



# 82<sup>nd</sup> UNECE GRPE Session - Workshop on Brake Emissions

**Towards a Regulation on Brake Wear Emissions**



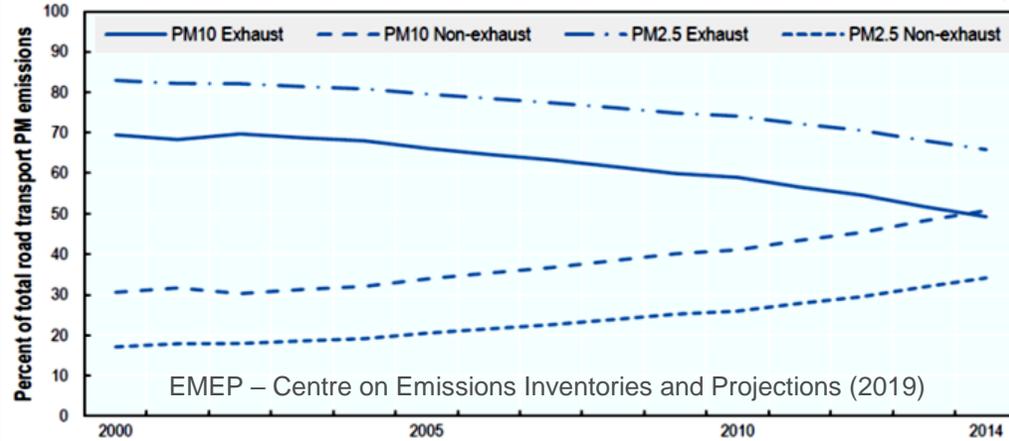
*T. Grigoratos, G. Martini,  
Webconf, 13<sup>th</sup> JAN 2021*

# Outlook

- Short background on brake emissions
- Short background on PMP involvement
- Brake emissions method development
- Future activities within the PMP
- Introduction to the workshop discussion

# Exhaust vs. Non-exhaust Emissions

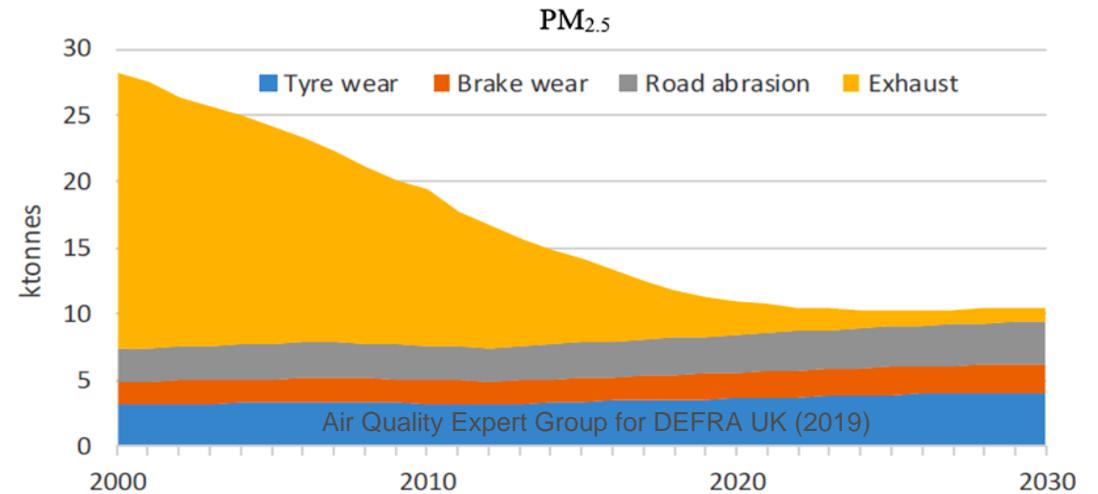
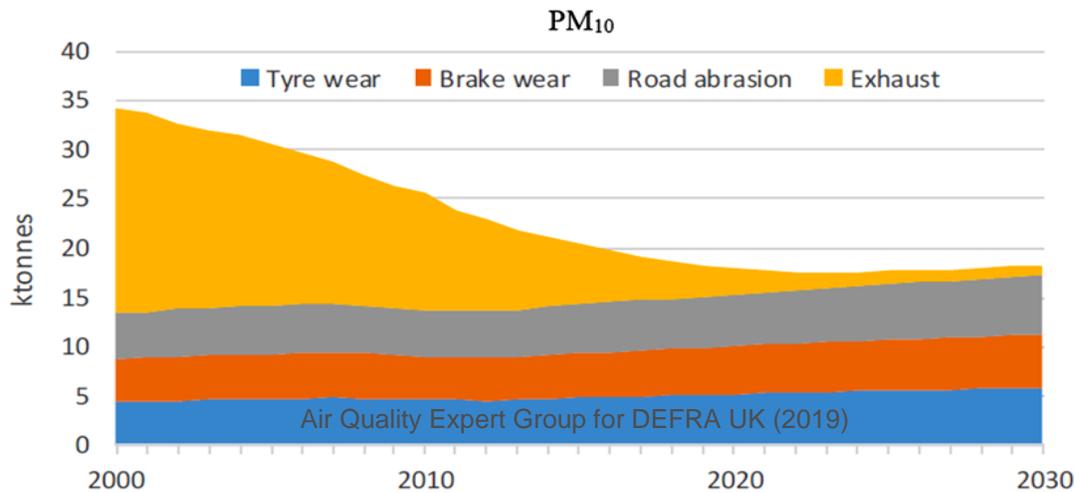
EU-28 – Primary PM<sub>10</sub> & PM<sub>2.5</sub>



