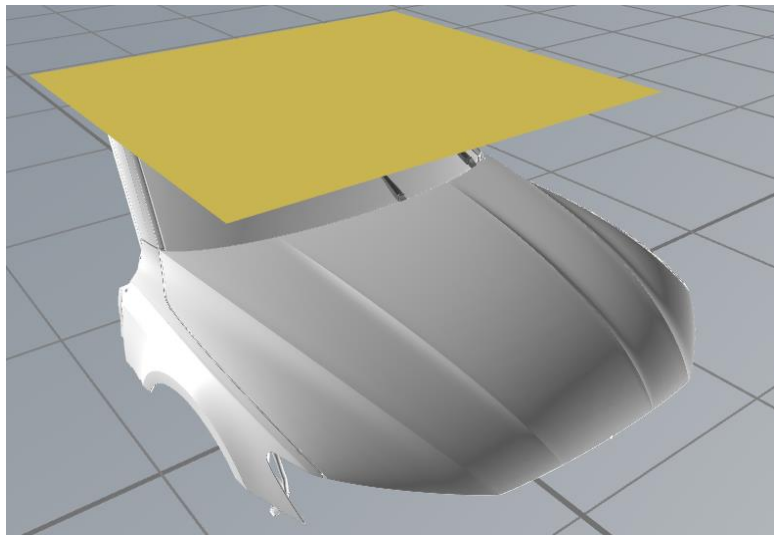
Water Management Simulations

- Using simulation techniques that have never been used before at Audi, at least when looking back 5 to 10 years

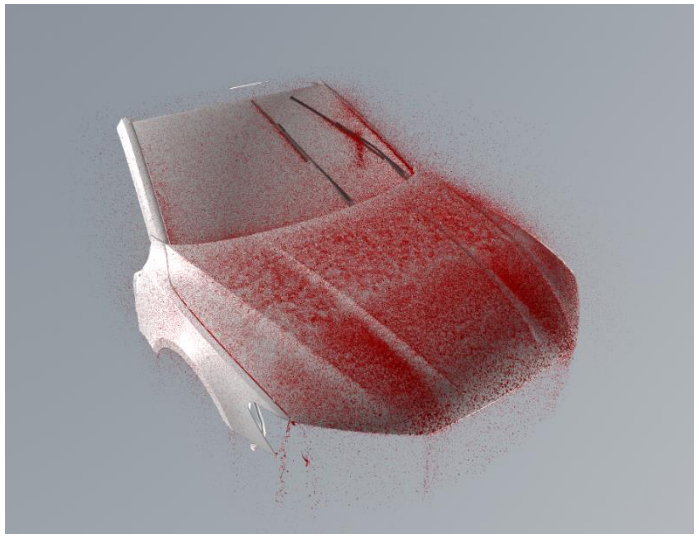
- Water Management Simulations are of huge interest in order to predict water pathes

- In the following, the simulation of the water path around the front part of the vehicle is investigated
  - Wetting of the air intake for HVAC
  - Wetting of components, in particular metallic components, in the water box located under to root of the front window

