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BRAKE PARTICLE EMISSIONS

BRAKE EMISSION TASK FORCES PROGRESS UPDATE

DEVELOPMENT OF A COMMONLY ACCEPTED METHOD FOR MEASURING BRAKE PARTICLE EMISSIONS

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51ST PMP IWG Meeting – Brussels (BE) – 30.10.2019

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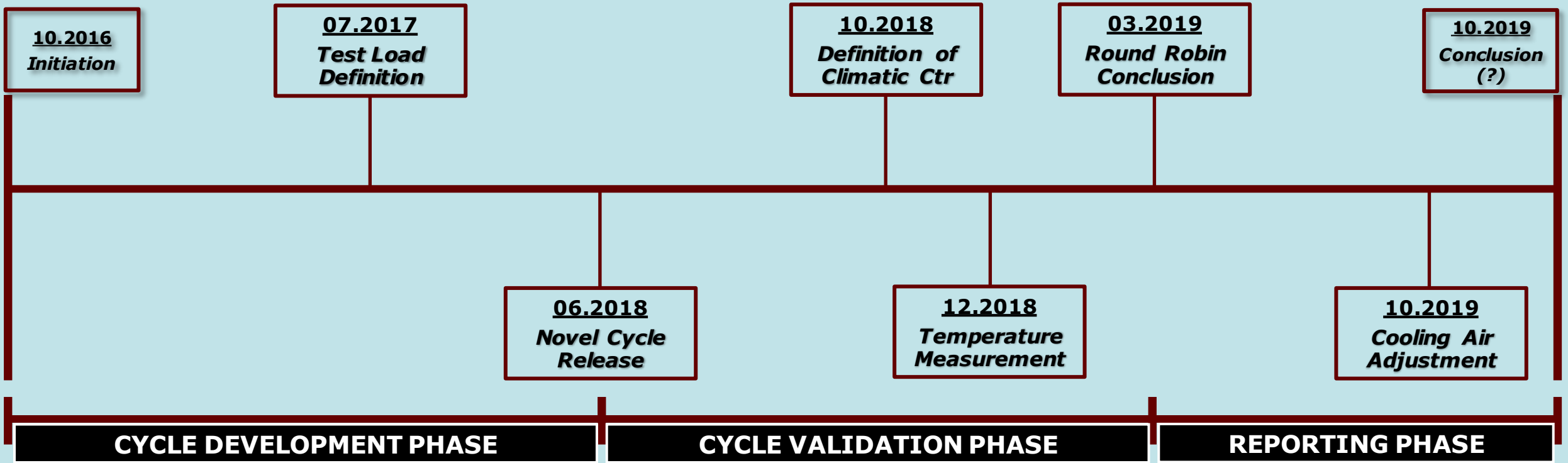
TF1 – BACKGROUND

June 2015: The PMP IWG identified the need for the adoption of a representative of real-world conditions brake cycle as an important step for the development of the commonly accepted methodology - A four steps approach was followed

- WLTP Database Analysis - Definition of "typical" and "extreme" driving/braking conditions (Concluded)
- Comparison of WLTP statistics extracted from Step 1 with those of existing braking cycles (i.e. LACT, Mojacar, AK Master) (Concluded)
- Development of a first version of the novel braking schedule (Concluded)
- Validation of the cycle at vehicle and dyno level through an interlaboratory study - Round Robin exercise (Concluded)

TF1 – ACHIEVED MILESTONES

October 2016: The PMP decided to proceed with the development of a **NOVEL CYCLE** which would represent real-world braking applications - A specific Task Force (TF1) within the PMP IWG was created