1. EFs are based on type-approval tests while real-world exhaust PM emissions are expected to be higher

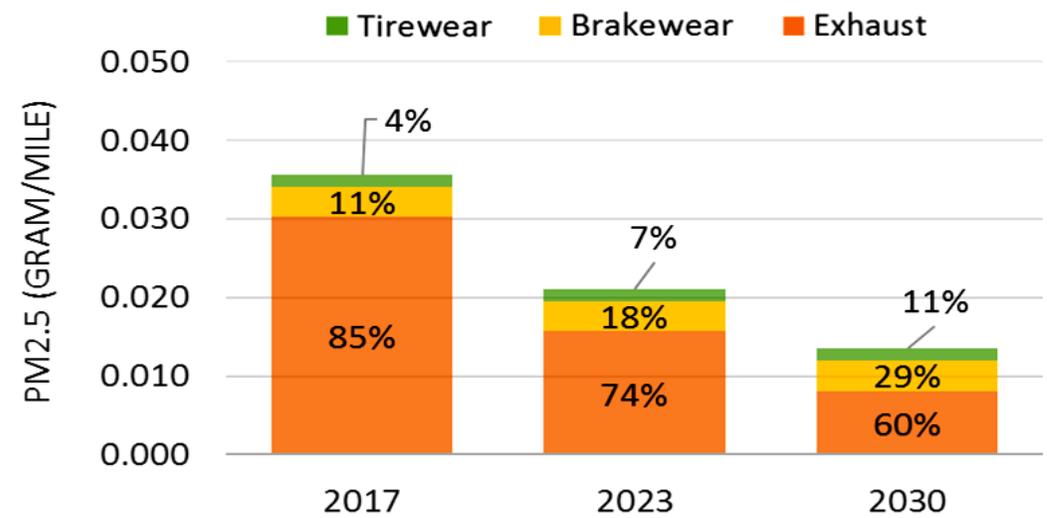
2. Question regarding the underlying assumptions since no standardized methods for non-exhaust emissions exist

UK – Primary PM<sub>10</sub> & PM<sub>2.5</sub>



**Despite the reported differences non-exhaust emissions have become much relevant for air pollution**

# Brake Emissions – Importance



MOVES – Sonntag et al. (2020) HEI Virtual Workshop on non-tailpipe PM emissions and health

- ✓ Brake PM<sub>10</sub> and PM<sub>2.5</sub> are approximately 3 times higher than tire PM<sub>10</sub> and PM<sub>2.5</sub> (road wear not included)
- ✓ Projections show similar brake/tire emissions ratio in 2030; however, EFs are not updated – do not include technological improvements and do not take into account future technologies
- ✓ The AQEG (UK) reported equal contribution of brake, tire and road wear to LDVs PM<sub>10</sub> emissions in 2016