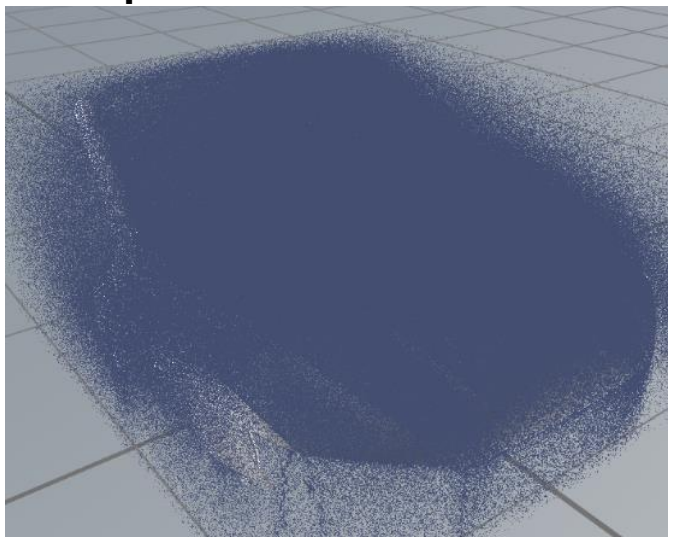
Rain Source



Rain – Mainly visible the wetted surface



Rain – Mainly visible the rain in space



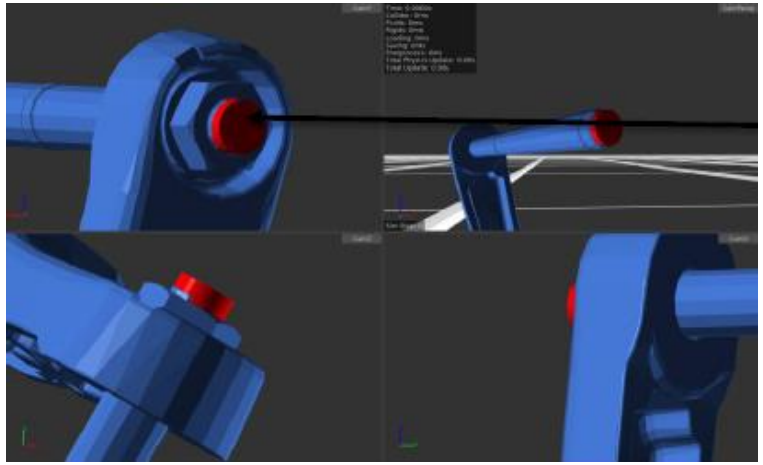
Bildquelle: D. Bäder, F. Paur, M. Ehlen: Simulation of the air intake of the air conditioning unit of a vehicle in heavy rain , NAFEMS 2018

Modeling of the Movement of the Windscreen Wipers

Definition of the movement:

- Very complex movements can be modeled
- Different rotational velocities around different pivots can be defined
- The real movement of the pivots can be defined
- A challenge is the bending of the wiper itself

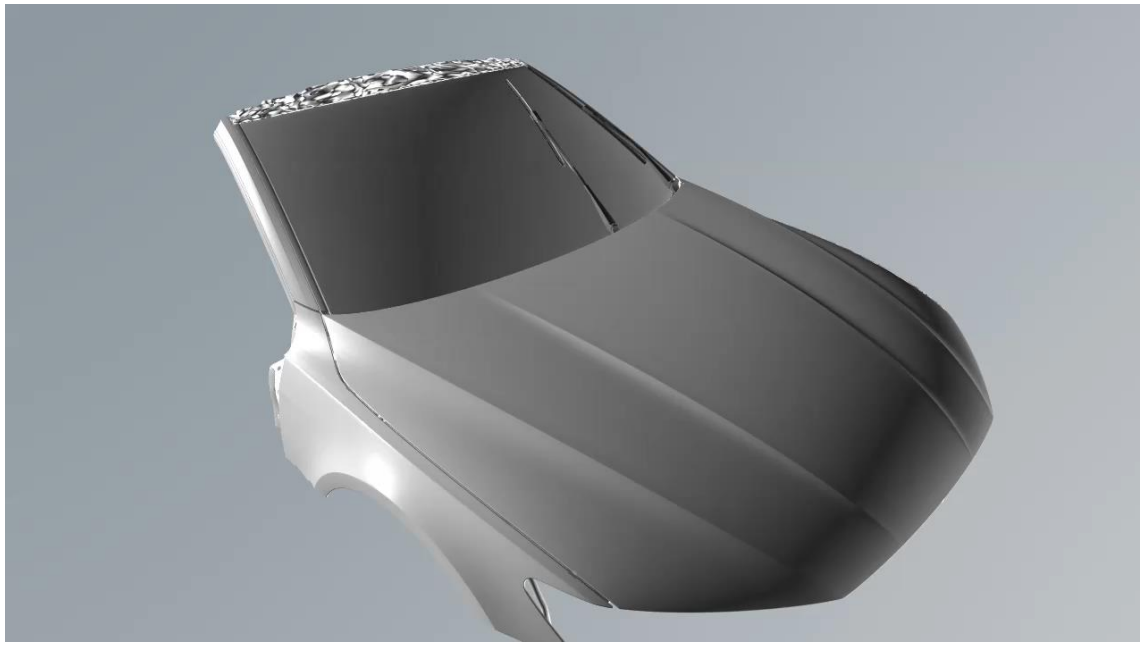
Pivots



Wiper rods

Visualization of the wiper movement:

- Audi A6
- Only front part of the geomtry is used



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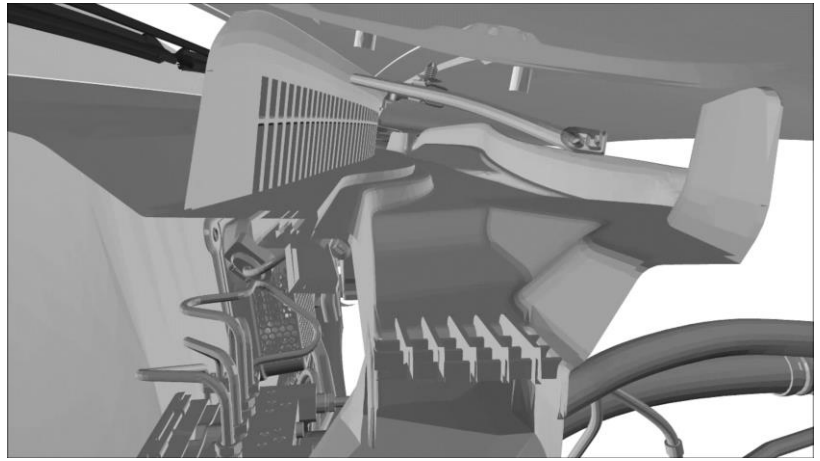
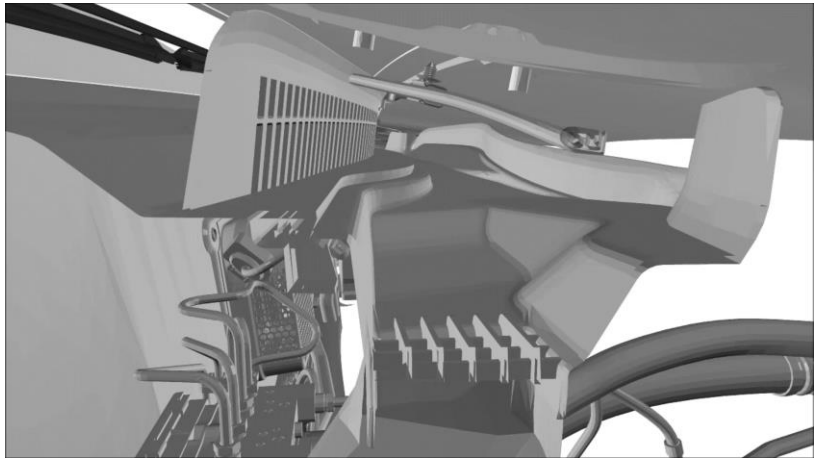
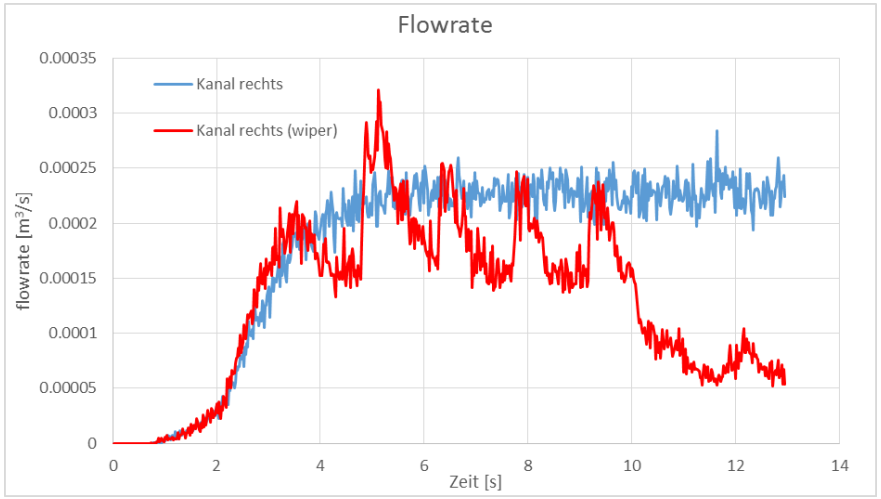
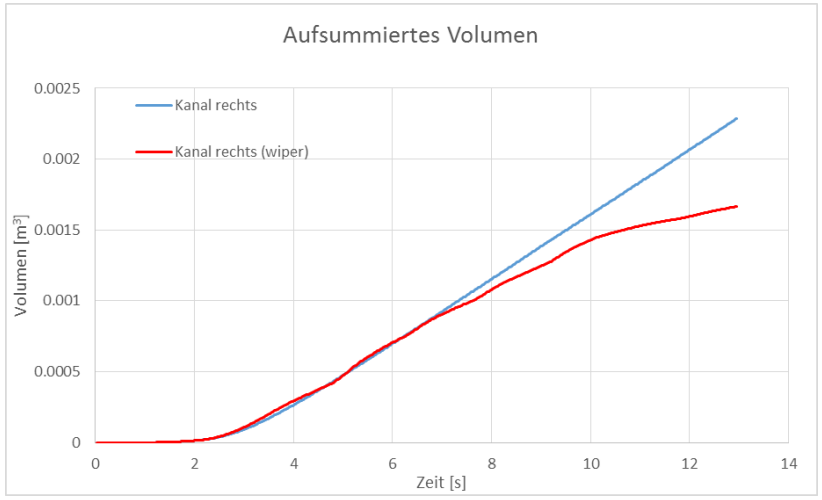
Influence of Wiper Movement









