Contents of Work Package 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

Coordinator of the WP

České vysoké učení technické v Praze, Vojtěch Klír

Participants of the WP

VUT v Brně, J. Fišer, M.Omasta, Univerzita Pardubice, P. Voltr, ŠKODA AUTO a. s., J. Hrnčíř, M. Klofec, J. Hradiský, TUV SÜD Czech, J. Trubač, Tribotec, spol. s r.o., P. Rosendorf, Škoda Transportation, P. Špalek

Main Goal of the WP

Complex coverage of the issue of particles generated by the car, trains and their monitoring. Particles generated by brakes + tires, emissions from powertrains = emissions. Particles in the environment / surroundings of the vehicle + technologies for their measurement at the vehicle level, their penetration into the cabin, exposure for humans in the crew space = immissions of particles, their measurement and mitigation of their effects on human health.

Partial Goals for the Current Period

Use of knowledge for the construction of systems for removing particles/aerosols from the environment for the crew.

Critical review about possible solution for future combustion engines. Test bench for particle measurements – design.

Development of experimental approaches towards the knowledge base for the R&D of materials and technologies for low-emission rail transport while focusing on non-exhaust emissions.

Contents of Work Package 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

Official 3-WP08 Deliverables:

- 3-WP08-001: **Engine control strategy and aftertreatment setup toward EU7 limits fulfillment**, G-funk, V./2026, CVUT FME 0.6; SA 0.3; TÜV SÜD 0.1
- 3-WP08-002: **Test bench for particle measurements**, G-funk, V./2026, CTU FME 0.4; TÜV SÜD 0.3; SA 0.3
- 3-WP08-003: **Technologies for aerosol concentration mitigation in vehicle cabins - feasibility study**, O – ostatní výsledky, XII./2025, BUT FME 0.7 , CTU FME 0.1, SA 0.2
- 3-WP08-004: **Description of vehicle emission behavior in the lab. and under real driving conditions - methods and procedures for measurement in context of regenerative braking systems**, O – ostatní výsledky, XII./2024, CTU FME 0.5; BUT FME 0.2; TÜV SÜD 0.1; SA ost. 0.2
- 3-WP08-005: **Device for an evaluation of particulate matter emissions from railway sanding (ZV)**,G-funk, XII./2024, BUT 0.65; TRIBT 0.2; ŠTRN 0.1; UPa 0.05
- 3-WP08-006: **Research on the traction enhancers and technologies towards low non-exhaust emissions**, O – ostatní výsledky, G-funk, VI./2026, BUT 0.65; TRIBT 0.2; ŠTRN 0.1; UPa 0.05

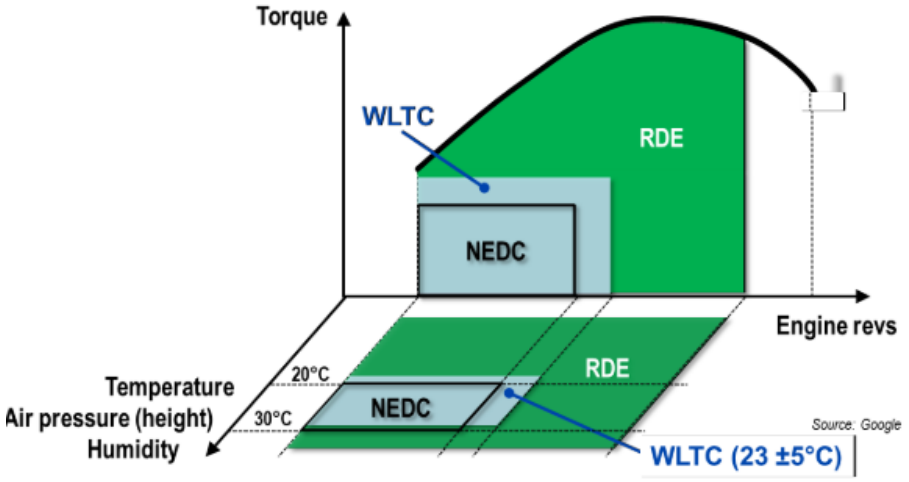
Activities in 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

3-WP08-001: Engine control strategy and aftertreatment setup toward EU7 limits fulfillment

CVUT FME 0.6; SA 0.3; TÜV SÜD 0.1

Monitoring & obtaining knowledge from EU7 proposal (still running).
Critical review about possible solution for future combustion engines.
Euro7 – RDE CF=1 for NOx and PN
Particles from braking 7mg/km PM10 from test cycle (4.5 hour, WLTP, 303 x brake decelaration events)

		Mass in running order (MRO) (kg)	Mass of carbon monoxide (CO)		Mass of total hydrocarbons (THC)		Mass of non-methane hydrocarbons (NMHC)		Mass of oxides of nitrogen (NOx)		Combined mass of total hydrocarb ns and oxides of nitrogen (THC + NOx)		Mass of particulate matter (PM)		Number of particles (PN_{23})	
			L_1 (mg/km)		L_2 (mg/km)		L_3 (mg/km)		L_4 (mg/km)		$L_2 + L_4$ (mg/km)		L_5 (mg/km)		L_6 (#/km)	
Category	Class		PI	CI	PI	CI	PI	CI	PI	CI	PI	CI	PI^{20}	CI	PI^{20}	CI
M_1	-		1000	500	100	-	68	-	60	80	-	170	4.5	4.5	$6x10^{11}$	$6x10^{11}$
N_1	I	MRO ≤ 1280	1000	500	100	-	68	-	60	80	-	170	4.5	4.5	$6x10^{11}$	$6x10^{11}$
	II	1280 < MRO ≤ 1735	1810	630	130	-	90	-	75	105	-	195	4.5	4.5	$6x10^{11}$	$6x10^{11}$
	III	1735 < MRO	2270	740	160	-	108	-	82	125	-	215	4.5	4.5	$6x10^{11}$	$6x10^{11}$



Future...?