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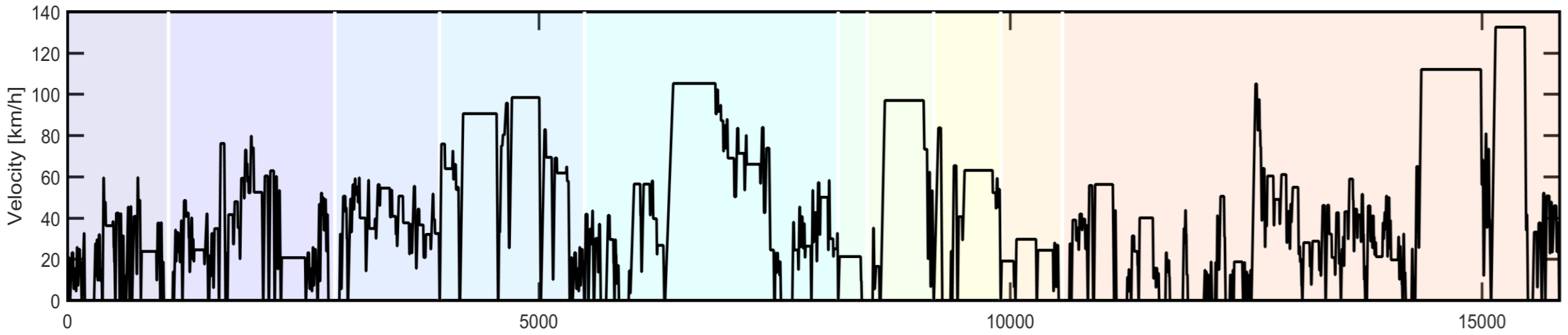
ACHIEVED MILESTONES
BRAKE CYCLE

Novel cycle release: Ford took over the development of the cycle based on PMP initial work. Development phase lasted almost 2 years including vehicle validation



