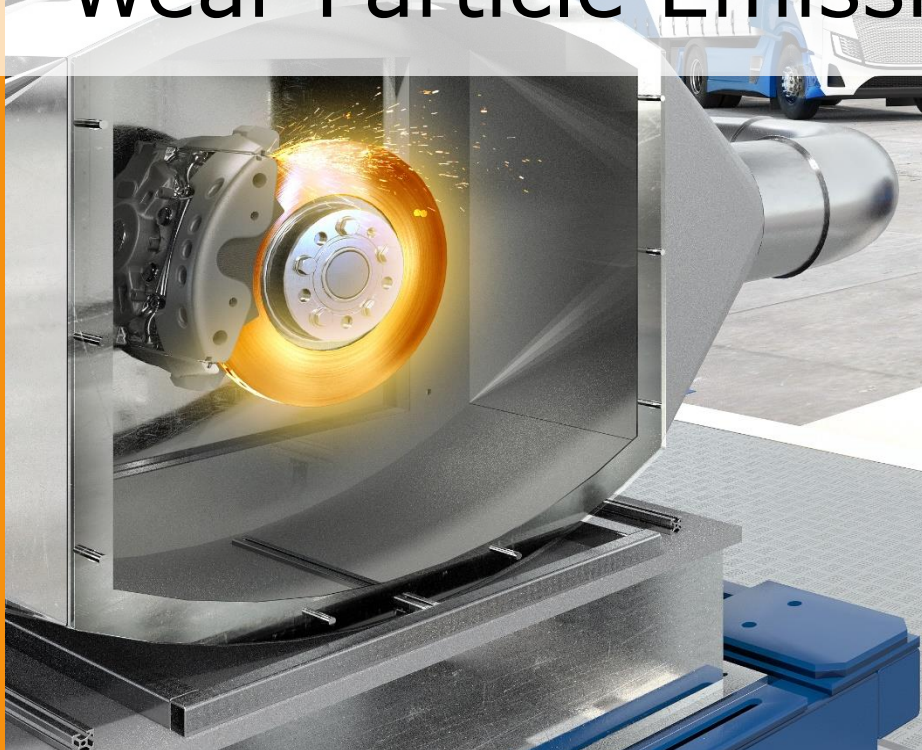
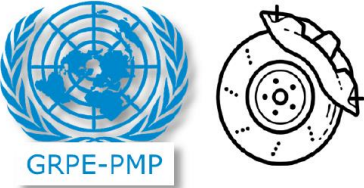




Measuring a Vehicle's Real-World Brake Wear Particle Emissions on Public Roads



From United Nations Global Technical Regulation UN GTR to EURO 7 – Brake Emission Measurement



GRPE-PMP

PMP Working Group

2017 - 2022



GRPE-PMP

UN GTR Brake official release

Jan. 2023



European Commission

EU7*
Incl. Brake Particle Emissions
(M1 & N1)

July 2025



European Commission

EU7*
Incl. Brake Particle Emissions
(M2, M3, N2, N3)

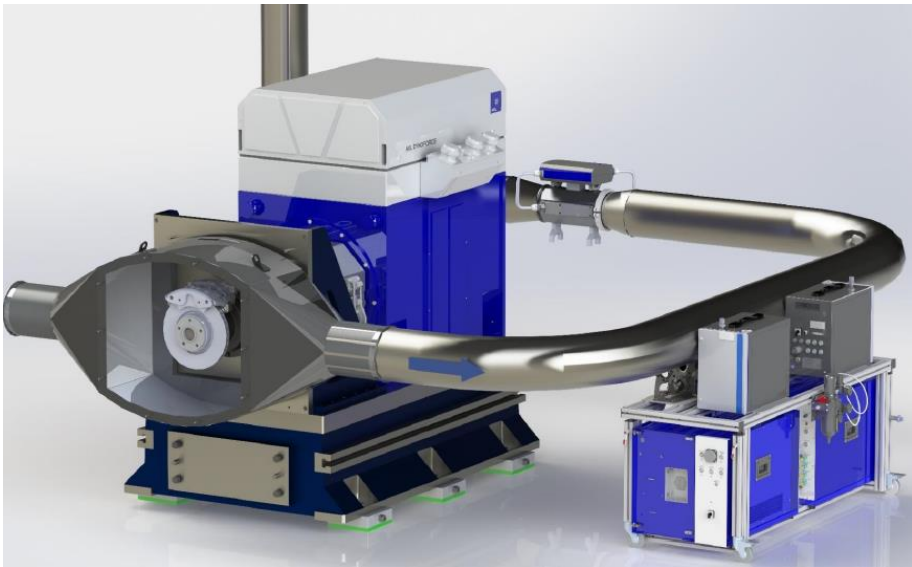
July 2027



European Commission

EU7*
Brake Particle Emissions RDE**
Tire Abrasion

202x – 203x

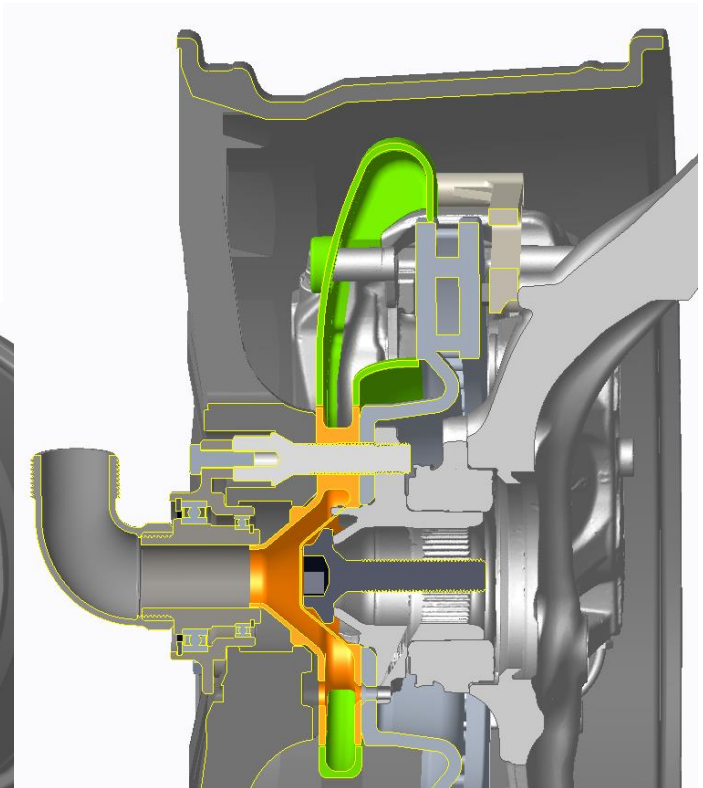
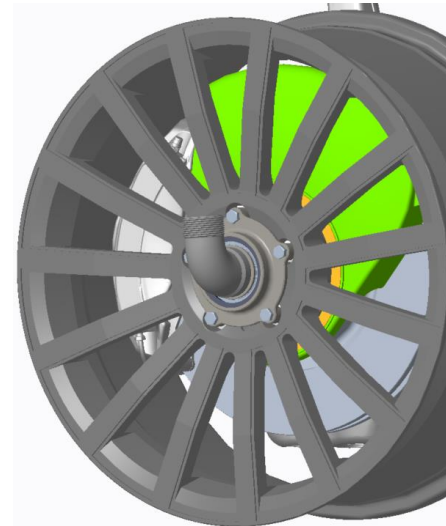
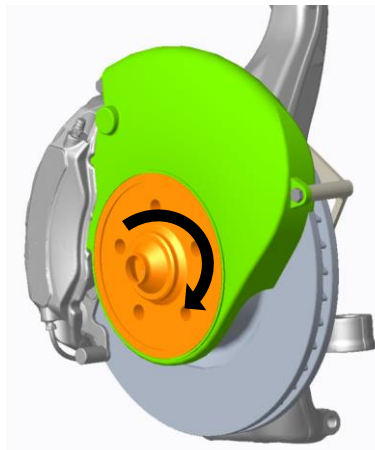
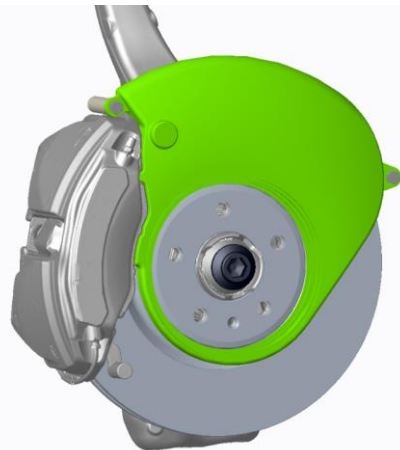
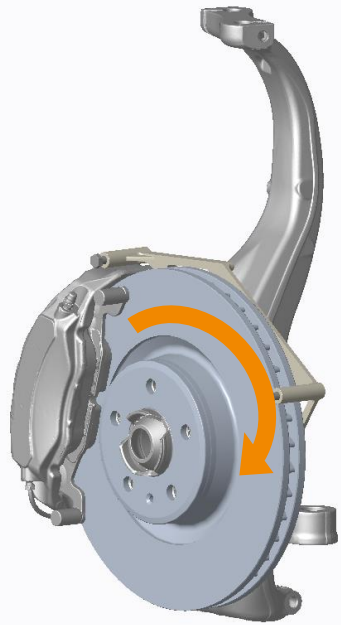