Based on powertrain layout

EOBD +OBM

New vehicle on-board measured quantities

Calibration

TWC GPF TWC

Optionally EHC, burner

Optionally NH_3 oxidation catalyst

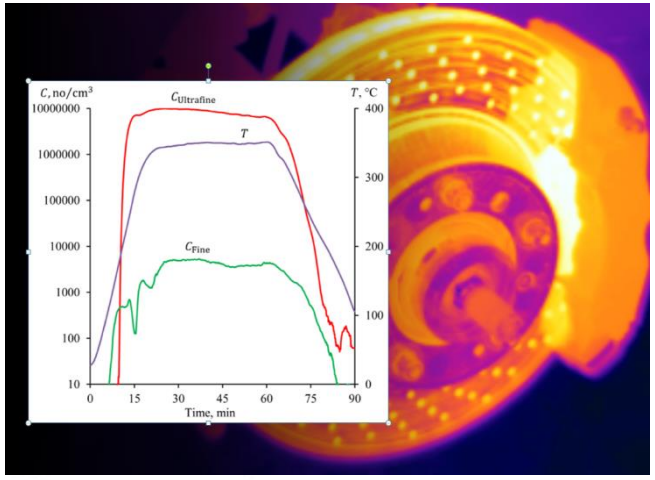
Issues:
Cold start
Low ambient temperatures
Engine in idle mode
Engine in high load
New species, limits – NH_3
CAT, GPF
Vehicle categories - max. weight?

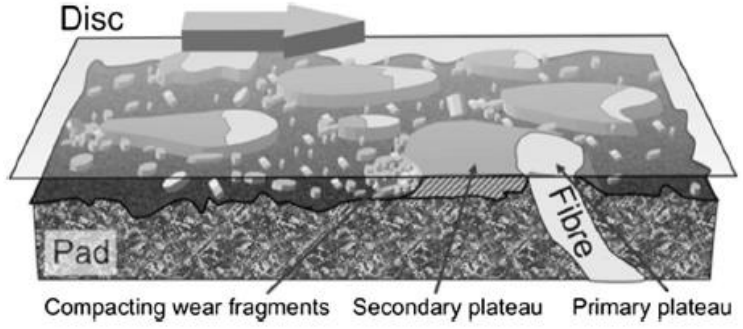
Measuring equipment – possibilities, accuracy

Activities in 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

3-WP08-002: Test bench for particle measurements

CTU FME 0.4; TÜV SÜD 0.3; SA 0.3

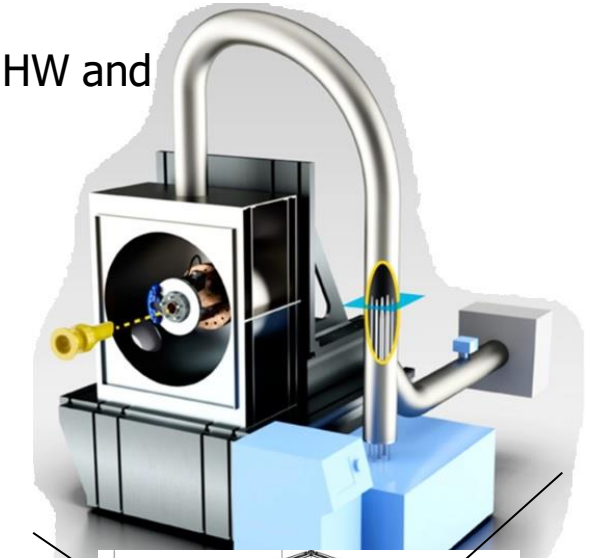




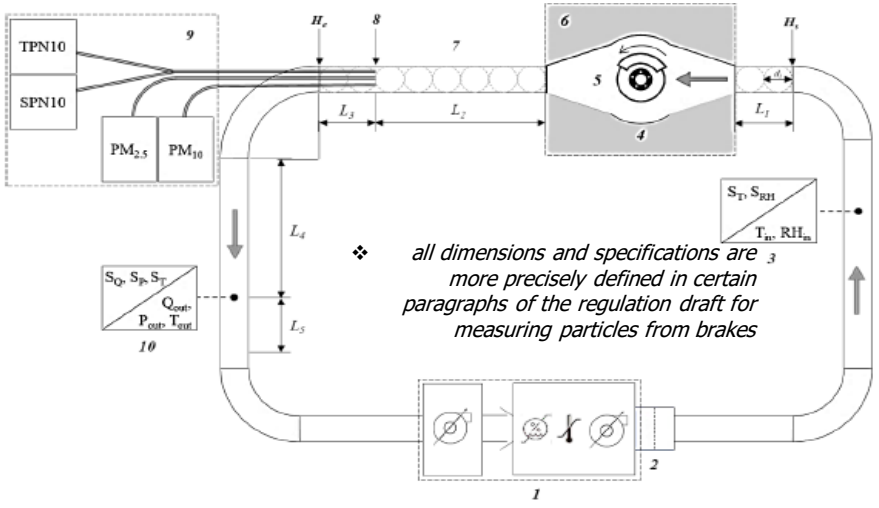
Test rig basic design definition – concept related to HW and SW solution.

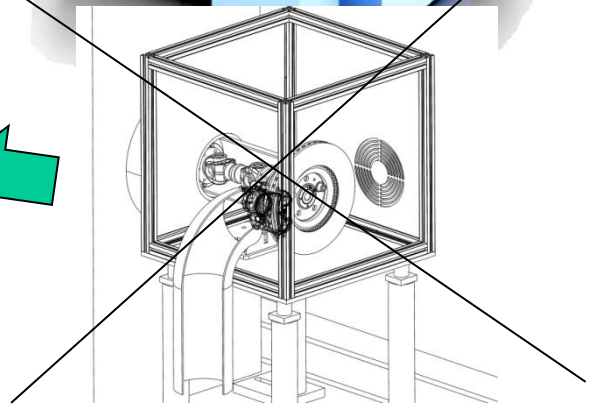
3D model appropriate for further development.

Manufacturing of certain parts for prototype.



