OICA

OICA contribution to PMP

24.05.2023

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Topics

- Recap – basic principle
- Status of informal document Annex C
- P Sensor Calibration
- Cp Calibration Method

Non-friction energy share methods

- **Method A (Brake torque measurements)** could help to verify other methods
  - on its own it is not suitable for homologation, because of the instrumentation effort needed?
  - Not "first choice" due to issues with direct torque measurement for drum brakes and potentially disc brakes with sliding calipers

For Reference

- **Method B (Brake torque calculation (pressure) equivalent signal for EMB (electromechanical brakes) needed**
  - Need to agree on the Method for friction coefficient estimation/measurement
  - seems to be a workable approach

Master

- **Method D (Brake torque on CAN)**
  CAN values have to be available for the front and back axel for every vehicle

- **Method C Calculation from E-motor and engine drag**
  - Other losses will be neglected
  - Powertrain Efficiency has to be estimated/calculated

- **Method E Calculation from electric energy (battery)**
  - For pure BEV this method could be easy and suitable

Alternative

Status of informal document Annex-C

<u>The proposal presented at last PMP meeting (27.04.2023) has been updated:</u>

- Chapter 3 (Definitions) and Chapter 4 (Abbreviations and Symbols)
- Equation 1 (Eq.1) and definitions clarified
- Calibration procedure for Cp (chapter 5.3)
- Schematics of pressure measurement (chapter 6)
- Clarified data recording (chapter 6.2) and test sequence (chapter 6.4)
- Improved equivalence criterion of methods (chapter 7.3.)

Status of informal document Annex-C – ToDo's

- Formula for separate Wbrake at front and rear brake (Chapter 5.2)
- Formula to calculate Wbrake for electromechanical brakes (Chapter 5.2.)
- Calibration procedure for Ce (electromechanical brakes)
- Correlation factor converting c determined at WLTC(Exhaust) in WLTP(Brake)

Accuracy of Pressure Transducers and Calibration protocol

exemplary application :

Range 10 BAR

non-Linearity, Hysteresis and Repeatability typ. max ± 0.5% FSO

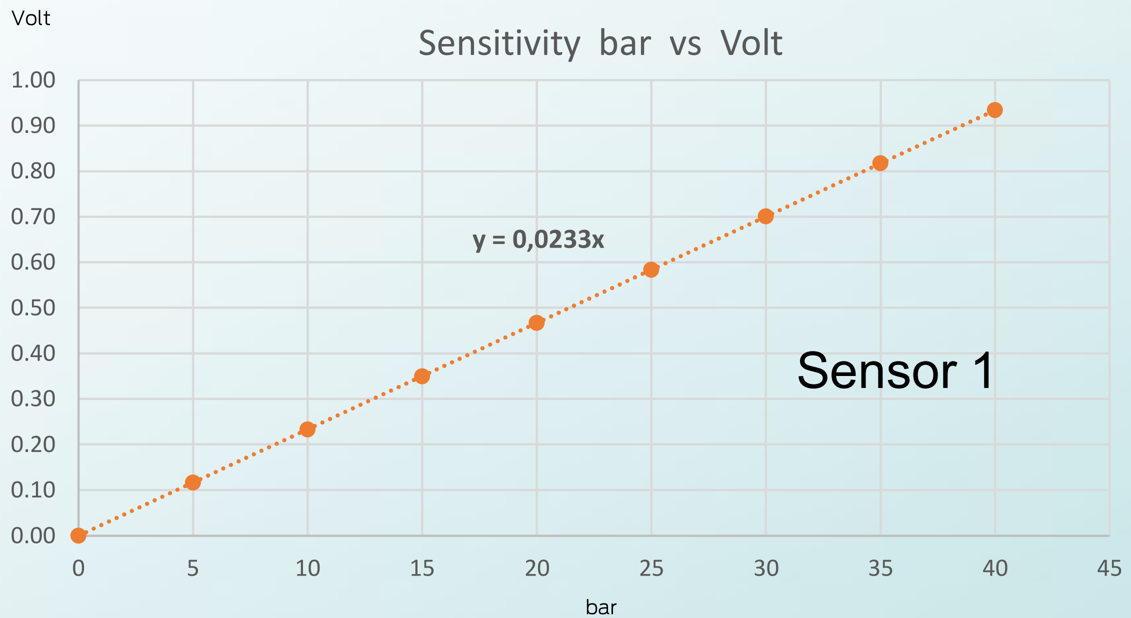
Calibrated in the cycle relevant Pressure range from **0-40 bar**