**Despite the reported differences – which reflect different methodological approaches – brake emissions make up a significant fraction of non-exhaust emissions**

# Brake Emissions – Regulation

Despite the high relevance of the topic to air pollution – as well as the multiple on-going initiatives worldwide – there are no brake emissions regulations in any part of the world

## EFs and Air Pollution

- ✓ Brake  $PM_{10}$  and  $PM_{2.5}$  EFs vary significantly depending also on the calculation method (HEI, 2020)
- ✓ Reported brake  $PM_{10}$  and  $PM_{2.5}$  EFs are outdated
- ✓ Relative contribution of brake PM to ambient air PM varies significantly (JRC, 2014; OECD, 2020)

## Measurement Procedure

- ✓ No standardized method for measuring brake particle emissions exists, yet
- ✓ Applied methods vary and often result in non-comparable results
- ✓ Experience from exhaust methods is useful but cannot be directly applied to brake emissions studies

## Health Relevance

- ✓ Very few studies on the field reporting contrasting results. More research to come soon
- ✓ Need to study brake PM toxicity along with exposure which depends upon various parameters (HEI, 2020)
- ✓ Few epidemiology studies. Certain brake constituents linked to adverse effects (HEI, 2020)

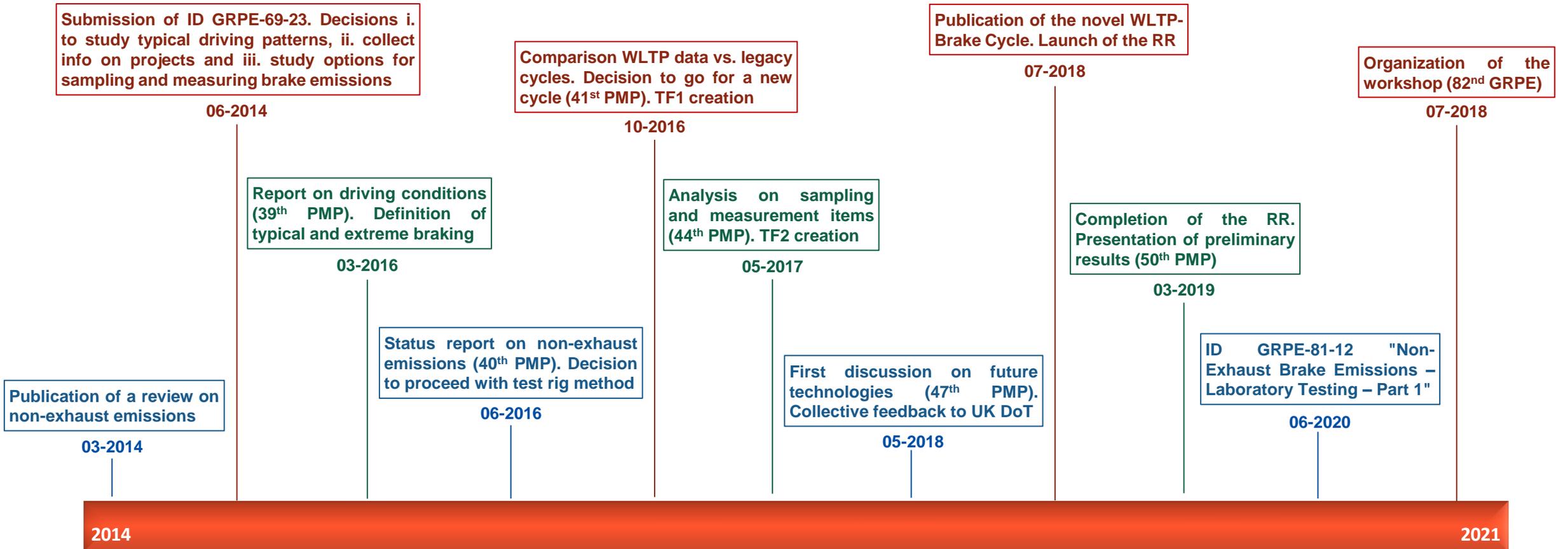
PMP  
Engagement

# PMP Background – Mandate

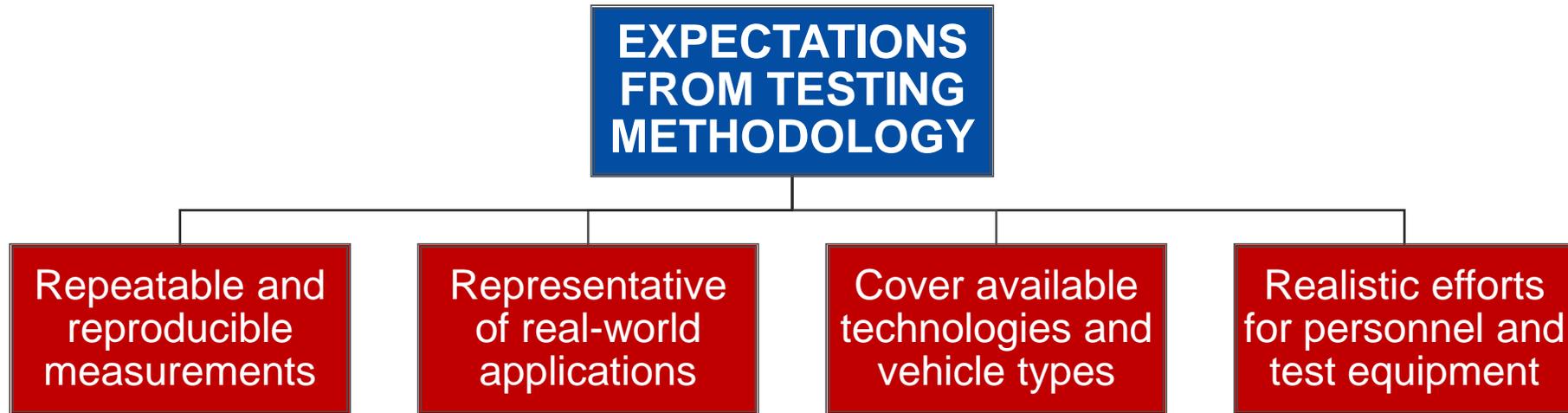
- ✓ June 2013: The PMP IWG started looking into non-exhaust emissions following a request from the Russian federation – DG-GROW requested to research also other non-exhaust sources (i.e. brakes)
- ✓ June 2016: The GRPE approves the new ToR – Mandate for the development of a suggested common test procedure for sampling, measurement and characterization of brake wear particles