The number of publications on brake emission studies adopting the novel cycle is continuously increasing. The cycle is freely available at: **https://data.mendeley.com/datasets/dkp376g3m8/1**

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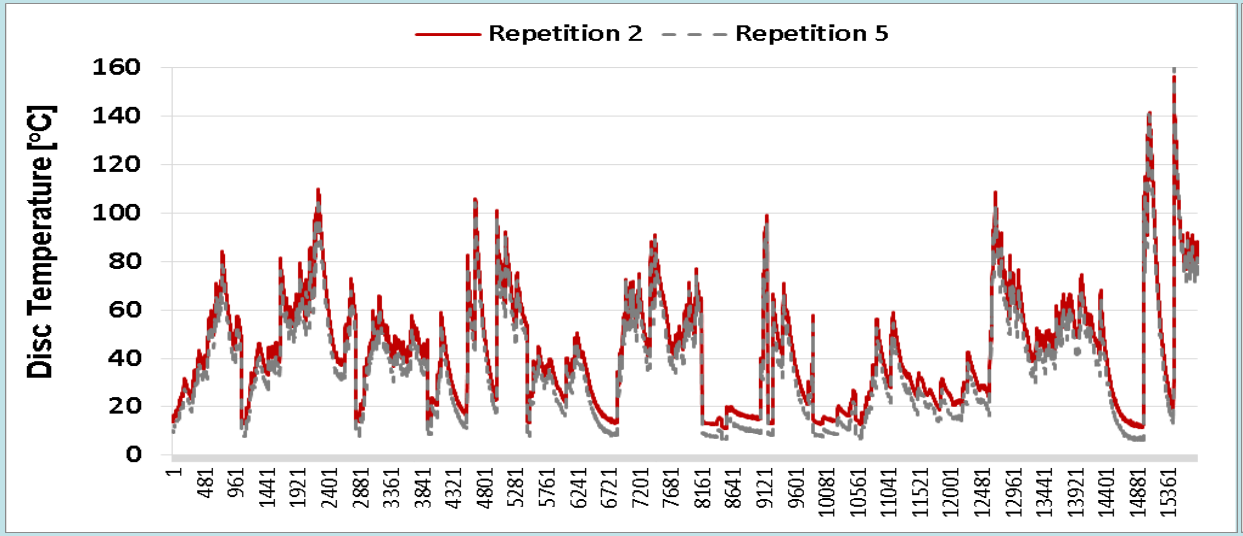
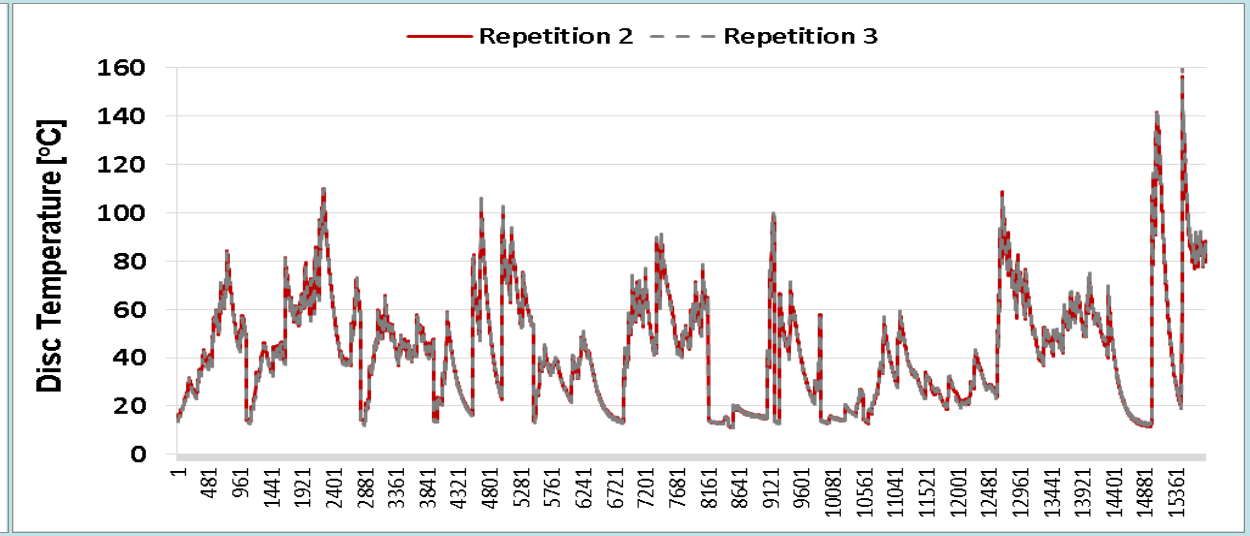
ACHIEVED MILESTONES
CLIMATIC CONTROLS