Indicative layout





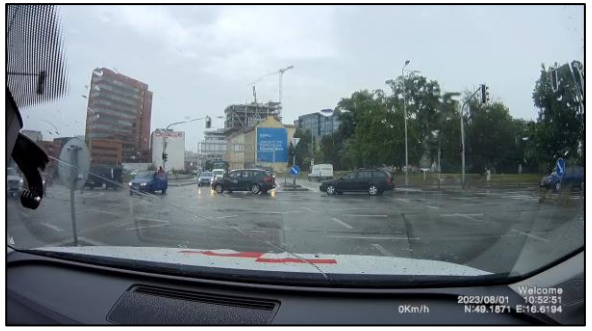
Activities in 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

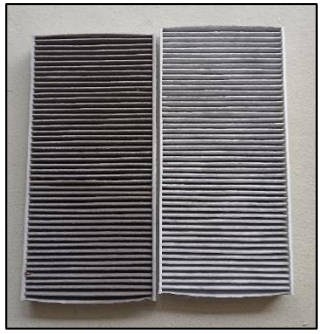
3-WP08-003: Technologies for aerosol concentration mitigation in vehicle cabins - feasibility study

BUT FME 0.7 , CTU FME 0.1, SA 0.2

Evaluation and feasibility study of improved systems for aerosol control in car cabin.

- Mapping of aerosols (particulate matter) that entering the cabin from the environment through the car's ventilation system. The mapping is made in the cabin of a real vehicle under real driving and climatic conditions so as to use real filters that are used/tested in Škoda Auto a.s. (EKC).
- Obtained data was used to evaluate the filtration quality in current MEB platform vehicles and to identify target values for the development of filtration media for very fine particles/aerosols.
- The data will be compared with the results from the previous project implemented for the MQB platform to compare the performance of cabin filtration.



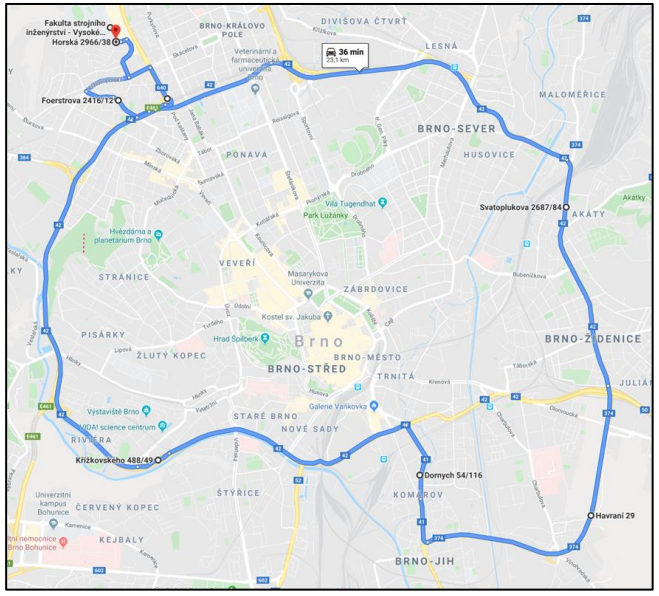


Activities in 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

3-WP08-003: Technologies for aerosol concentration mitigation in vehicle cabins - feasibility study

Aerosol mapping, summer tests, from 31.7. to 4.8.2023, city circuit/ring Brno

AirCare system on/off



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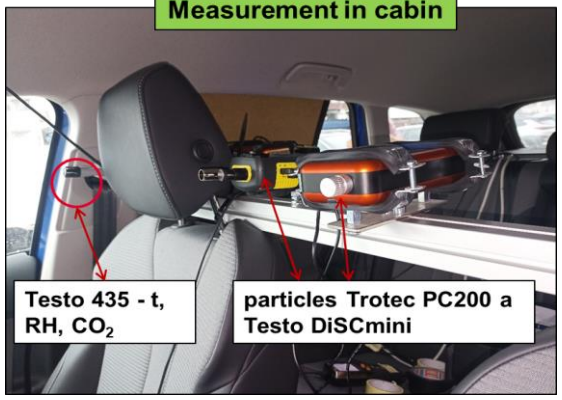
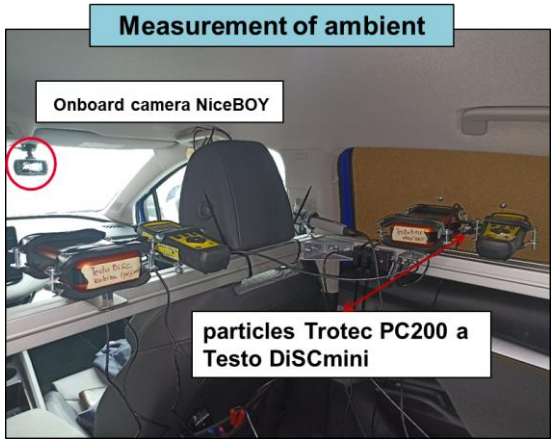
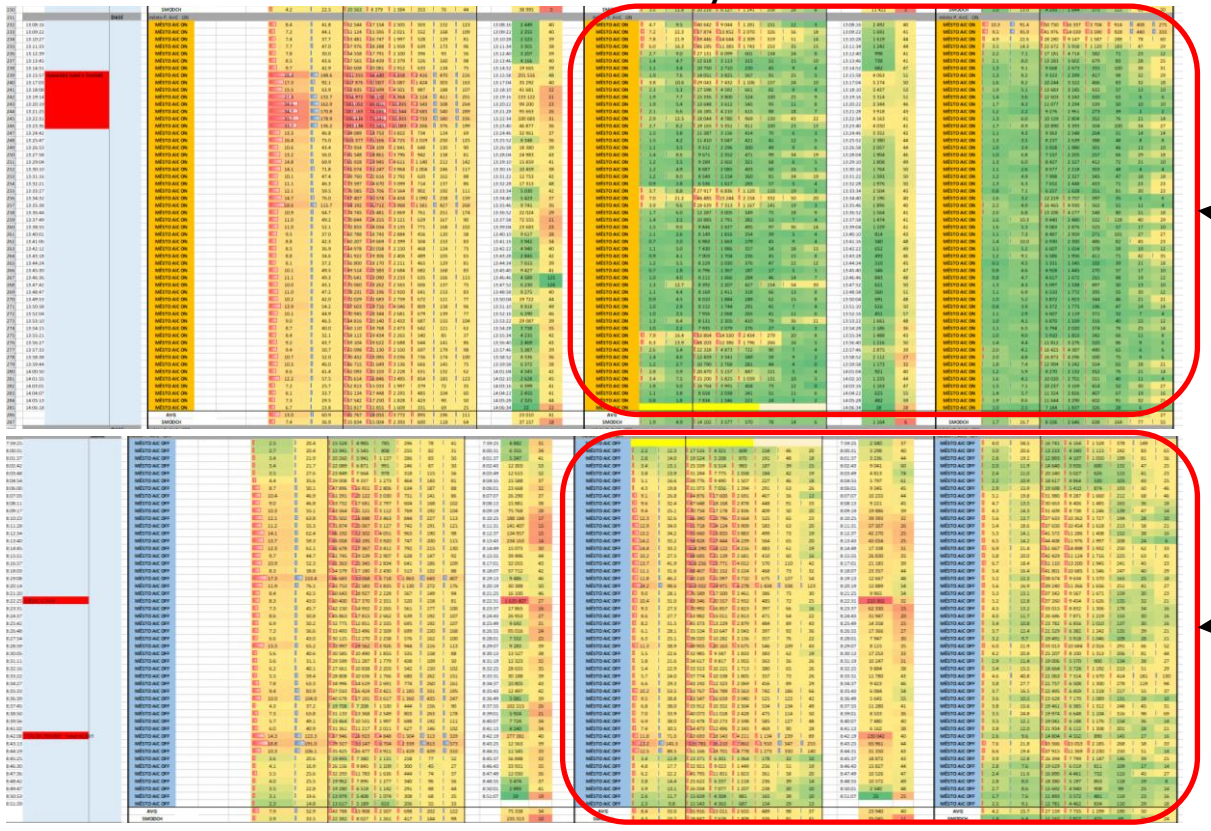