PM₁₀

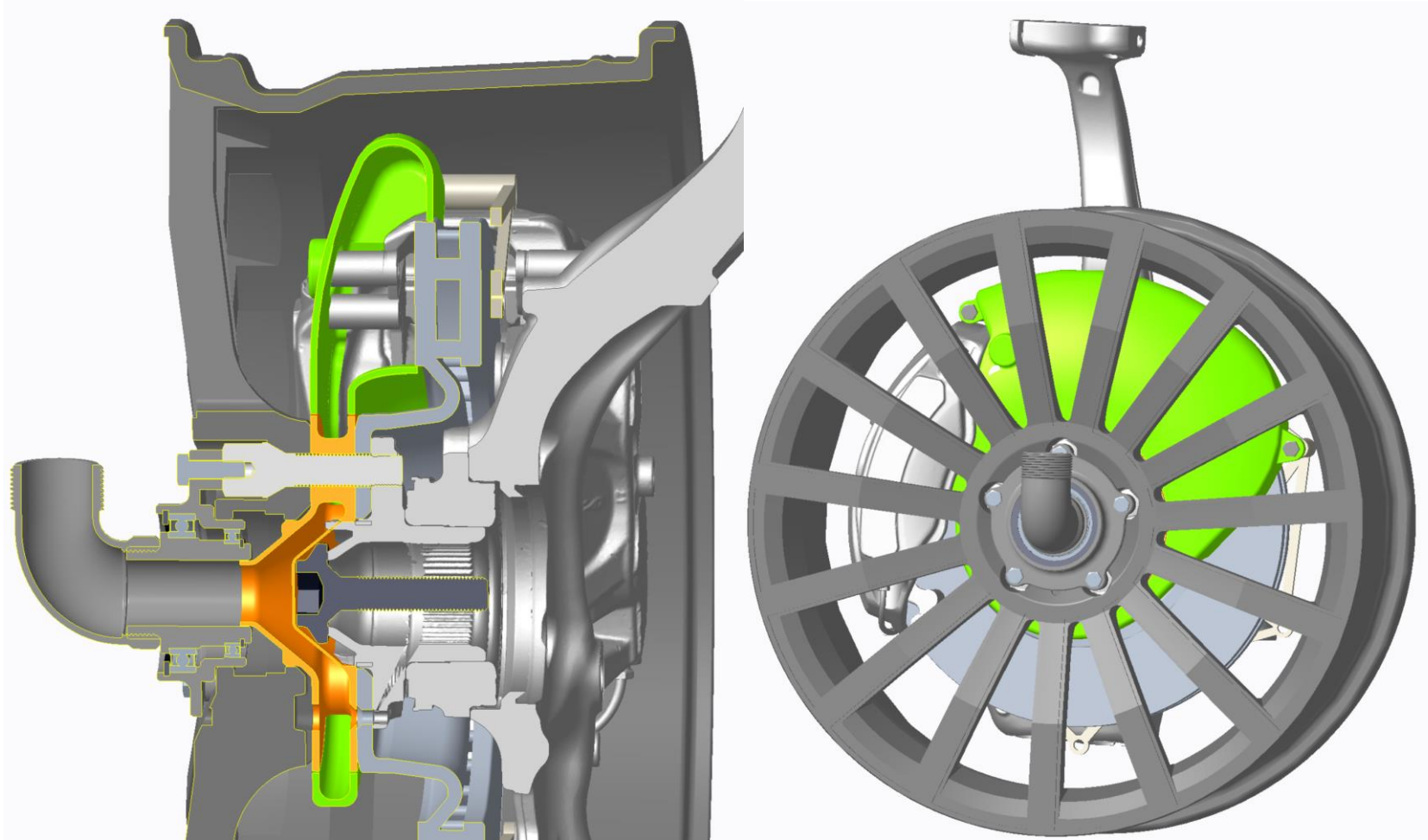
7 mg/km/vehicle



RDE Brake Wear Sampling System

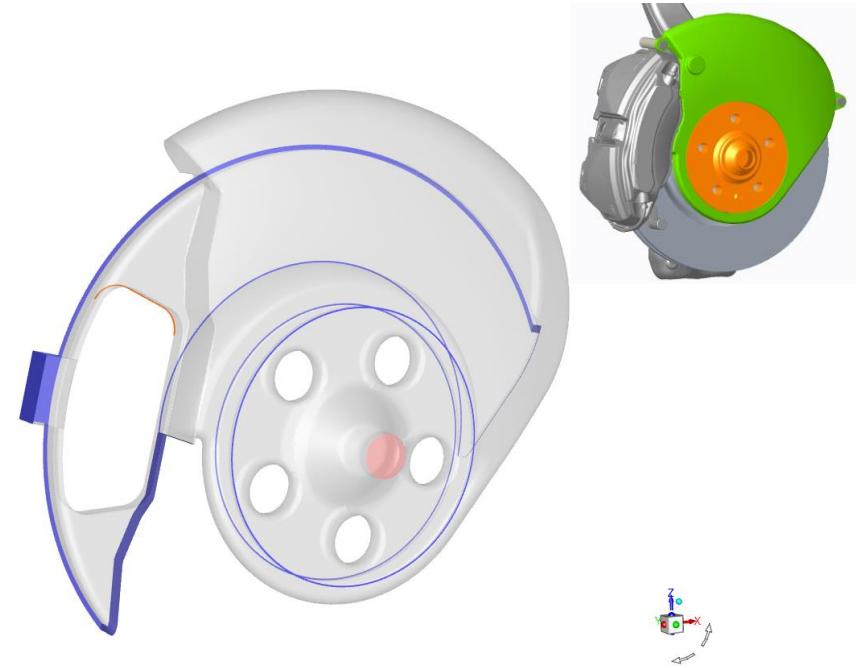


RDE Brake Wear Sampling System



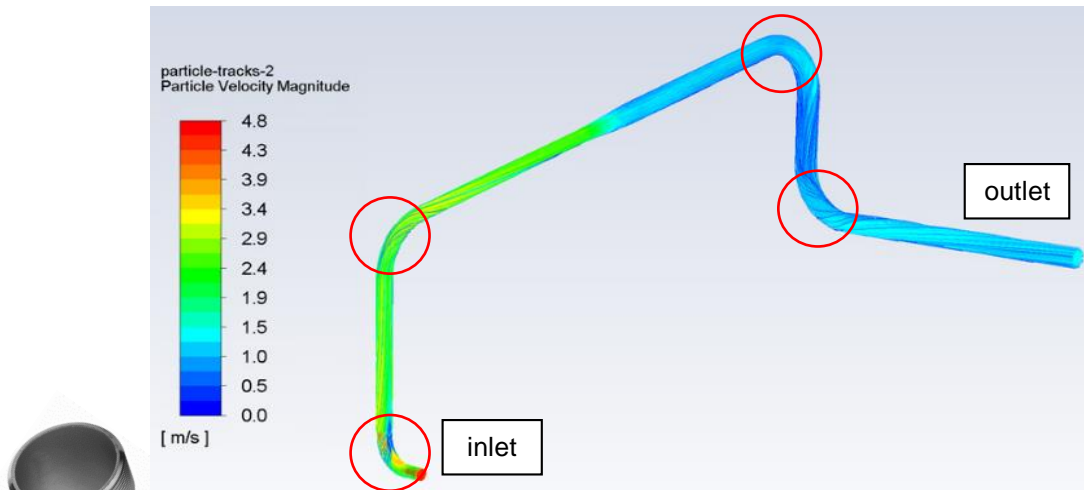
- Sufficient natural cooling
- No influence on brake temperature
- Assuming symmetric release of particles