- ✓ June 2019: The GRPE approves the extended ToR – The method development includes (a) Validation of the novel test cycle; (b) Definition of the requirements for brake particles generation and sampling; (c) Selection of the appropriate instrumentation; (d) Validation of the proposed approach
- ✓ June 2020: The GRPE approves the revised ToR – ... (e) Extend the proposed methodology to include regenerative braking and future technologies

***In January 2020, for the first time several UNECE GRPE Contracting Parties have asked the PMP IWG to start considering a possible use of the proposed method as a regulatory tool***

# PMP Background – Milestones at a Glance



# Brake Emissions Methodology – Expectations



***Standardization is the key for i. rendering future studies comparable to each other and ii. providing the necessary tool for possible future regulations***

# Brake Emissions Methodology – Expectations

***Repeatable and reproducible measurement results for brake  $PM_{10}$ ,  $PM_{2.5}$  and PN emissions***

- ✓ Well defined cycle and execution protocol (WLTP-Brake Cycle)
- ✓ Brake dynamometer related specifications and checks (i.e. background concentrations, dyno climatic controls, brake enclosure design, etc.)
- ✓ Brake hardware specifications (i.e. brake temperature measurement (method, instrumentation, positioning, etc.), defined bedding-in procedure, etc.)
- ✓ Well defined cooling protocol
- ✓ Measurement related specifications for PM and PN (methods, instrumentation, calibration, etc.)

# Brake Emissions Methodology – Expectations

*The method shall reflect – to the extent possible – real-world applications and conditions*

- ✓ WLTP-Brake cycle reflecting real-world driving and braking conditions
- ✓ Definition of test inertia based on the force distribution specified by the vehicle manufacturer
- ✓ Options for correcting for parasitic vehicle losses
- ✓ Adjustment of the cooling airstream speed based on real-world vehicle temperature profile data

... but on the other hand...