Definition of climatic controls: Cooling air temperature and RH are important factors affecting the brake temperature. Round Robin data were used to evaluate the significance of these parameters



Disc temperature profile measured by embedded TC over R2 (Cooling air Temp = 13°C) and R5 (Cooling air Temp = 8°C)



Disc temperature profile measured by embedded TC over R2 (Cooling air Temp = 13°C) and R5 (Cooling air Temp = 13°C)

Cooling air is proposed to be adjusted to **20°C±2°C and 50%±5% RH**. These values refer to the averages during the whole cycle duration. Labs need to make sure they stay as close to the target value as possible

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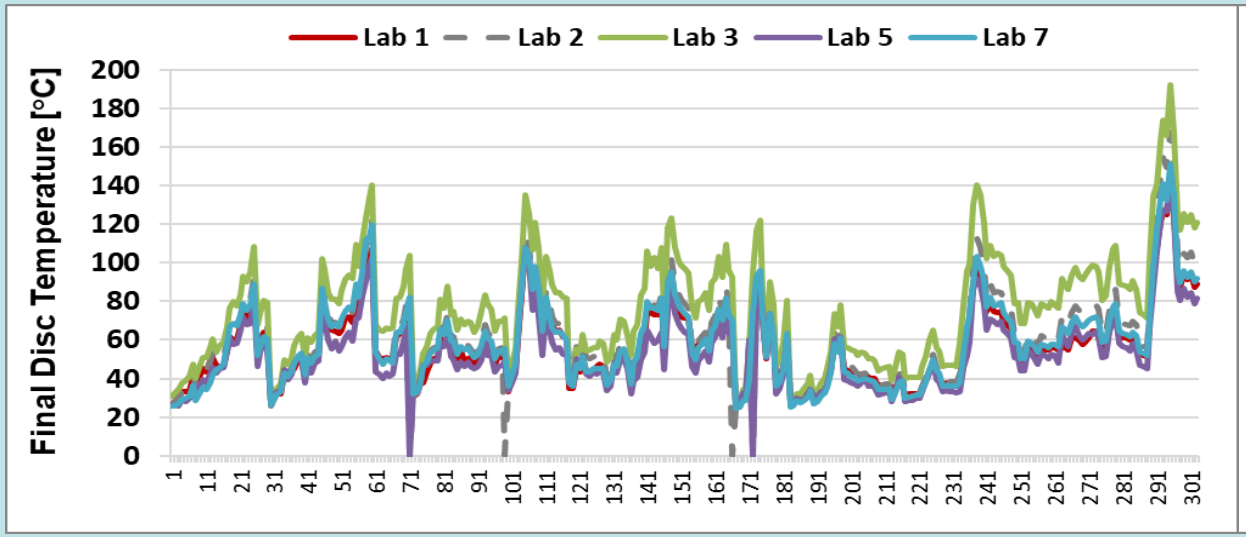
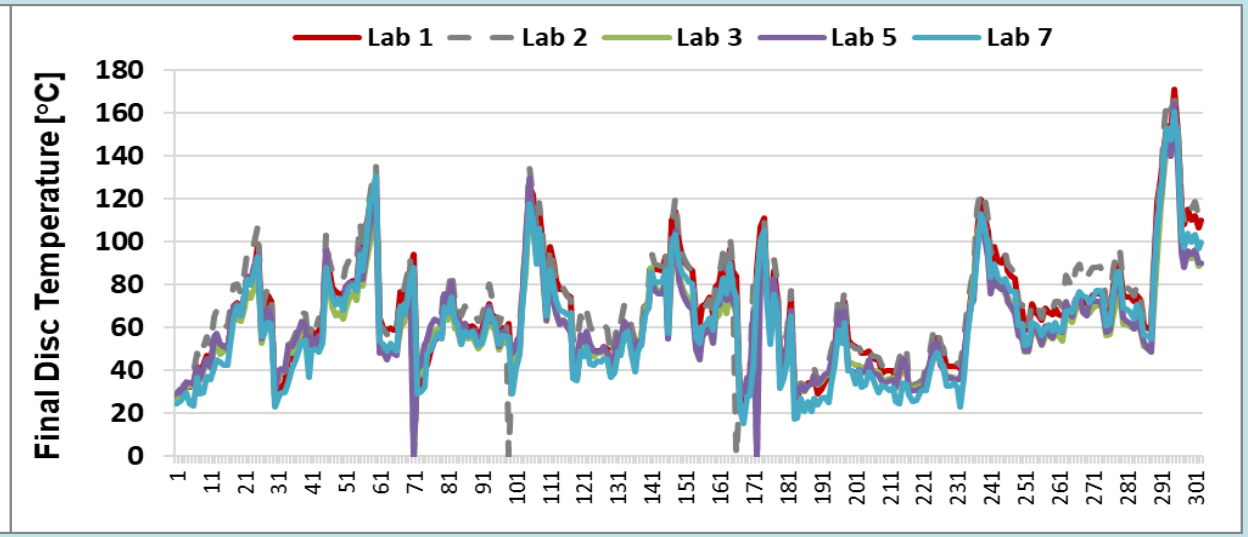
ACHIEVED MILESTONES
TEMPERATURE MEASUREMENT

Temperature measurement: Brake temperature can be measured with embedded or/and sliding TC. The two methods do not provide the same level of accuracy. Round Robin data were used to evaluate the differences



Final disc temperature profile measured by sliding TCs over the 1st repetition of T1 for 5 different labs



Final disc temperature profile measured by embedded TCs over the 1st repetition of T1 for 5 different labs

Disc temperature measurement and subsequent analysis shall be performed by means of **embedded thermocouples**. Recommendations on the correct installation and use of the TCs will be provided by TF1