CFD Particle Tracking



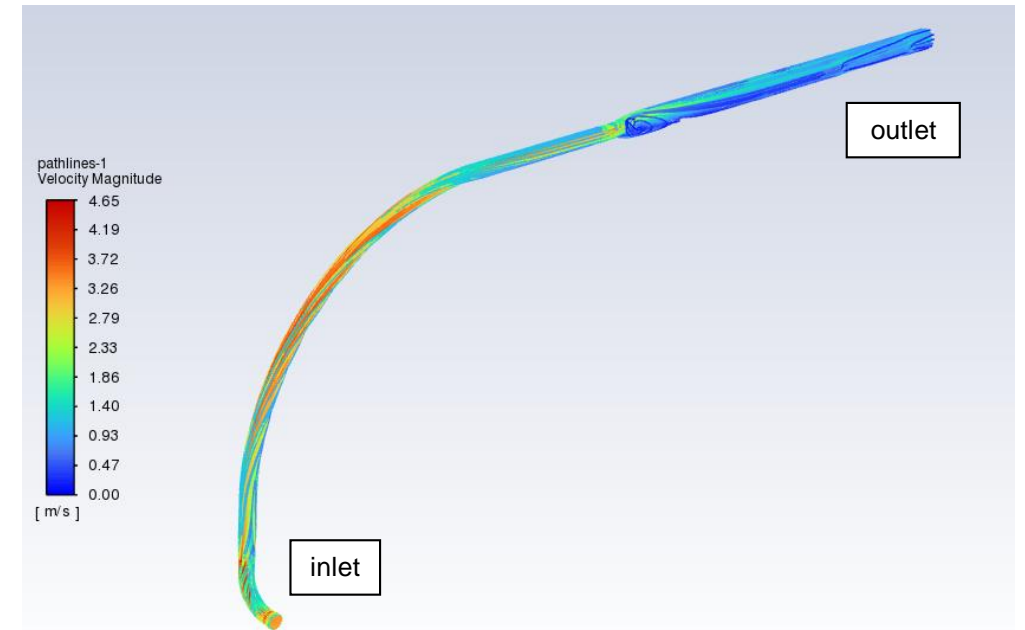
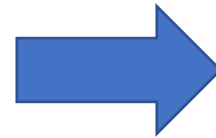
- Colours represent different injection zones at the brake pad
- Particles follow the rotation
- Key parameters:
 - Extraction flow
 - Gap size

CFD Simulation – Sampling Line



	PM2.5	PM10
Particle output	91.3 %	50.0 %

- Inertial losses
- Gravitational losses



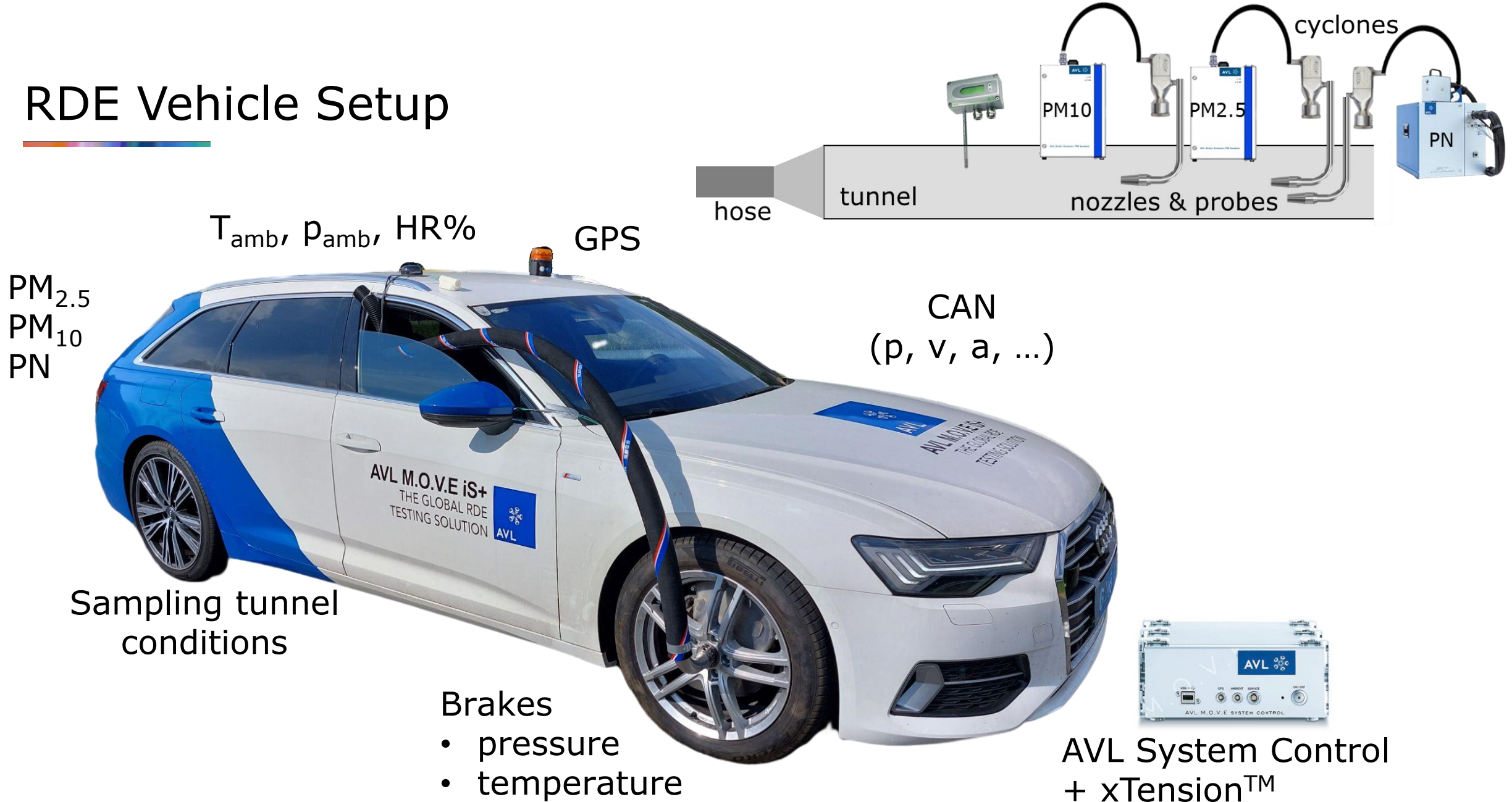
	PM2.5	PM10
Particle output	96.8 %	90.8 %

- Reduced length & horizontal passages
- Reduced 90° bends & increased bending radius