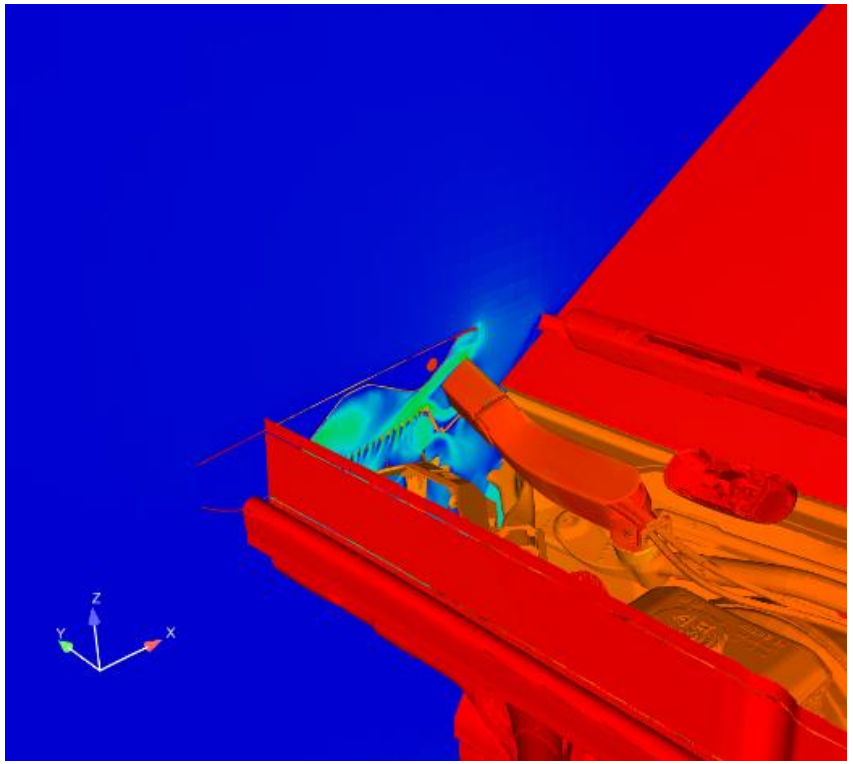
Bildquelle: M. Ehlen: Juni 2017

Simulation of the Influence of the Airflow Field

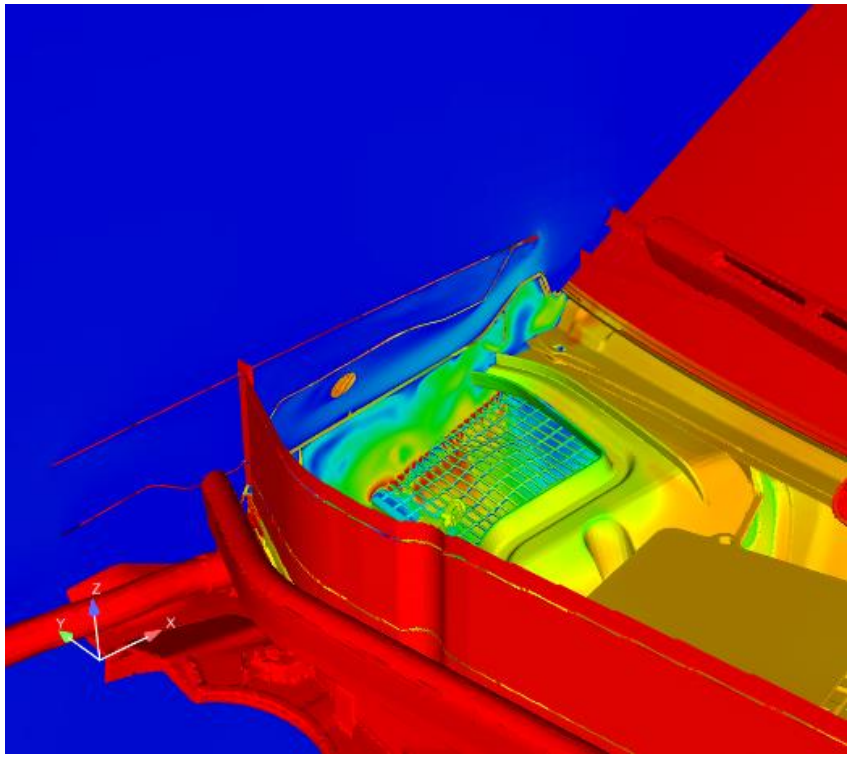
Bildquelle: D. Bäder, F. Paur, M. Ehlen: Simulation of the air intake of the air conditioning unit of a vehicle in heavy rain , NAFEMS 2018

- Simulation of the Airflowfield using FV-Methods, in this case with OpenFOAM®