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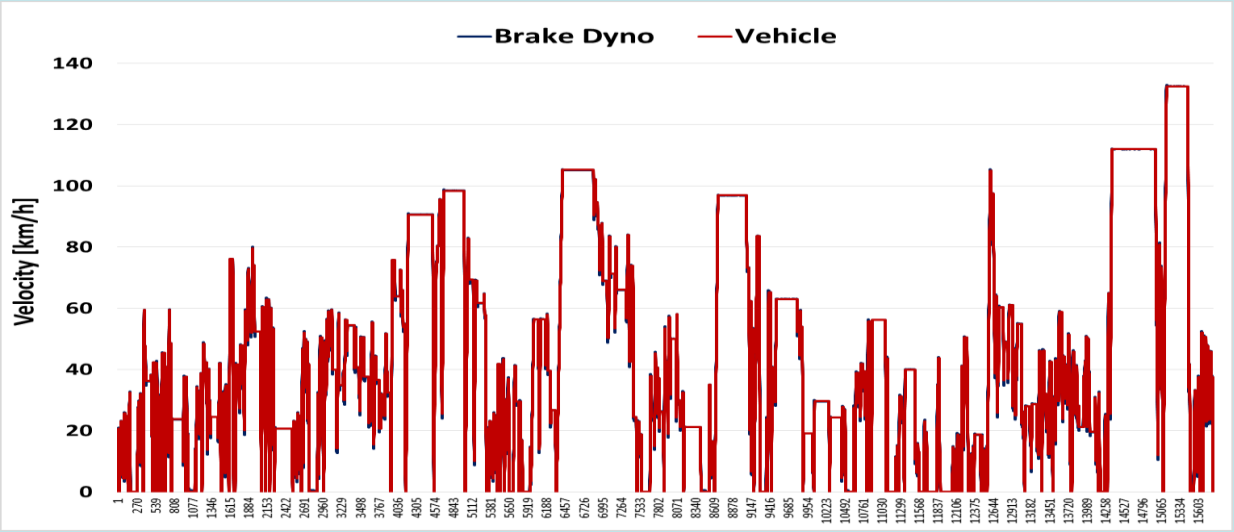
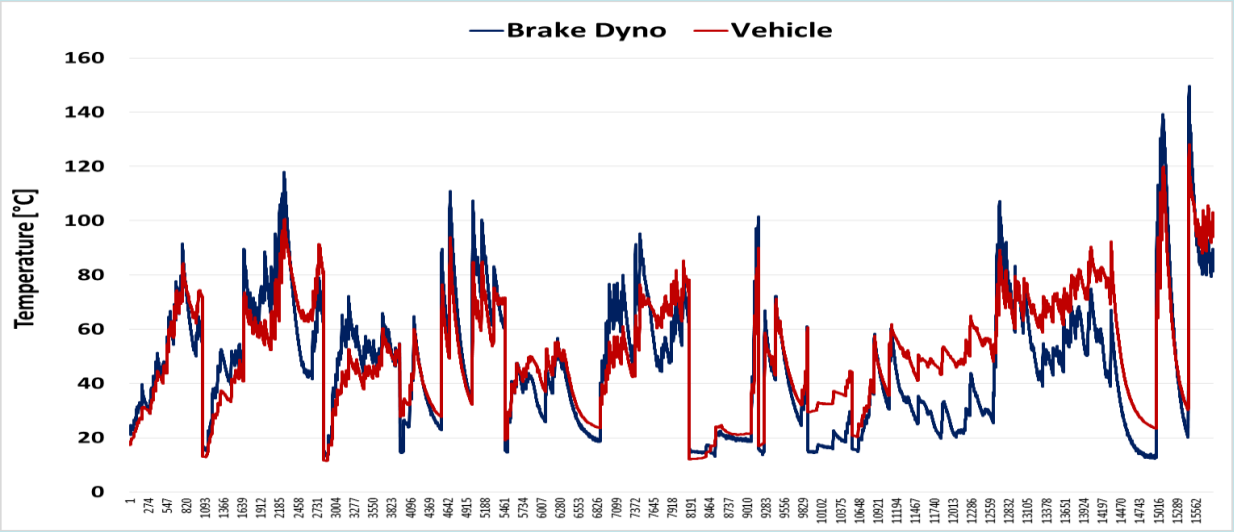
ACHIEVED MILESTONES
ROUND ROBIN

Round Robin: Primary objective was to reproduce the novel cycle at brake dyno level and compare the temperature levels of the brake system to those recorded at the vehicle level



Second by second speed trace recorded at the vehicle and the brake dyno [Grigoratos et al. – To be published]



Second by second disc temperature profile recorded at the vehicle and the brake dyno [Grigoratos et al. – To be published]

The novel cycle seems to be repeatable and reproducible at dyno level. **Results indicate that the cycle can replicate vehicle temperatures provided that a very well defined measurement protocol is followed**