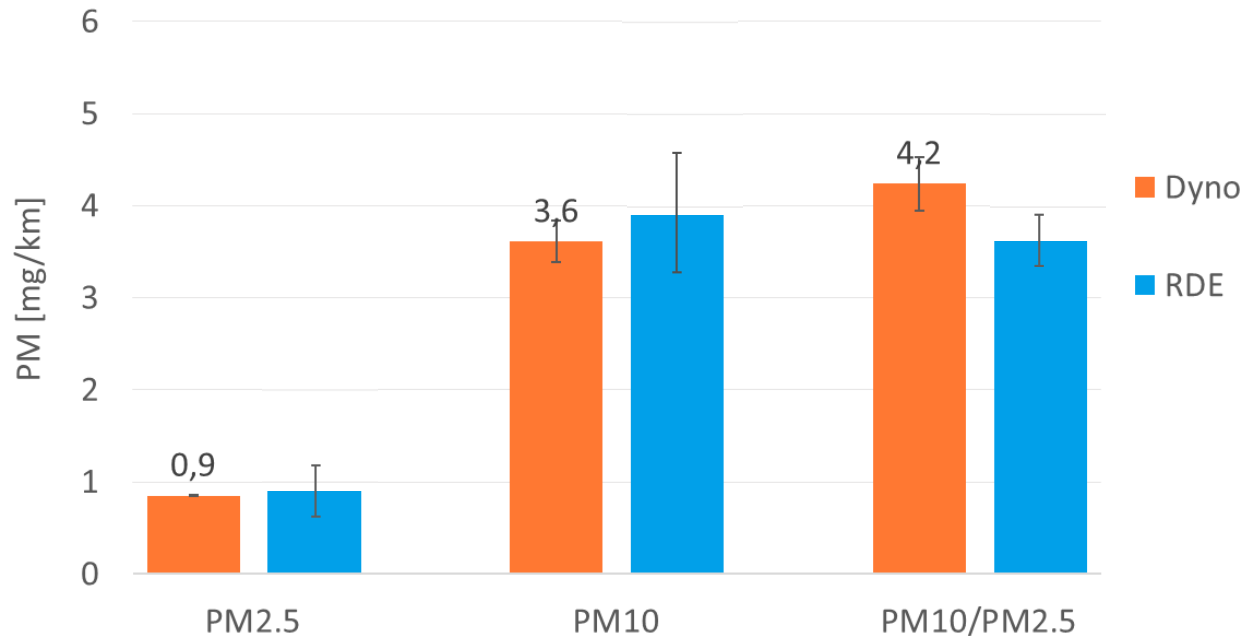
RDE Brake Wear Sampling System



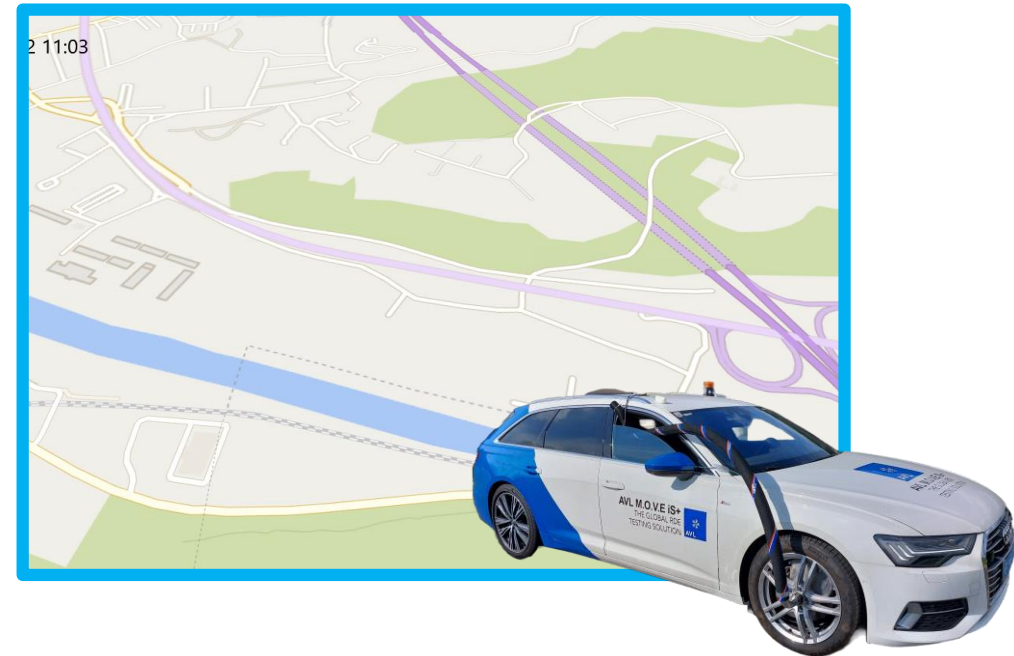
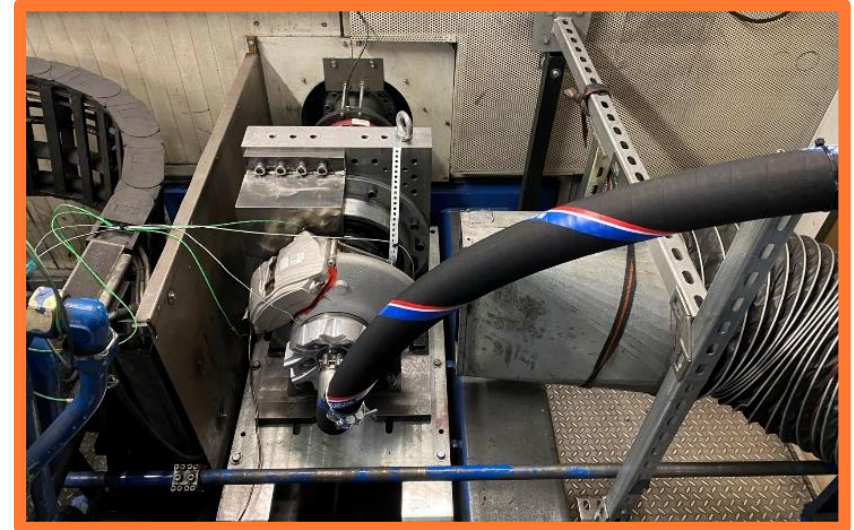
RDE Vehicle Setup