- ✓ There is no possibility to mimic vehicle aerodynamics taking into consideration the wide variety of configurations available in the market
- ✓ Method will replicate primary brake emissions under strictly controlled lab conditions and will not capture environmental dilution, particle transport, losses, settlement to vehicle and road that occur in real-world
- ✓ Method will not account for various weather conditions (i.e. wet, snow/icy) or very extreme braking events (i.e. very high deceleration rate) that might occur in real-life

# Brake Emissions Methodology – Expectations

*The methodology shall take into account available technologies and cover all vehicle types*

**So far, the method development targeted brakes from ICE LDVs**

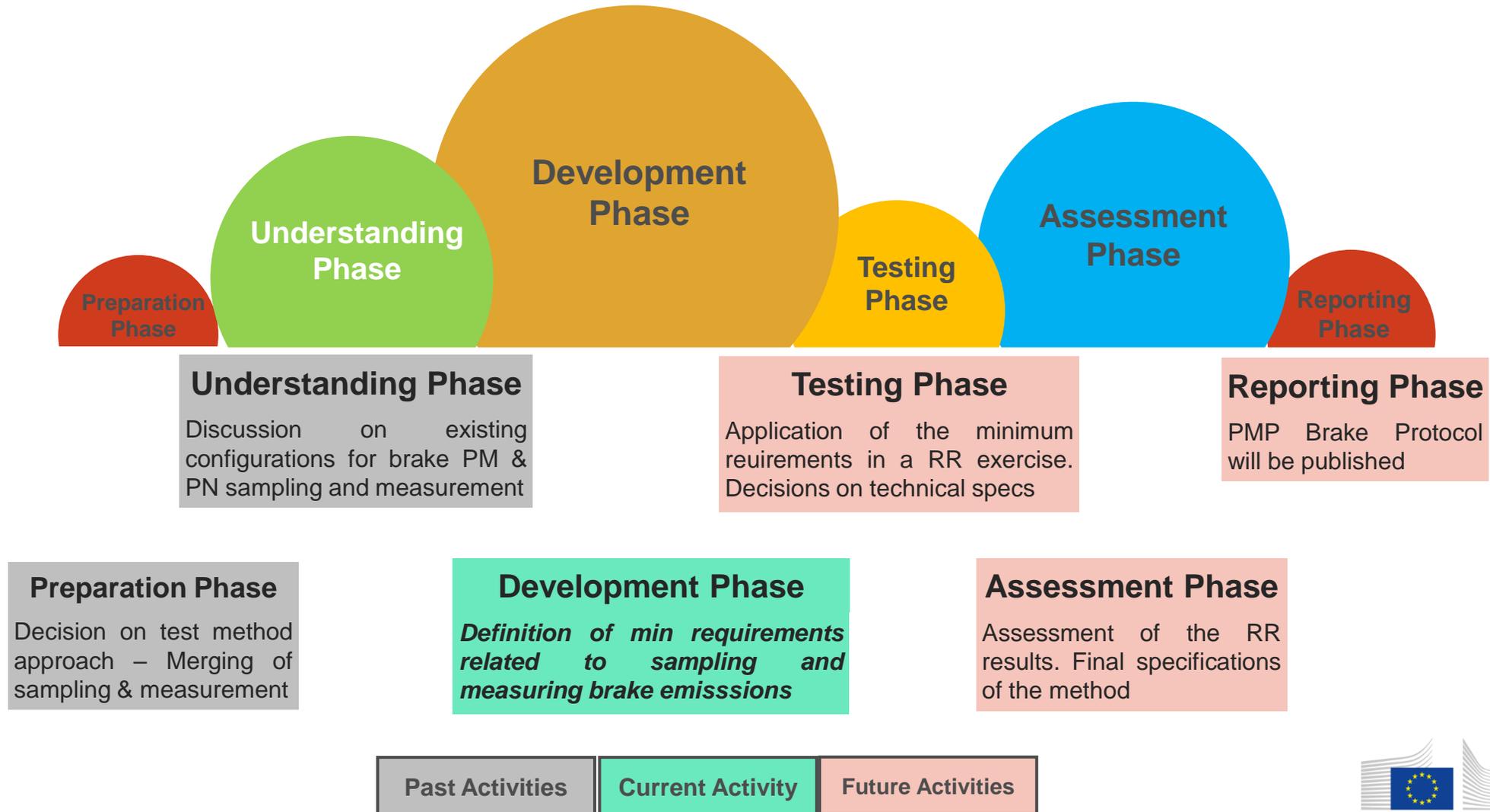
- ✓ Brakes from Hybrid Light Duty Vehicles<sup>1</sup>
- ✓ Brakes from Full Electric Light Duty Vehicles<sup>2</sup>
- ✓ Brakes from Medium and Heavy Duty Vehicles<sup>3</sup>