- Standard-RANS simulation seem to be good enough, averaged DES or LES seem to be too computationally too expensive

Cut through y = 0 m



Cut through air inflow

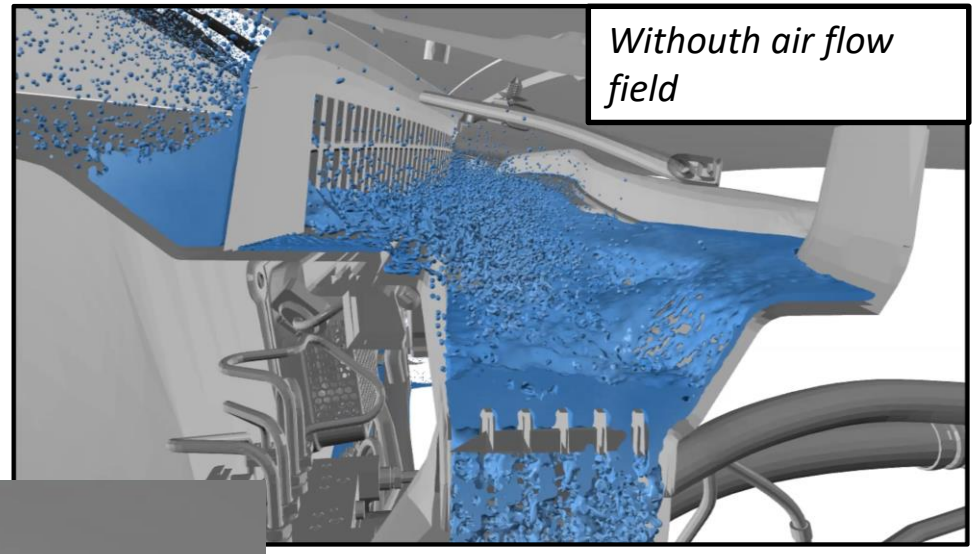


On the surface: The pressure is visualized (red high pressure, blue = low pressure)
On the plane: The velocity is visualized (red = high velocity, blue = low velocity)