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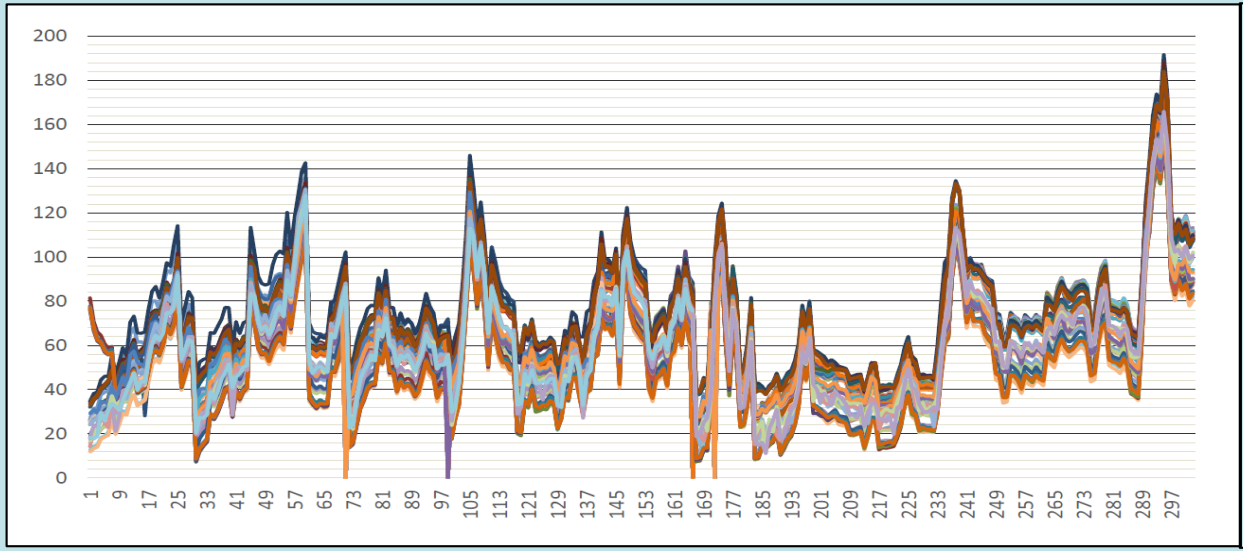
ACHIEVED MILESTONES
COOLING AIR ADJUSTMENT

Cooling air adjustment: The application of non-comparable cooling air speed between labs will result in significant differences of the temperature regime thus affecting particle measurements



Final disc temperature profile for all labs participated to the RR [Grochowicz et al. 2019 – 50th PMP Meeting]

Available options for the adjustment of the cooling air flowrate

~~a) Application of a fixed air speed (i.e. 45 kph)~~

~~b) Adjustment based on trip #10 cooling curve~~

~~c) Adjustment based two different cooling curves~~

d) Adjustment based on key parameters (trip #10)

The proposed methodology for the cooling air adjustment takes into account inertia split, parasitic losses and other important technical details. **The method applies for all brakes featured in passenger cars**

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TF1 – OVERVIEW

REQUIREMENTS FROM TF1

- Recommendations regarding the adjustment of the cooling air flowrate √
- Recommendations regarding the measurement of the brake temperature √
- Recommendations regarding the application of soak times √
- Recommendations on how to treat other vehicle classes √

FUTURE TF1 ACTIVITIES

- Preparation of RR statistics report as well as of PMP protocol to be incorporated to the final proposed method
- Might need to revise the cooling air flowrate adjustment methodology when (and if) vehicle data are fed by OEMs, TIER1 and/or others

TF1 – OVERVIEW

	Laboratory	Representative(s) in TF1
1	AUDI	Sebastian Gramstat
2	BREMBO	Guido Perricone / Matteo Federici / Giorgio Valota
3	FORD	Jarek Grochowicz / Marcel Mathissen
4	GM	Matt Robere
5	ITT Motion	Agusti Sin / Simone Ansaloni
6	LINK Europe	Marco Zessinger
7	LINK US	Carlos Agudelo / Ravi Vedula Alejo Hortet / Quinn O'Hare
8	TMD FRICTION	Andreas Paulus