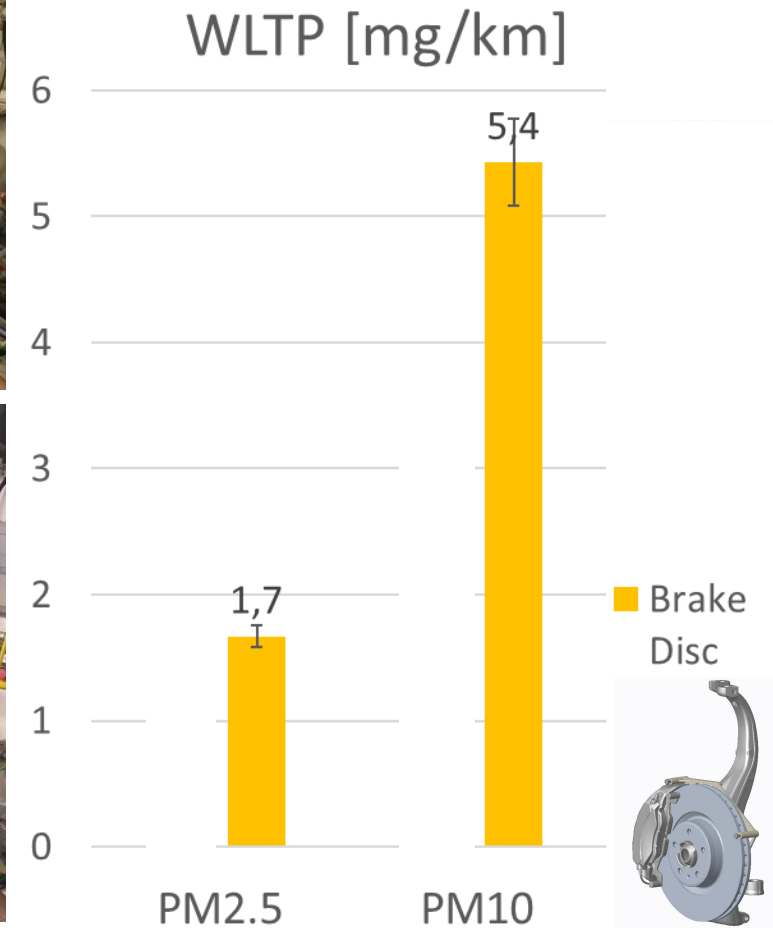
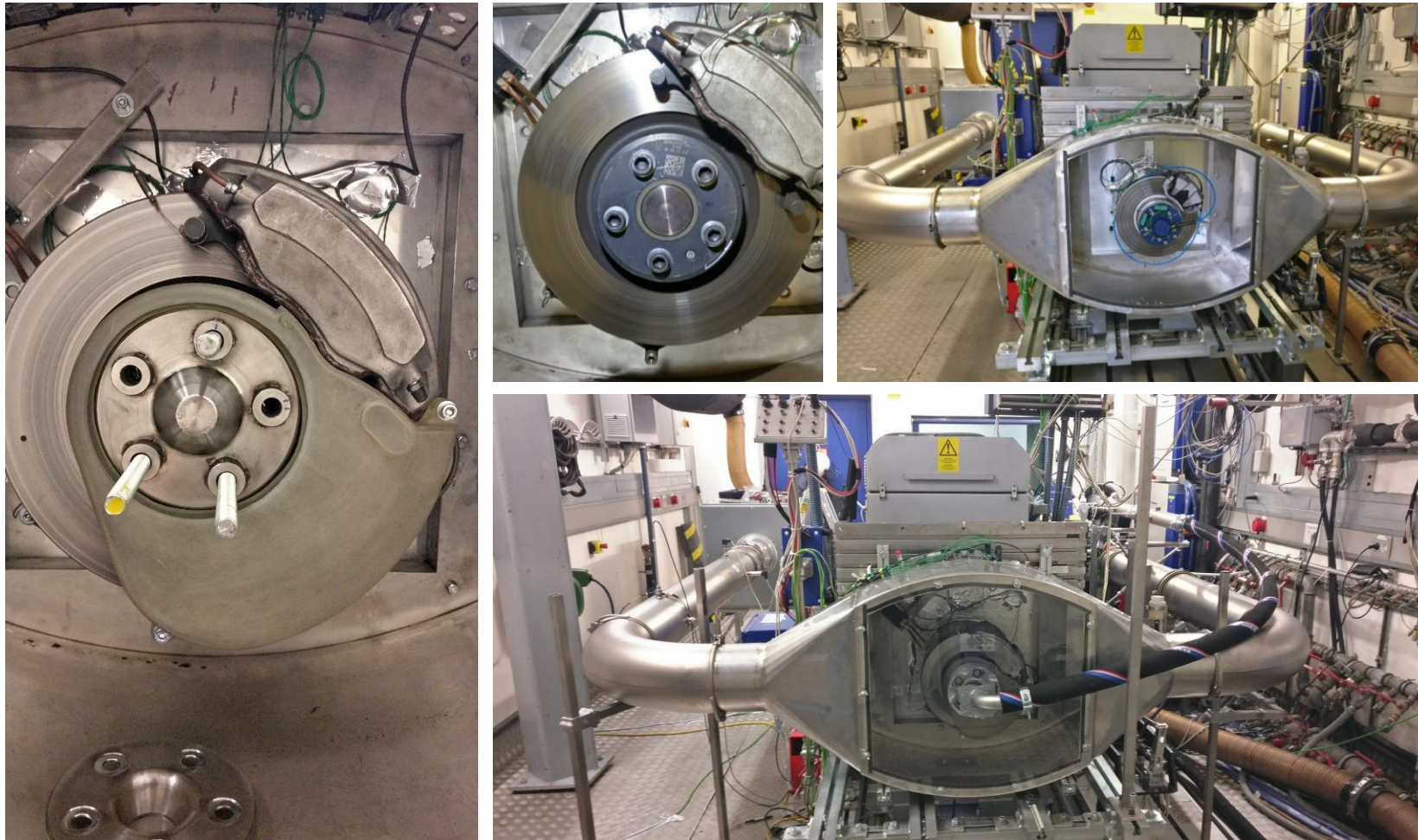
Comparison – Dyno vs. Test Track



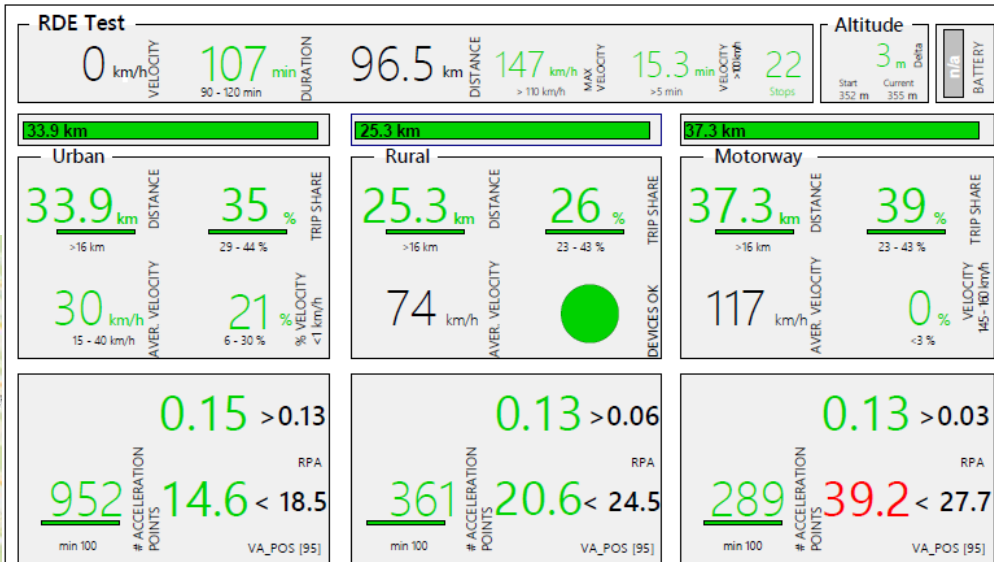
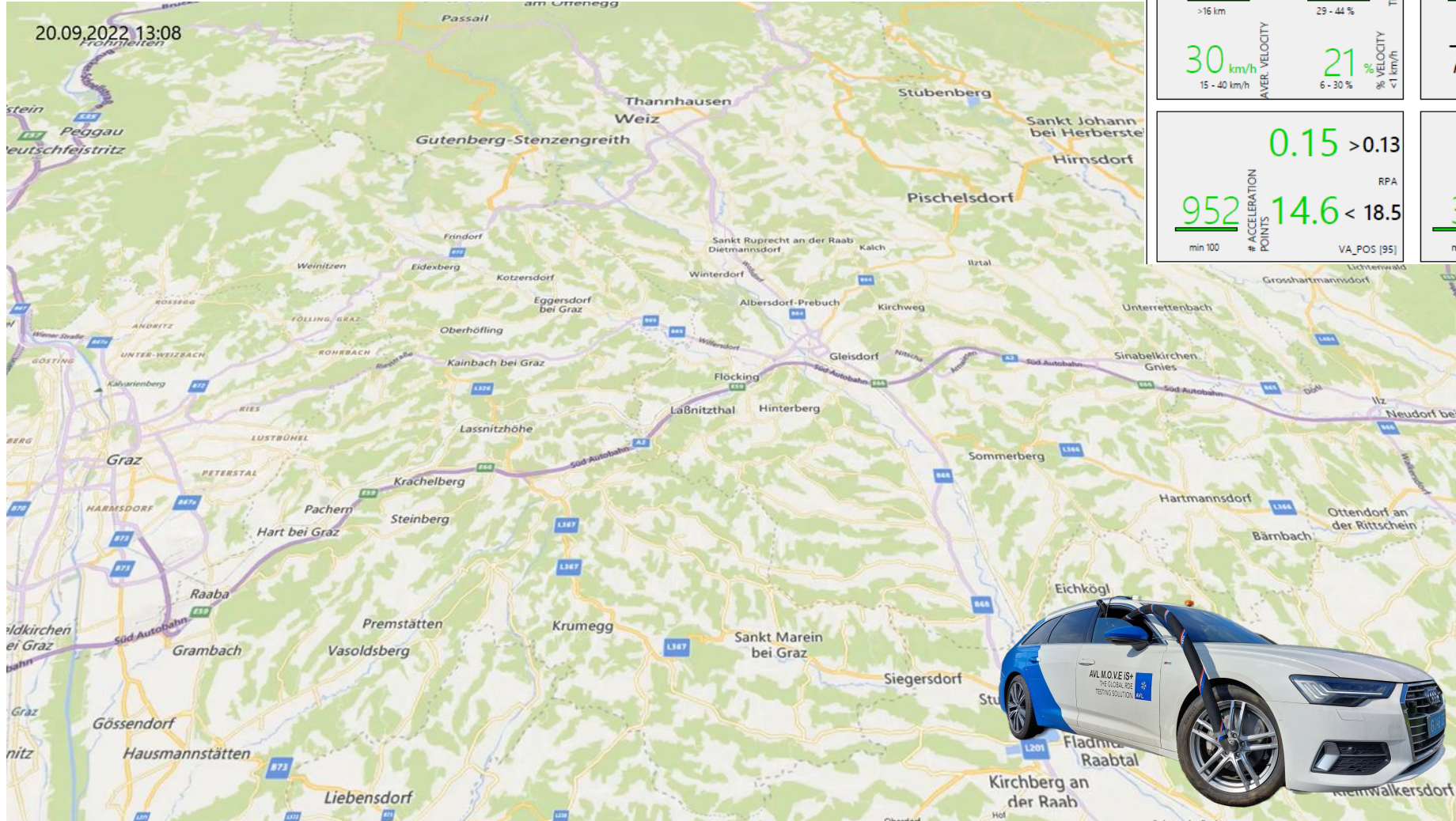
PM₁₀: 7-8 mg /km/brake