Activities in 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

3-WP08-003: Technologies for aerosol concentration mitigation in vehicle cabins - feasibility study

Particles in cabin air – Air Care system effect

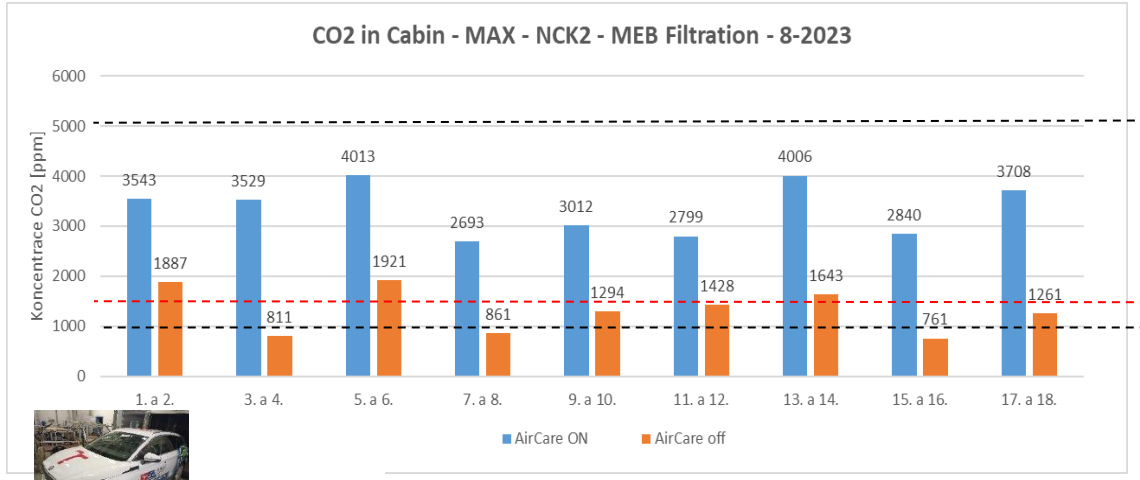


AirCare ON
clean cabin air,
without particles

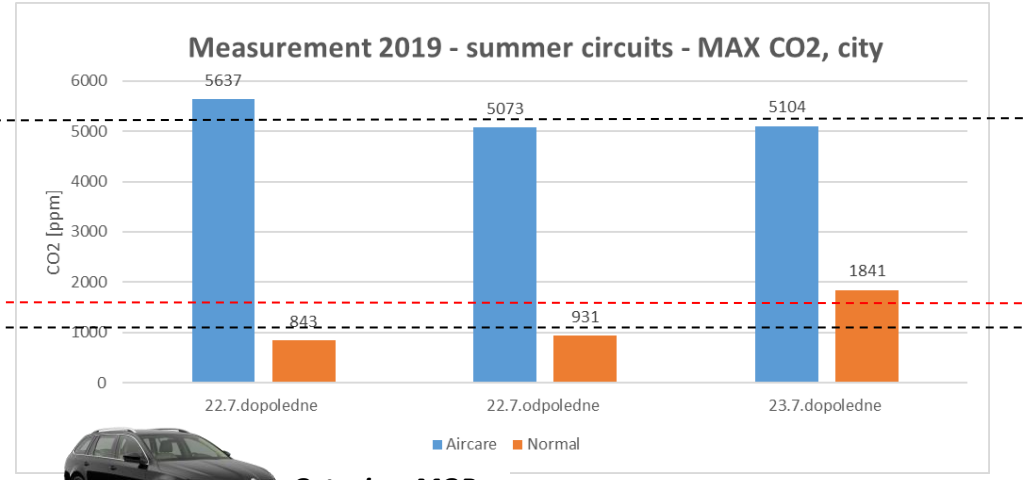
AirCare OFF
dirty cabin air, with
particles

Activities in 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

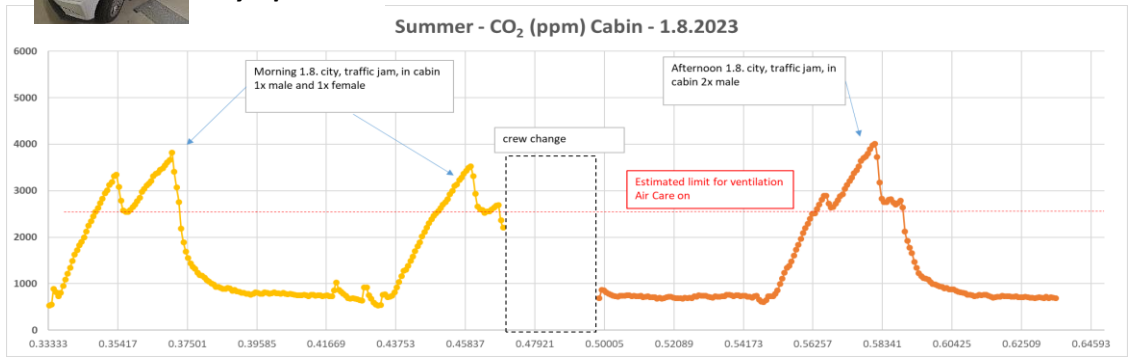
3-WP08-003: Technologies for aerosol concentration mitigation in vehicle cabins - feasibility study, Aerosol mapping, summer tests, CO2 in cabin air - results