<sup>1</sup>A CARB-ERG-LINK study tested a Hybrid LDV successfully on the dyno – it seems feasible to apply the (under development) method with minor adjustments mostly related to the cooling method

<sup>2</sup>The CalTrans has funded a study looking to a fully electric vehicle. Important aspects to consider are the variety of operating strategies and the influence of driving assistance systems to the driving profile

<sup>3</sup>The CalTrans has funded a study looking into brake emissions of HDV. Aspects to consider relate to the different driving profile of HDVs compared to LDVs and the wide variety of cycles within the HD sector

# Brake Emissions Methodology – Phases



# Brake Emissions Methodology – Upcoming

*A Round Robin testing campaign will be initiated in the next months*

## Primary Objectives

- ✓ Application of the agreed specifications – recommendations on improving and extending the minimum specifications
- ✓ Control the repeatability (within the labs) and reproducibility (among the labs) of PM and PN measurements with the application of the proposed minimum specs

## Participating Labs

- ✓ TF2 and PMP members (labs) with the ability to follow the specified minimum requirements can participate to the RR. So far, approximately 10 labs have expressed their interest

## Indicative Timeline

- ✓ The campaign will start in Q2 2021 and finish by the end of Q4 2021. Details about the campaign will become available at the next F2F PMP Meeting

# On-going & Collaborating Projects



## Series of Projects

- ✓ Update non-exhaust EFs
- ✓ Understand roadside exposure
- ✓ Study health effects

World's first automotive standard for brake emission

# JASO

JASO C 470 : 2020

Passenger cars- Measurement method for  
brake wear particle emissions



Department  
for Transport

Umwelt  
Bundesamt

***Some of these projects already apply completed solutions on sampling and measurement of brake particle emissions. Many elements of these solutions could be incorporated to the PMP method***

# Brake Emissions Workshop - Introduction

## *Ideal scheme for regulating brake emissions from conventional ICE Light-Duty vehicles?*

### Preliminary Questions

- ✓ Type approval/certification at vehicle or component level? Type approval of aftermarket brake products? Type approval of brake drums?
- ✓ Emission limit based approach. Application for both brake wear PM and PN? Absolute limits (mg/km and # particles/km) or relative limits (reference system)?
- ✓ Relationship between laboratory based tests and real world emissions? How to ensure that laboratory measurements are representative of real world applications?
- ✓ Feasibility of classification/labeling on top of type approval. Should it rely only on PM emissions or PN emissions should be considered, too?
- ✓ Other possible approaches including both brake PM and PN emissions?

# Brake Emissions Workshop - Introduction

*How should non-conventional LDV (HEVs, EVs) be handled in a future regulatory approach?*

## Preliminary Questions

- ✓ Importance of brake PM and PN emissions from non-conventional Light-Duty vehicles?
- ✓ Feasibility of following a similar approach to that of conventional ICE LDVs?
- ✓ How could other innovative technologies (car-to-car communication, ADAS systems, etc.) be assessed and considered in possible future regulation?
- ✓ Other possible approaches (i.e. modelling, eco-innovation scheme, etc.)?

# Brake Emissions Workshop - Introduction

*How should HD Vehicle brake emissions be handled in a future regulatory approach?*

## Preliminary Questions

- ✓ Importance of brake PM and PN emissions from Heavy-Duty vehicles?
- ✓ Feasibility of following a similar approach to that of conventional ICE LDVs?
- ✓ Other possible approaches

# Keep in touch



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# Thank you



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