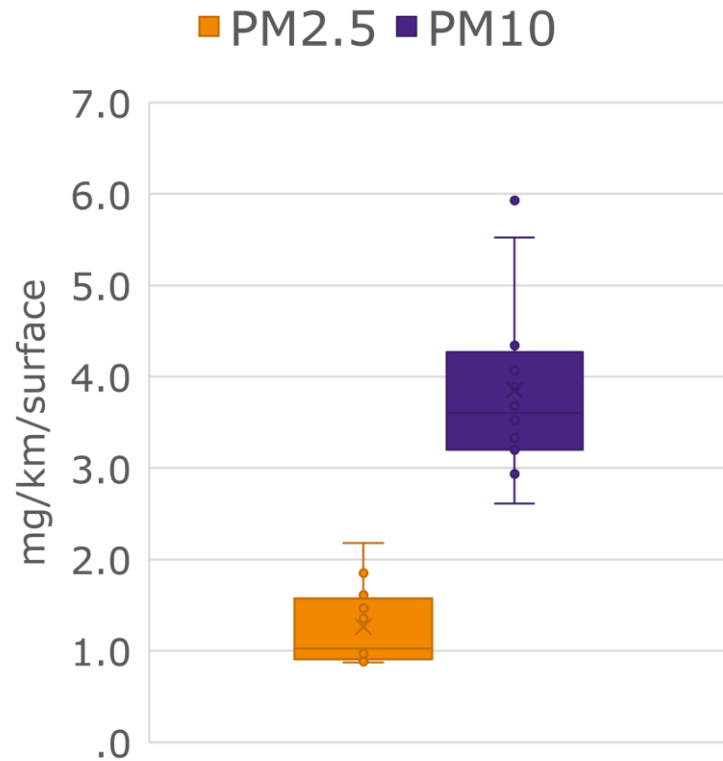
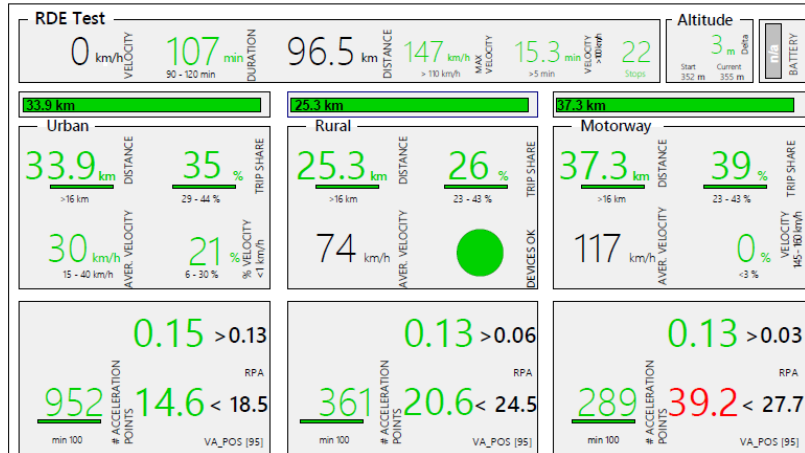
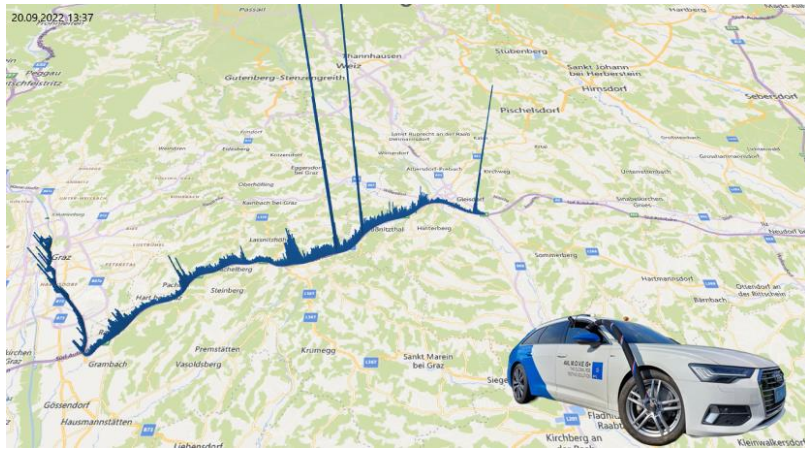
Results – RDE System @ AVL Brake Dyno