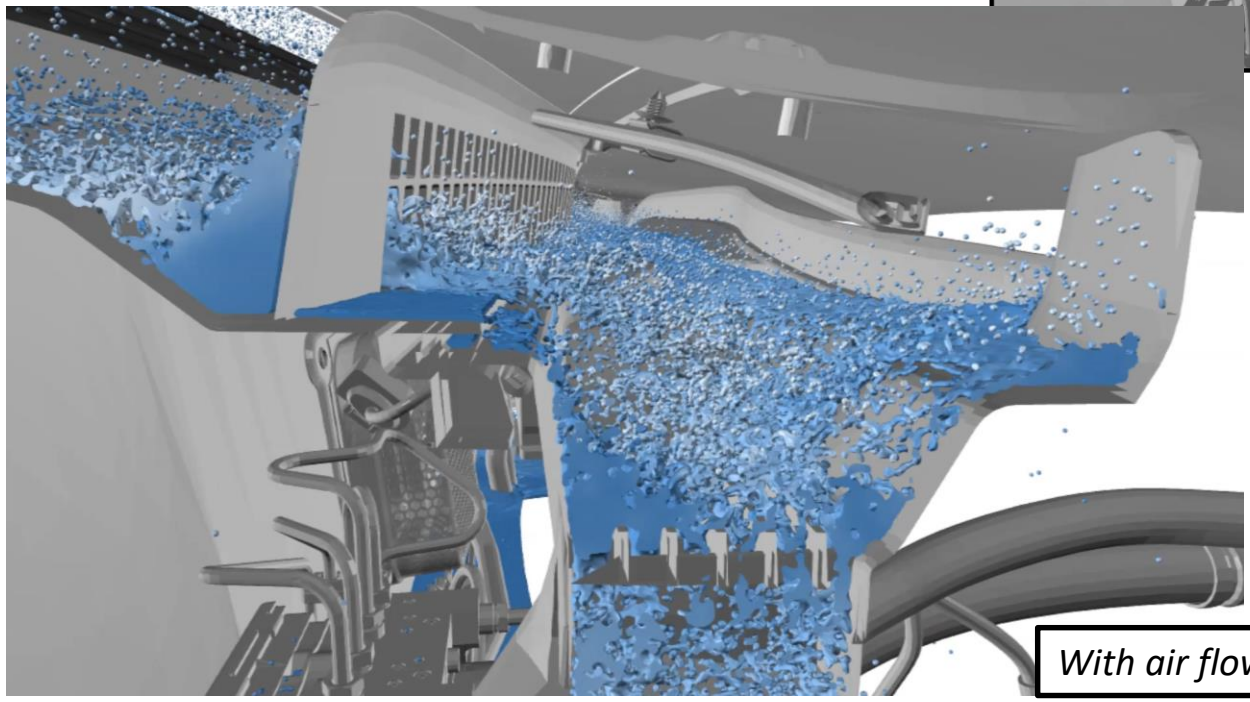
Evaluation of the rain simulation

Cut through the right drain channel

- Influence of the Air-Flow field is recognizable
- Influence of the Wiper Movement
- Investigation of the flow through the drain channel