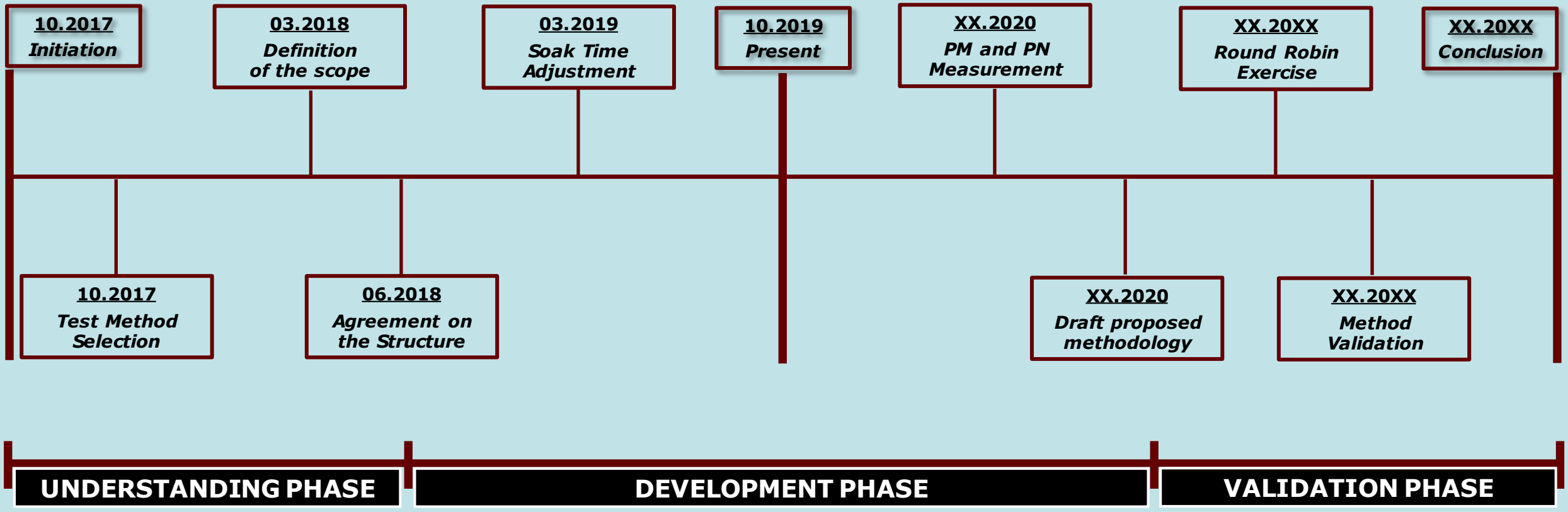
- **30 full group meetings plus several preparation bilateral meetings**
- **A full experimental campaign (RR) with 2 sets of 6 repetitions of the novel cycle plus several adjustment tests with dummy parts**
- **Two independent validation campaigns at vehicle and dyno level from Ford and Link**
- **A detailed report of the main results and statistics of the RR along with recommendations on the correct application of the cycle on the brake dyno (to be submitted in 2019)**

TF2 – BACKGROUND

June 2017: The PMP IWG identified the need for merging Task 2 (Development of a method for sampling BW particles) & Task 3 (Selection of the most suitable methods for BW particles measurement and characterization) as described in the ToR (2016) in one Task handled by TF2

- Selection of the testing methodology (Concluded)
- Comparison of existing systems/test rig configurations (Concluded)
- Selection/definition of testing parameters and collection of experimental data (On-going)
- Validation of the selected configuration(s) & measurement methodologies (Deadline: To be defined)

TF2 – (FORESEEN) MILESTONES



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TF2 – COMPOSITION

- **OEMs:** AUDI; BMW; Ford; GM; Opel
- **Instrument and Brake Dyno Manufacturers:** AVL; DEKATI; HORIBA; LINK Engineering; TSI
- **Brake Industry:** Brembo; Federal Mogul; ITT Motion Technologies; TMD Friction
- **Research Institutes and Academia:** Japan Automobile Research Institute (JARI); Joint Research Centre (JRC); Technical University of Ilmenau
- **Other Organizations**: California Air Resources Board

Any questions?

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