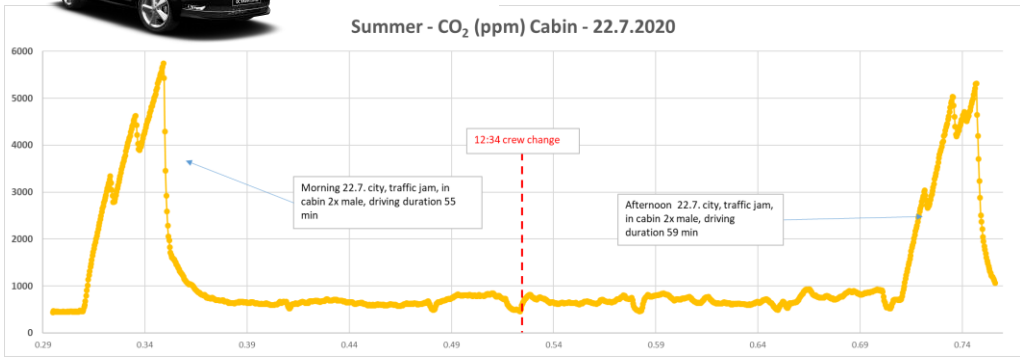


Enyaq - MEB



Octavia - MQB

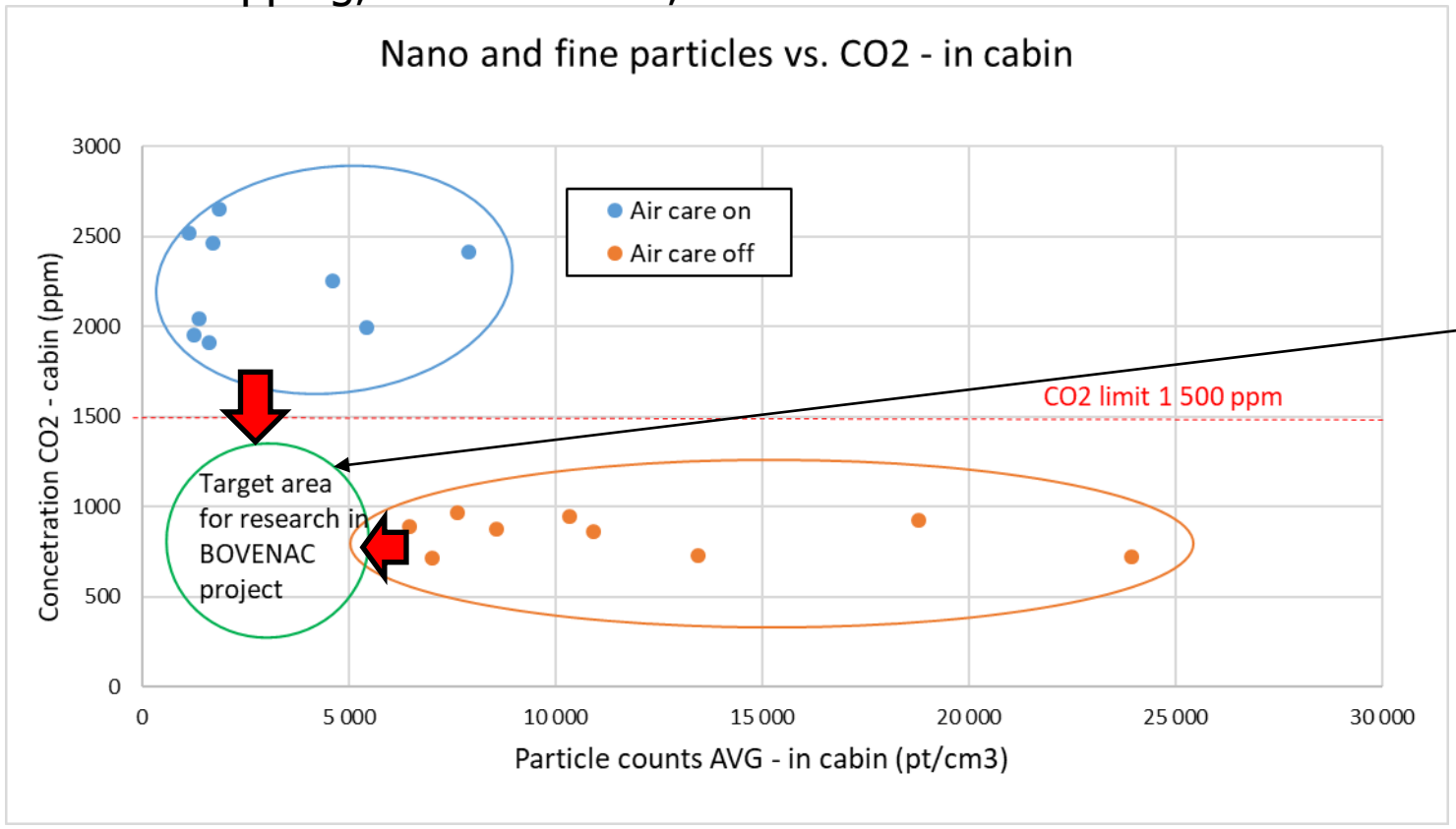




Activities in 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

3-WP08-003: Technologies for aerosol concentration mitigation in vehicle cabins - feasibility study

Aerosol mapping, summer tests, CO2 in cabin air - results



Main target for research in 3-WP08:

Good ventilation of cabin without fine particles

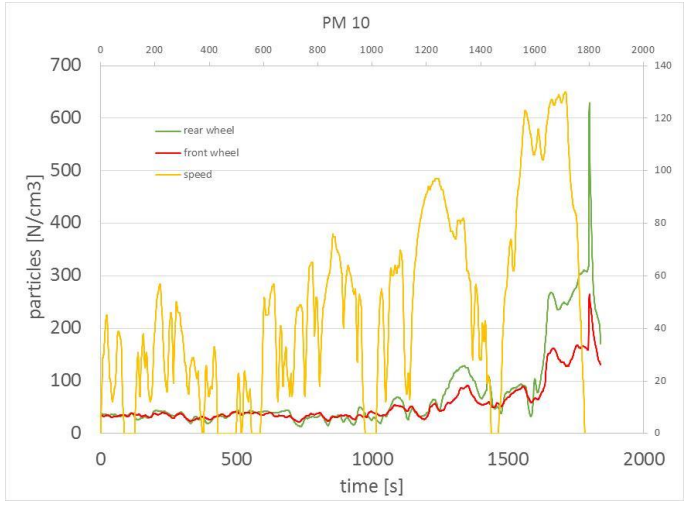
Activities in 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

3-WP08-004: Description of vehicle emission behavior in the lab. and under real driving conditions - methods and procedures for measurement in context of regenerative braking

CTU FME 0.5; BUT FME 0.2; TÜV SÜD 0.1; SA ost. 0.2

- Collecting current knowledge based on performed experimental activities.
- Creating the database for further processes.

Chassis dyno tests on hybrid vehicle



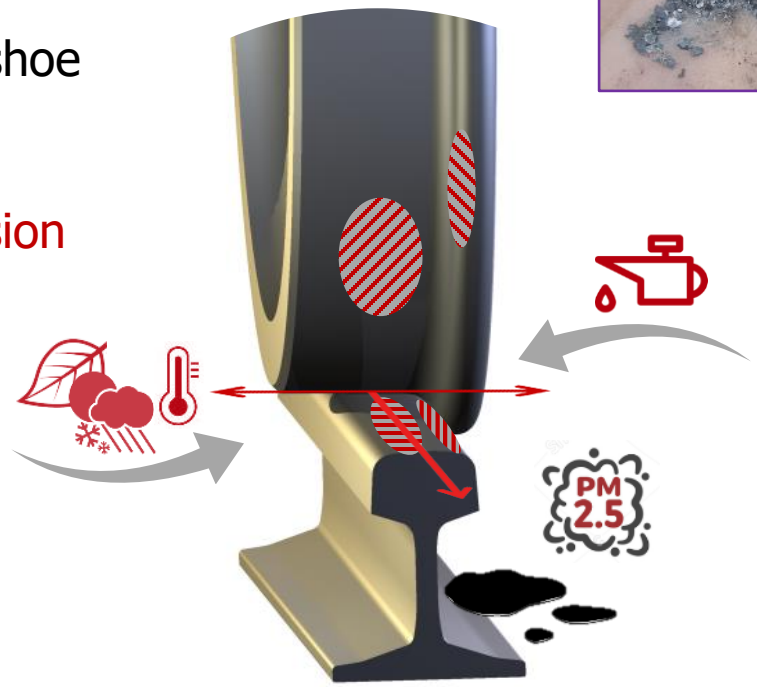
Stat	Valid Interval	Result	Validity
Time and Distance			
Urban Distance (km)	(16.0, +Infinity)	32.5	Valid
Rural Distance (km)	(16.0, +Infinity)	32.8	Valid
Motorway Distance (km)	(16.0, +Infinity)	32.3	Valid
Time (minutes)	(90.0, 120.0)	98.2	Valid
Distance Shares (%)			
Urban Distance Share (%)	(29.0, 44.0)	33.3	Valid
Rural Distance Share (%)	(23.0, 43.0)	33.6	Valid
Motorway Distance Share (%)	(23.0, 43.0)	33.1	Valid
Urban Driving			
Mean Urban Speed (km)	(15.0, 40.0)	33.9	Valid
Urban Low Speed Time (%)	(6.0, 30.0)	14.2	Valid
Max. Urban Cont. Low Speed Time (seconds)	(0, 300)	75	Valid
Motorway Driving			
Min. Motorway Speed (km/h)	(110.0, +Infinity)	144.3	Valid
Max. Motorway Speed (km/h)	(0.0, 160.0)	144.3	Valid
Motorway Time (seconds) Over 100.0 km/h	(300, +Infinity)	770	Valid
Motorway Time Share (%) Over 145.0 km/h	(0.0, 3.0)	0.0	Valid
Window Normality (%)			
Urban Normality (%)	(50.0, 100.0)	74.6	Valid
Rural Normality (%)	(50.0, 100.0)	77.1	Valid
Motorway Normality (%)	(50.0, 100.0)	90.8	Valid
Miscellaneous			
Absolute Elevation Difference (m)	(0.0, 100.0)	2.4	Valid
GPS Vehicle Speed Uninterrupted Time - Total (s)	(0, 300)	0	Valid
GPS Vehicle Speed Uninterrupted Time - Max Continuous (s)	(0, 120)	0	Valid

Activities in 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

3-WP08-006: Research on the traction enhancers and technologies towards low non-exhaust emissions

Particles sources in rail transport (non-exhaust)

- Wheel-rail contact wear
- Braking process
- Interaction of third rail and contact shoe
- Interaction of contact strip and overhead line
- Sanding to increase wheel-rail adhesion
- Friction management products
- Erosion by air turbulence



Activities in 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

3-WP08-006: Research on the traction enhancers and technologies towards low non-exhaust emissions

Problems in urban areas:

- Overuse of sanding
- Localised problem (stops, crossings, loops, uphill runs)
- Resuspension by road transport

Solutions:

- New application units
- New application strategies
- New materials

TriboTec ŠKODA

Required research activities:

- Study of the effectiveness of traction enhancers with respect to particle emissions
- Investigation into the particle-crushing process and dust formation
- R&D of new traction enhancers (alternative solid particles, traction gels, friction modifiers, etc.)
- Development of new application strategies (connected to NCC1)

Activities in 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

3-WP08-006: Research on the traction enhancers and technologies towards low non-exhaust emissions