Withouth air flow field



With air flow field

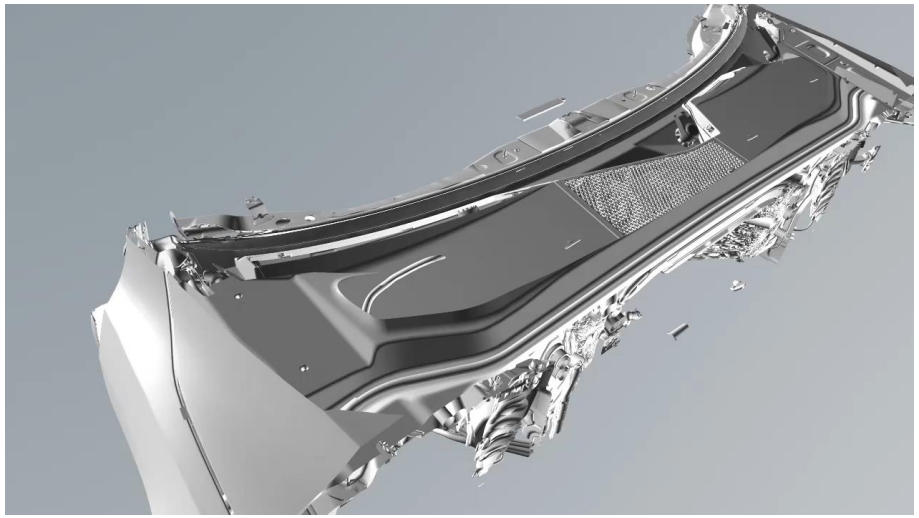
Bildquelle: M. Ehlen: Juni 2017

Results Wiper Movement + Airflowfield

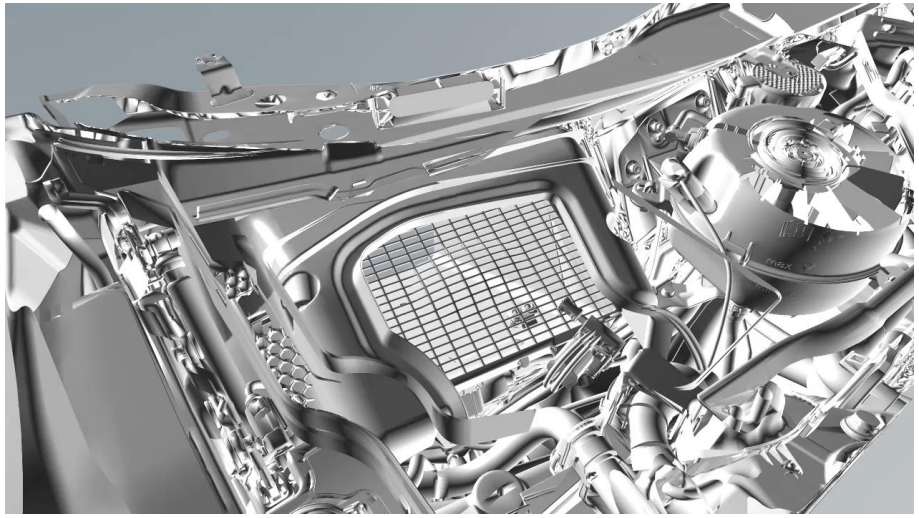
Bildquelle: D. Bäder, F. Paur, M. Ehlen: Simulation of the air intake of the air conditioning unit of a vehicle in heavy rain , NAFEMS 2018

Movies

Overview

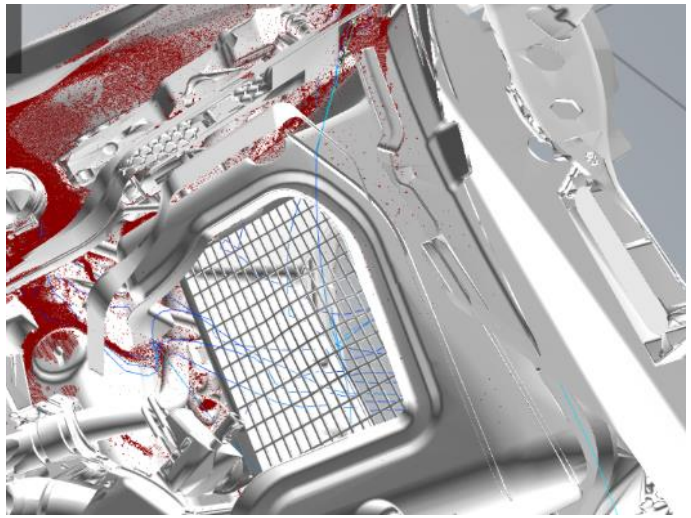


Detail around air suction

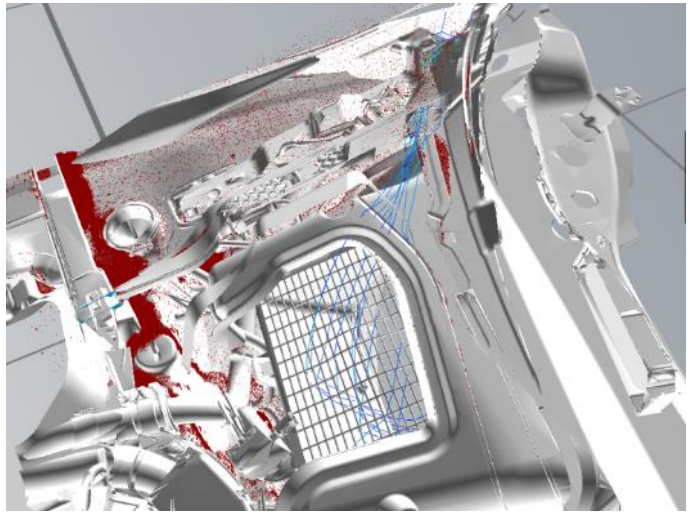


Static Pictures

Variant A with intentional leakage



Variant B without leakgae, but inclined vehicle (17°)



Summary and Outlook

Summary

- Challenging times need new simulation methods

- Simulation of water management of a real vehicle is established in the development process

- Necessary boundary conditions, depending on the type and the position of the part that needs to be investigated:
  - Wiper movement
  - Air flow field
  - Force field from real driving conditions

Outlook

- Better modeling of the bending of the rubber of the windscreen wipers

- Coupling of the unsteady air flow field due to different vehicle velocities and different driving directions with the water simulation

- Validation of complex simulation inlcuding wiper movement, air flow field and acceleration forces