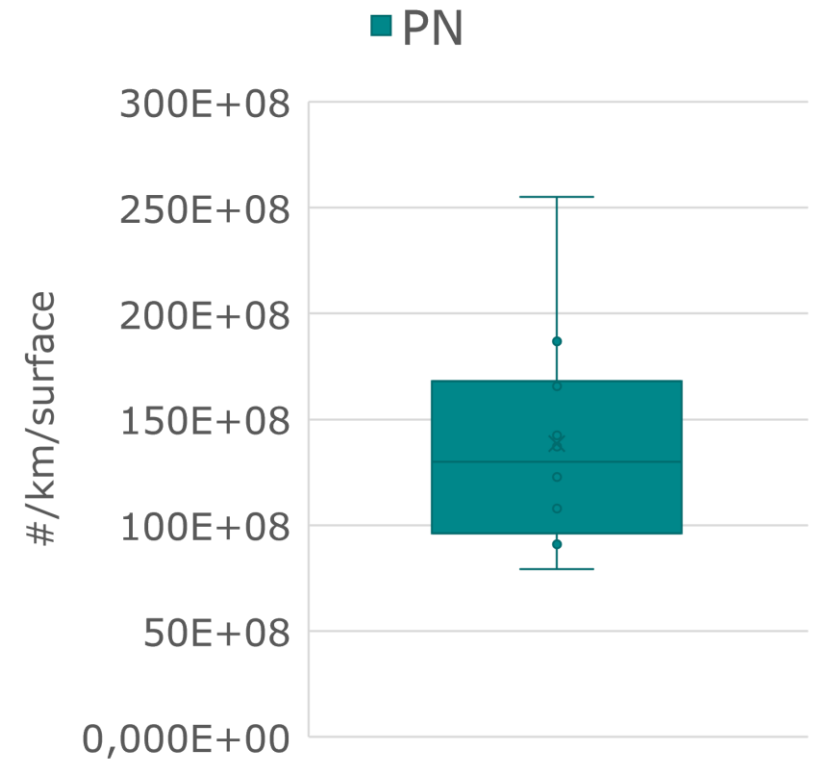
RDE Tests in Graz, Austria



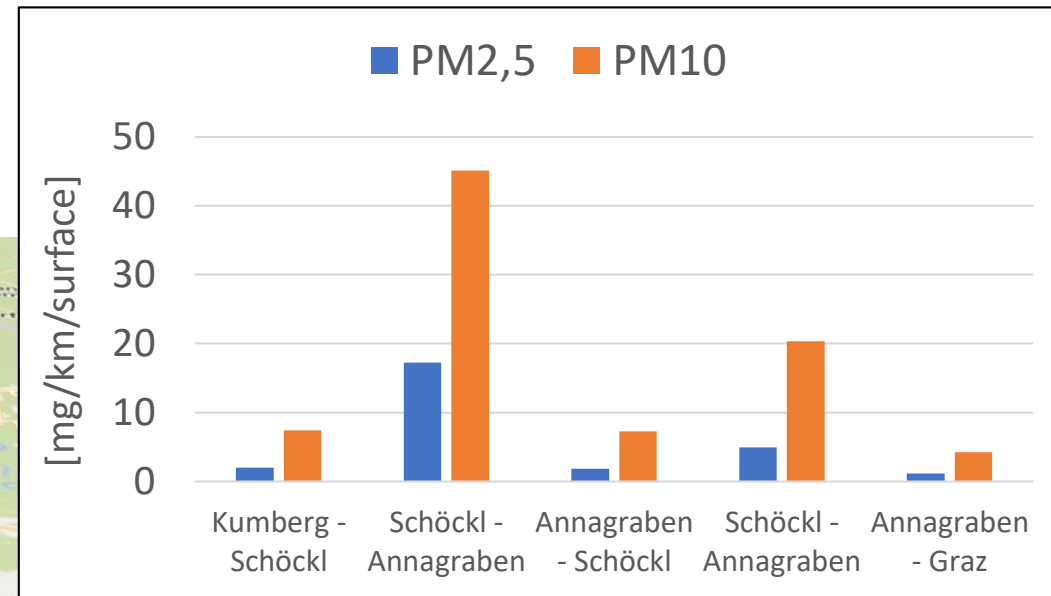
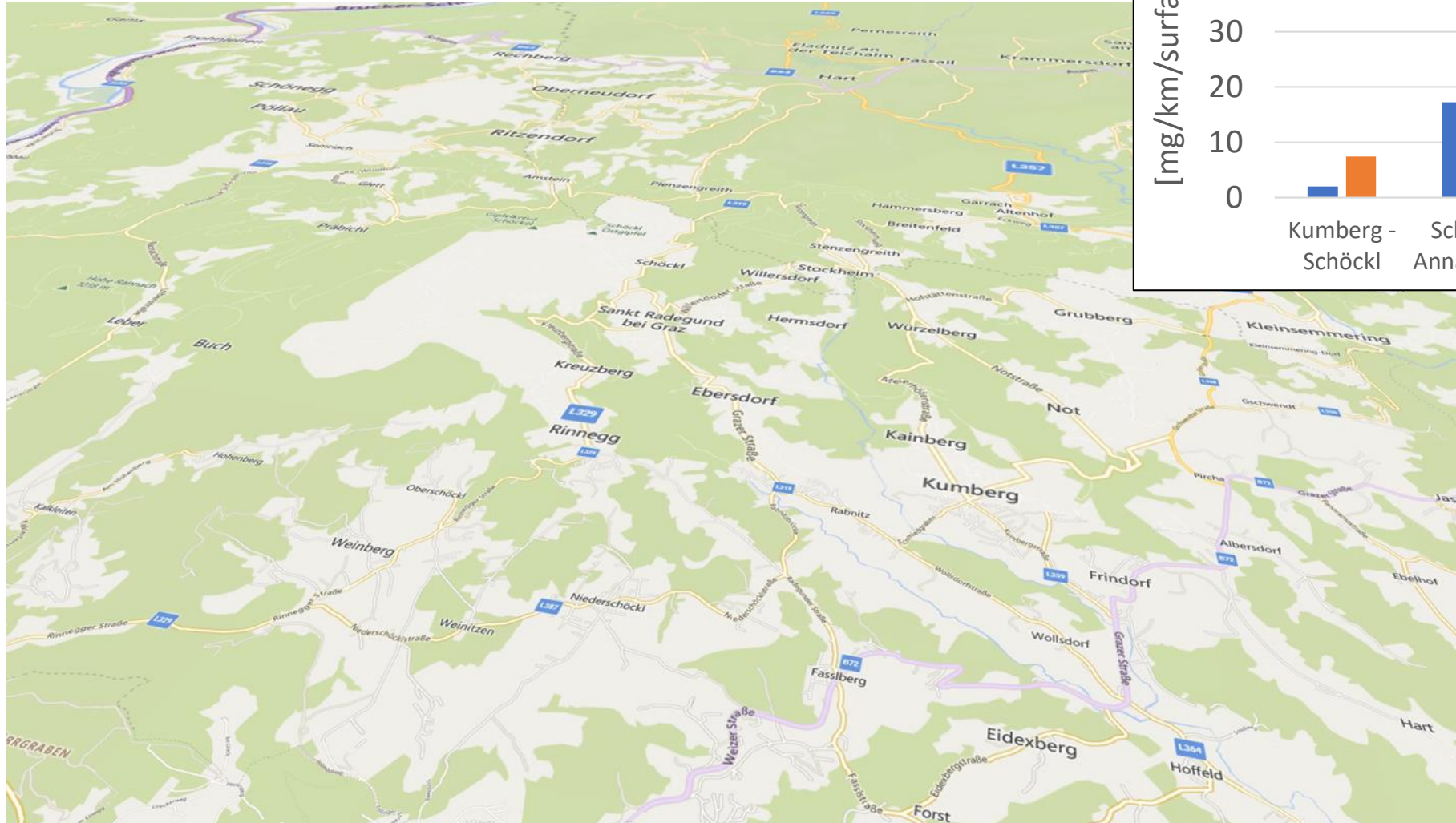
Results – RDE Tests in Graz, Austria



PM₁₀: 7 mg/km/brake



Extreme Scenario – Mountain Road



Brake T > 450 °C
 Brake T > 840 °F

PM₁₀:
 90 mg/km/brake

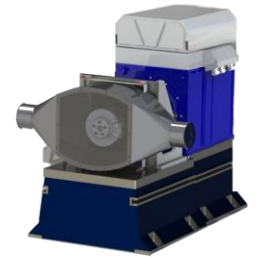
Conclusion

- Vehicle's correct **natural temperature behavior** to assess **real-world brake emissions**
- RDE sampling system has **no impact on the brake temperature**
- Good agreement between dyno and RDE test results under same conditions
- Recording of **all RDE relevant measurement data**
(brake pressure, temperature, speed profile, GPS, ambient conditions, flow...)



Euro7 PM₁₀ limit

7 mg/km/vehicle





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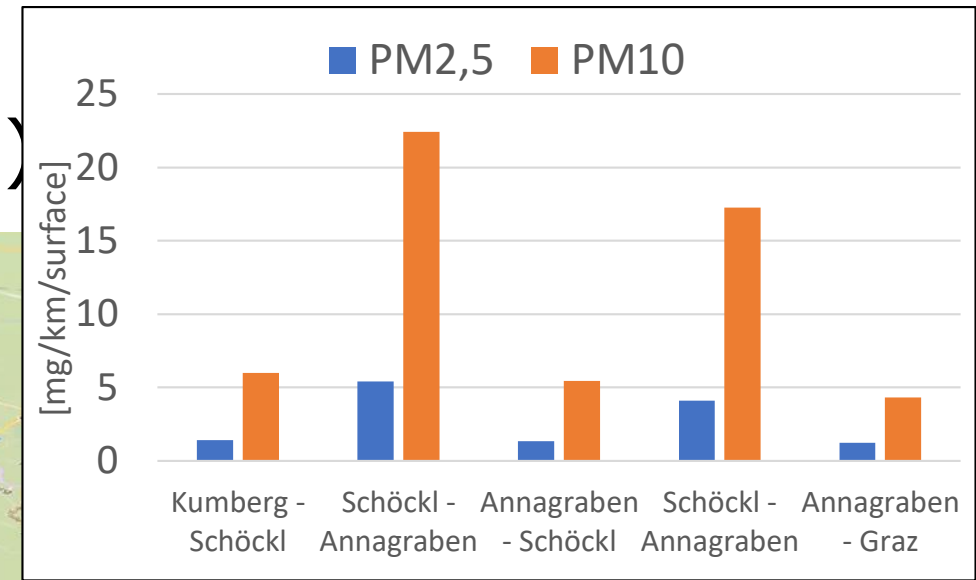
AVL