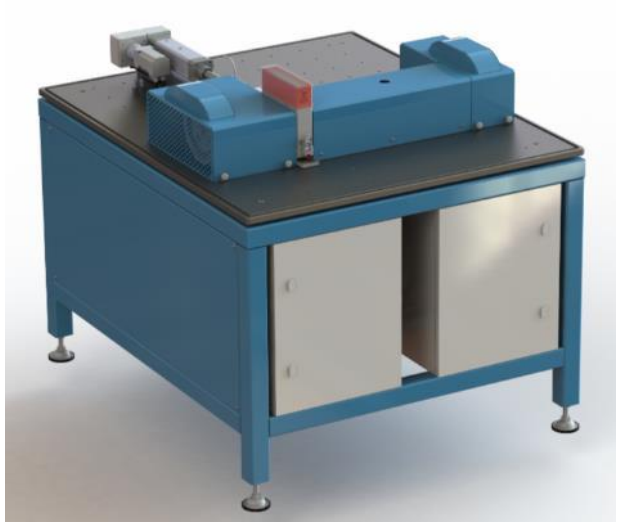
BUT 0.65; TRIBT 0.2; ŠTRN 0.1; UPa 0.05

Lab-scale methodology:

Small-scale ball-on-disc

Small-scale twin-disc

3-WP08-005



Full-scale twin-disc

UNIVERZITA PARDUBICE DOPRAVNÍ FAKULTA JANA PERNERA

Rail tribometer

Activities in 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

3-WP08-006: Research on the traction enhancers and technologies towards low non-exhaust emissions

Field test methodology

1. Tram braking tests with sanding – braking distance and particle emission measurement
2. Tests in real regular operation – particle emission monitoring

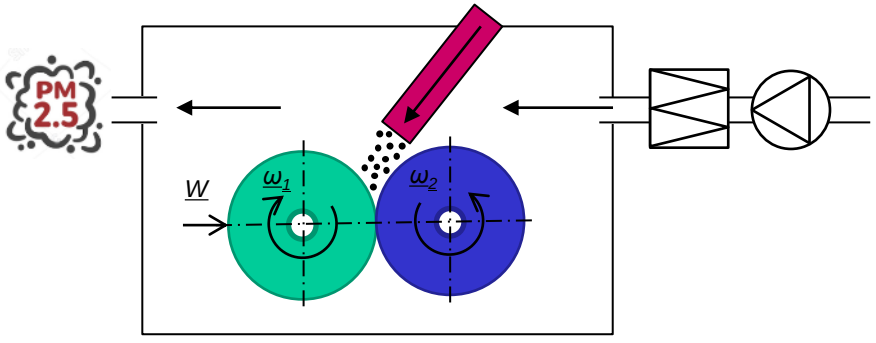
Activities in 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

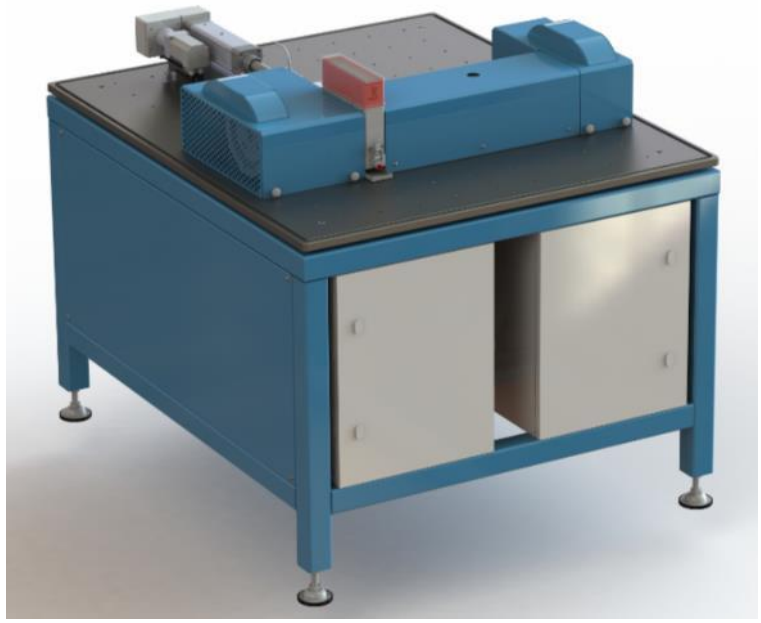
3-WP08-005: Device for an evaluation of particulate matter emissions from railway sanding

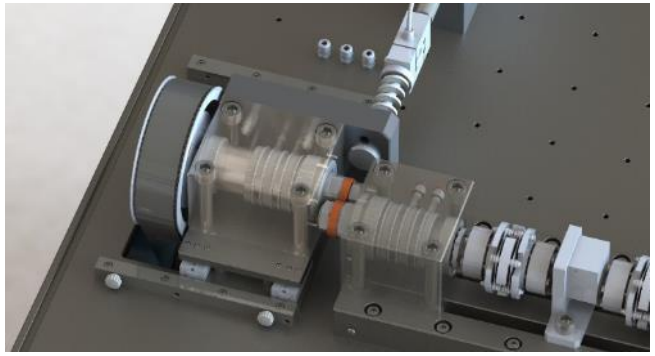
BUT 0.65; TRIBT 0.2; ŠTRN 0.1; UPa 0.05

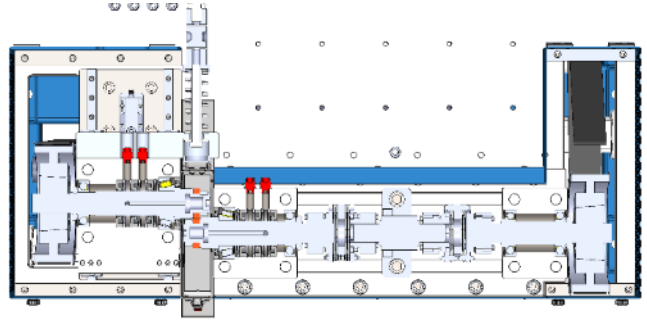
Design of a lab-scale test rig:

- Twin-disc approach
- Real materials and contact conditions
- Evaluation of CoT, wear, RCF
- PM measurement and sampling for further analyses









Fulfillment of goals and deliverables of 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

Current State of Deliverables, Milestones and Fulfillment of Goals

3-WP08-001: Critical review is creating based on current state of EU7 proposal.