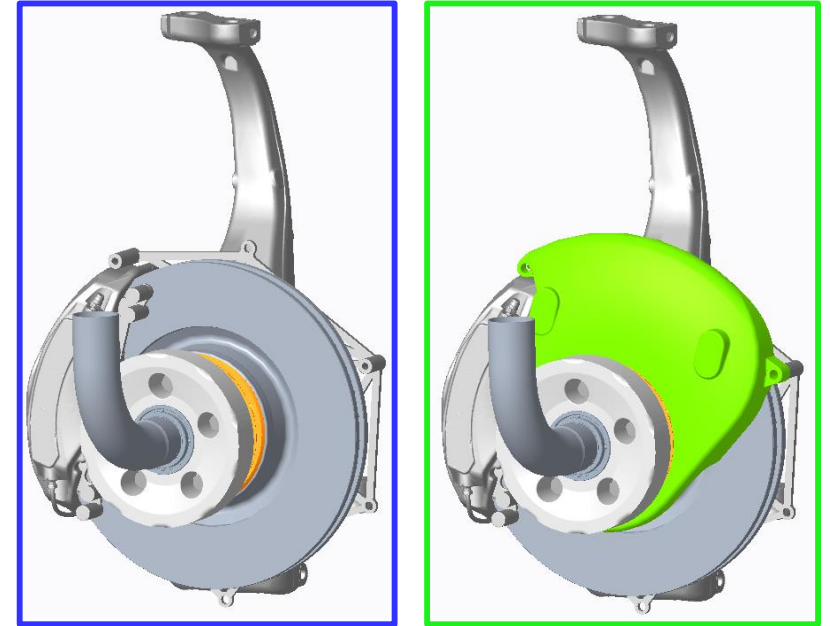
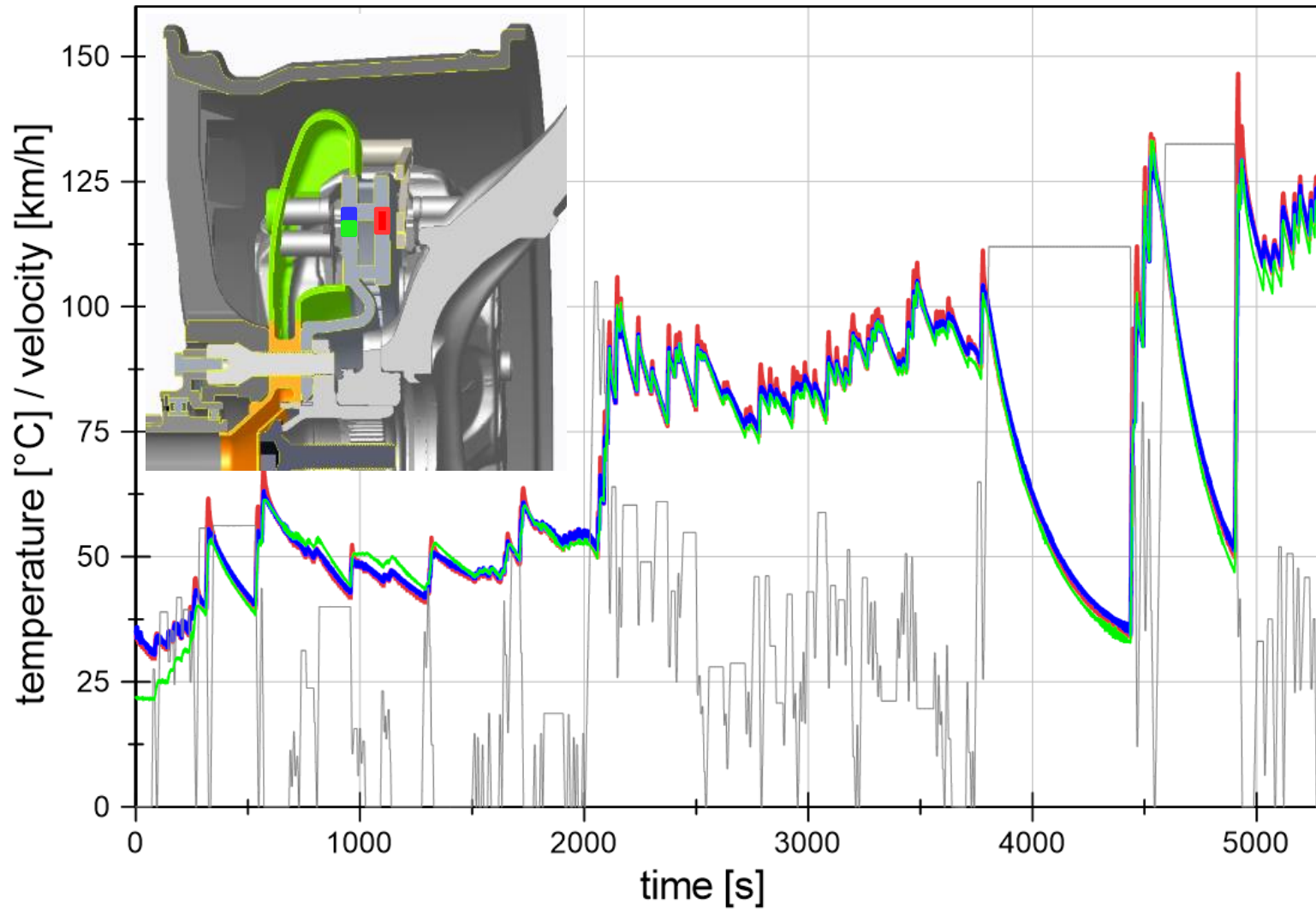
Thank you!



Extreme Scenario – Mountain Road (1)



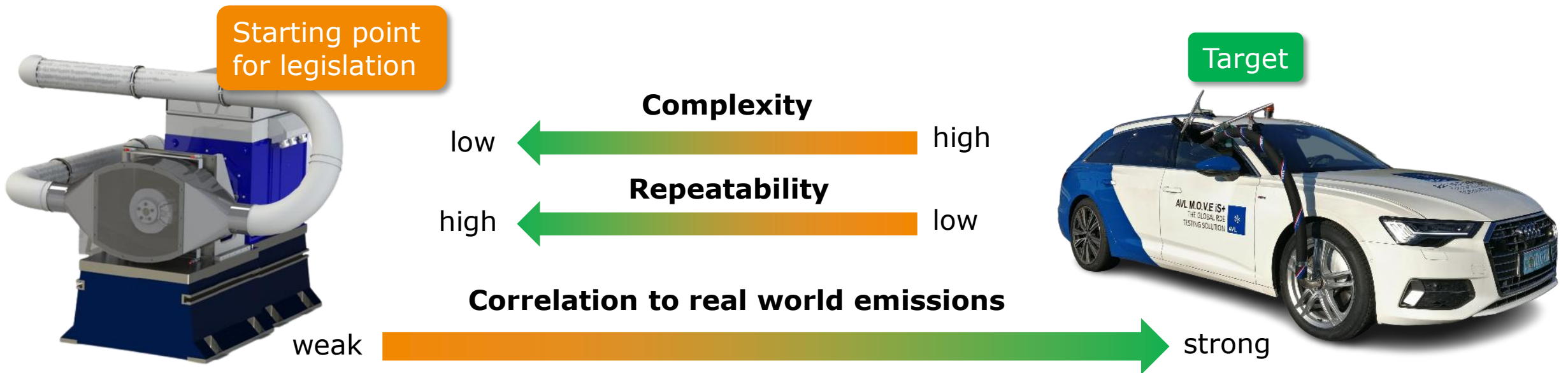
Results – Temperature Impact



ABT, IBT, FBT: ± 2 °C

Real Driving Emissions (RDE) measurement

- **Validate** WLTP based **test bench** environment
- Investigating the effects of **different driving characteristics** and **ambient conditions**
- **Real world TEMPERATURE** and emission behaviour
- **Geographically varying emissions** – influence of descents
- Fill knowledge gaps – **regenerative braking**
- Driver for legislation



Passive Pedestrian Safety



Introduction



Michael Peter Huber

- PhD, Institute of Automotive Engineering, TU Graz, Austria
- Research Engineer, AVL List GmbH

Research Focus

- RDE Brake Wear Particle Emissions
- Tire Wear Emissions



Zukünftige Untersuchungen – Korrosion