3-WP08-002: The basic design of testing rig was defined based on current knowledge and rulles.

3-WP08-003: Obtained data was used to evaluate the filtration quality in current MEB platform vehicles and to identify target values for the development of filtration media and system for removal of very fine particles/aerosols.

3-WP08-004: All boundary conditions were collecting like input data for creating new methodology related to RD tests.

3-WP08-005: The results respond to the long-standing unsatisfactory situation regarding dust from rail traffic in urban areas.

3-WP08-006: The results respond to the long-standing unsatisfactory situation regarding dust from rail traffic in urban areas.

List of Due Deliverables and Their Added Value

All activities within the 3-WP08 are in prescribed schedule. There are no delays. The deliverables will be prepared on planed time.

Fulfillment of goals and deliverables of 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

Current State of Deliverables and Fulfillment of Goals

- **3-WP08-001**: **Engine control strategy and aftertreatment setup toward EU7 limits fulfillment**, G-funk, V./2026, CVUT FME 0.6; SA 0.3; TÜV SÜD 0.1 – **in progress & no major delays:**
  - Monitoring & obtaining knowledge from EU7 proposal (still running).
  - Critical review about possible solution for future combustion engines.
  - Preparing necessary data for next steps.

- **3-WP08-002**: **Test bench for particle measurements**, G-funk, V./2026, CTU FME 0.4; TÜV SÜD 0.3; SA 0.3 – **in progress & no major delays:**
  - Test rig basic design definition – concept related to HW and SW solution.
  - 3D model appropriate for further development.
  - Manufacturing of certain parts for prototype.

Fulfillment of goals and deliverables of 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

Current State of Deliverables and Fulfillment of Goals

- **3-WP08-003**: Technologies for aerosol concentration mitigation in vehicle cabins - feasibility study, O – ostatní výsledky, XII./2025, BUT FME 0.7 , CTU FME 0.1, SA 0.2 – **in progress & no major delays:**
  - Mapping of aerosols (particulate matter) that entering the cabin from the environment through the car's ventilation system. The mapping is made in the cabin of a real vehicle under real driving and climatic conditions so as to use real filters that are used/tested in Škoda Auto a.s. (EKC).
  - Obtained data was used to evaluate the filtration quality in current MEB platform vehicles and to identify target values for the development of filtration media and system for removal of very fine particles/aerosols. .
  - The data will be compared with the results from the previous project implemented for the MQB platform to compare the performance of cabin filtration.

- **3-WP08-004**: **Description of vehicle emission behavior in the lab. and under real driving conditions - methods and procedures for measurement in context of regenerative braking systems**, O – ostatní výsledky, XII./2024, CTU FME 0.5; BUT FME 0.2; TÜV SÜD 0.1; SA ost. 0.2 – **in progress & no major delays:**
  - Collecting current knowledge based on performed experimental activities.
  - Creating the database for further processes.

Fulfillment of goals and deliverables of 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

Current State of Deliverables and Fulfillment of Goals

- **3-WP08-005**: Device for an evaluation of particulate matter emissions from railway sanding (ZV),G-funk, XII./2024, BUT 0.65; TRIBT 0.2; ŠTRN 0.1; UPa 0.05 – **in progress & no major delays:**
  - Design of a technical means for an experimental evaluation of airborne particle emissions of a wheel-rail contact was finished and implemented into a new small-scale twin-disc test rig (BUT + TRIBT).
  - Preparation for full-scale validation of the small-scale approach (BUT + UPa).
  - Assesment of the feasibility for the on-board PM monitoring (BUT + TRIBT + STRN).

- **3-WP08-006**: Research on the traction enhancers and technologies towards low non-exhaust emissions, O – ostatní výsledky, G-funk, VI./2026, BUT 0.65; TRIBT 0.2; ŠTRN 0.1; UPa 0.05 – **in progress & no major delays:**
  - Formulating an experimental methodology for research activities (BUT + UPa).
  - First lab-scale tests – degraded adhesion, solid lubricants, crushing proces, ... (BUT).
  - Draft concept for new approaches for traction enhancement (TRIBT + STRN).

Fulfillment of goals and deliverables of 3-WP08: Future Concepts in Pollutant/Emission Detection and Reduction

List of Due Deliverables and Their Added Value

- **3-WP08-001** - Novel engine and aftertreatment system setup can fulfill all main goals leading to lower emissions of vehicles while keeping the increase of the vehicle/power-train price as low as possible.
- **3-WP08-002** - Offering more efficient and easier to operate test device that would be used in the R&D process for simple testing to verify for example new designs of braking systems.
- **3-WP08-003** – Skoda auto expects to improve the filtration efficiency for nanoparticles and maintain the quality of ventilation in the cabin. Keep position and competitiveness on European and Asian markets.
- **3-WP08-004** - Saving time and money in area of R&D activities for vehicles manufactures. Next benefit will be shorter time for bringing the new braking technologies with lower level of dangerous pollutants.
- **3-WP08-005** - Allowing for the research of the materials for traction enhancement with respect to the particulate matter emissions from rail traffic and for the development of approaches to the emissions reduction
- **3-WP08-006** - Obtaining results and the experimental approaches forming the knowledge base for the development of materials and technologies for low-emission rail transport while focusing on non-exhaust emissions

Current contribution of 3-WP08 Future Concepts in Pollutant/Emission Detection and Reduction

Assessment of the Contribution of Deliverables

There is increase in international interest to characterize both exhaust and non-exhaust traffic-related gaseous and particle emissions. Until recently, exhaust dominated road transport emissions, and all regulatory efforts were aiming at their reduction. As exhaust emissions reduced, the relative contribution of non-exhaust emissions to overall ambient PM concentrations increased. Furthermore, there are concerns relative to possible adverse health effects of non-exhaust wear particles, and particularly of brake wear particles, due to their small size and their high metal content. The current methodology needs to simulate real-world driving conditions to the maximum extent possible and create harmonized measurement systems for scientific as well as for Research and Development (R&D) purposes.

Current contribution of 3-WP08 Future Concepts in Pollutant/Emission Detection and Reduction

Assessment of the Formal/Administrative Goals of the Work Package

All formal/administrative goals of the Work Package 3-WP08 are at the moment fulfilled.