Sensitivity (elec.Unit/engg.Unit): 0.0227 – 0,0233 VDC/Bar

Max. **Non-Linearity** (%FS): 0.04 -0.08 % Max. Hysteresis (%FS): 0.0187 %

Total uncertainty * (%FS): 0.04 -0.08 % Calibration Excitation Voltage 12 V

** The Total uncertainty indicated is the "root sum square" of the Max. Non-Linearity and the Max. Hysteresis*



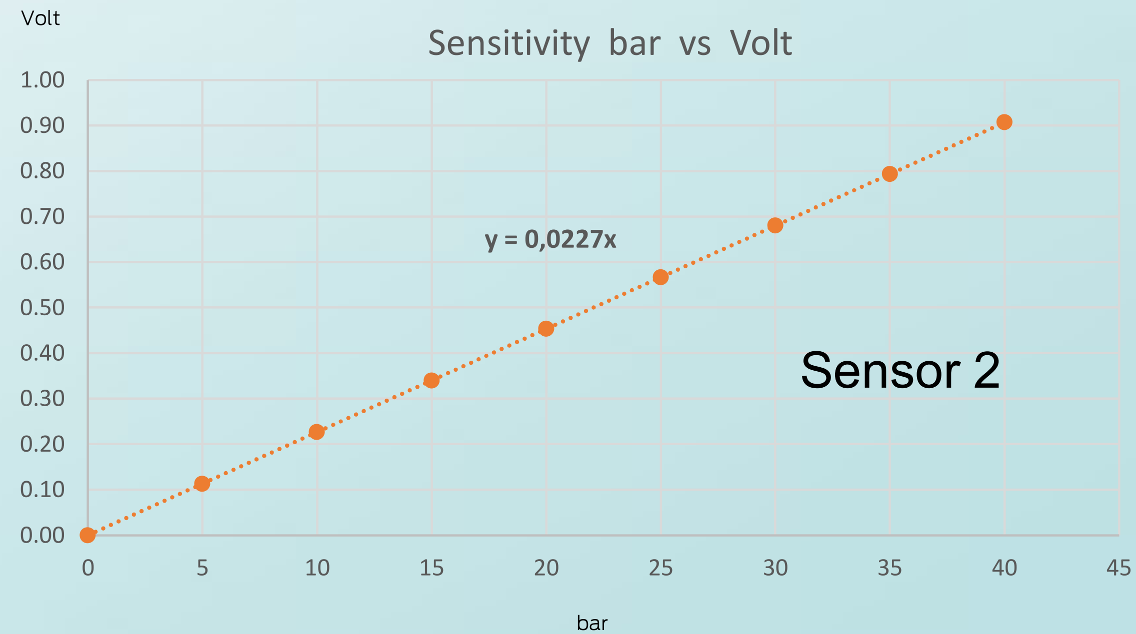
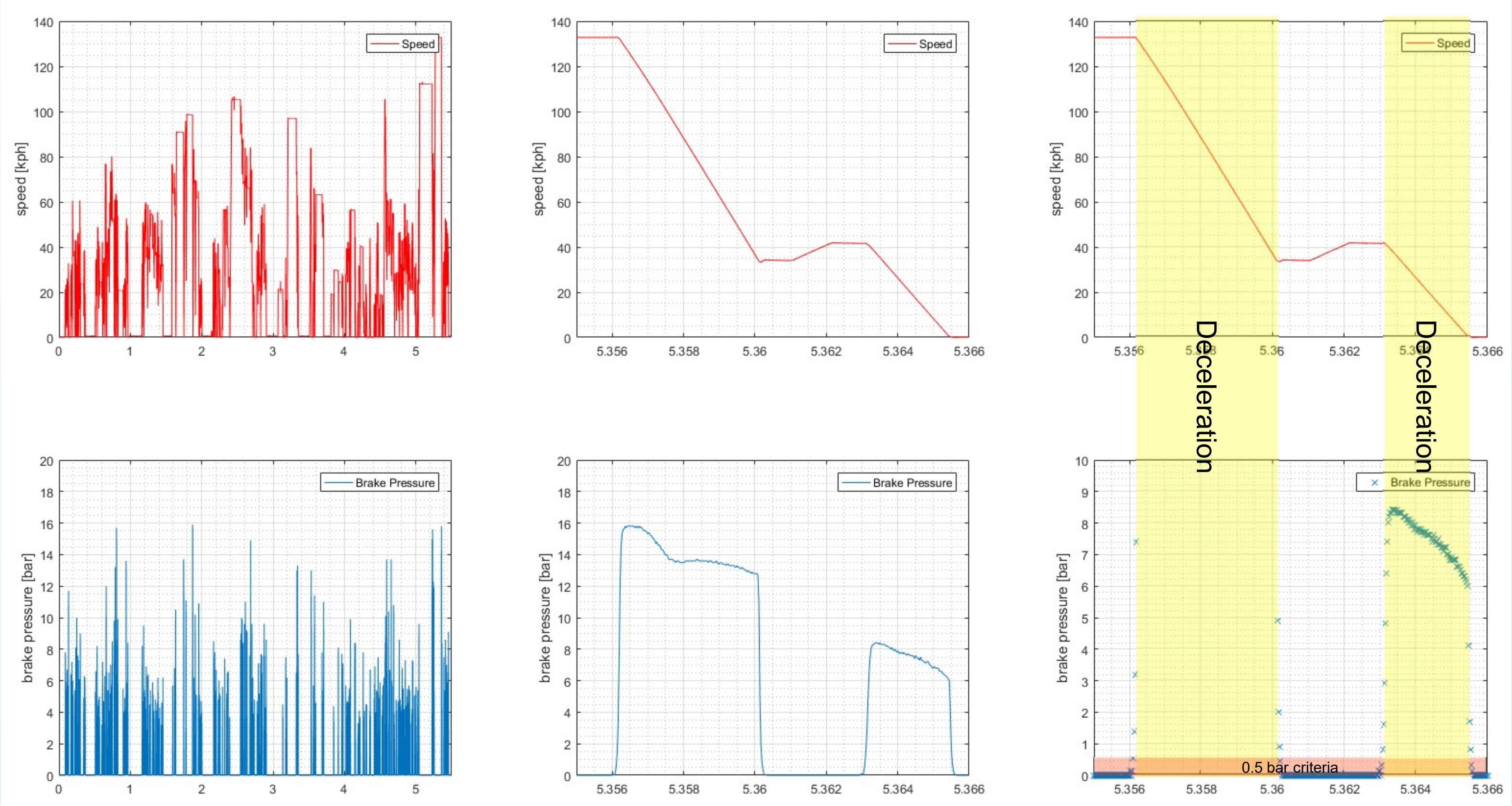


Fig1: Calibrated in the cycle relevant Pressure range from 0-40 bar

Effect of 0.5 bar cut-off criteria

- ➢ Due to synthetic speed profile, braking are clearly distinguished
- ➢ Energy dissipation @p<0.5bar: 0.3% of total dissipated energy

⇒ **Effect on cp-calculation neglectable**



Calculation of energy weighted c_p: WLTP-Brake vs. Trip 10

Comparison of c_p-calculation based on WLTP-Brake cycle vs. WLTP-Brake (Trip 10):

- Data base:

	WLTP brake	Trip 10
braking time	1714 s	626 s
avg. deceleration	0,97 m/s²	0,93 m/s²
avg. speed (braking) (energy weighted)	**47,2 kph**	**52,9 kph**

- Effect on c_p-calculation (one front axle brake):
  - c_p_WLTP-Brake = 37,61 Nm/bar
  - c_p_WLTP(Trip10) = 35,95 Nm/bar

⇒ according to evaluated example: **delta in c_p: 4 %**

⇒ c_p derived from WLTP brake leads to sightly higher values (worst case approach)

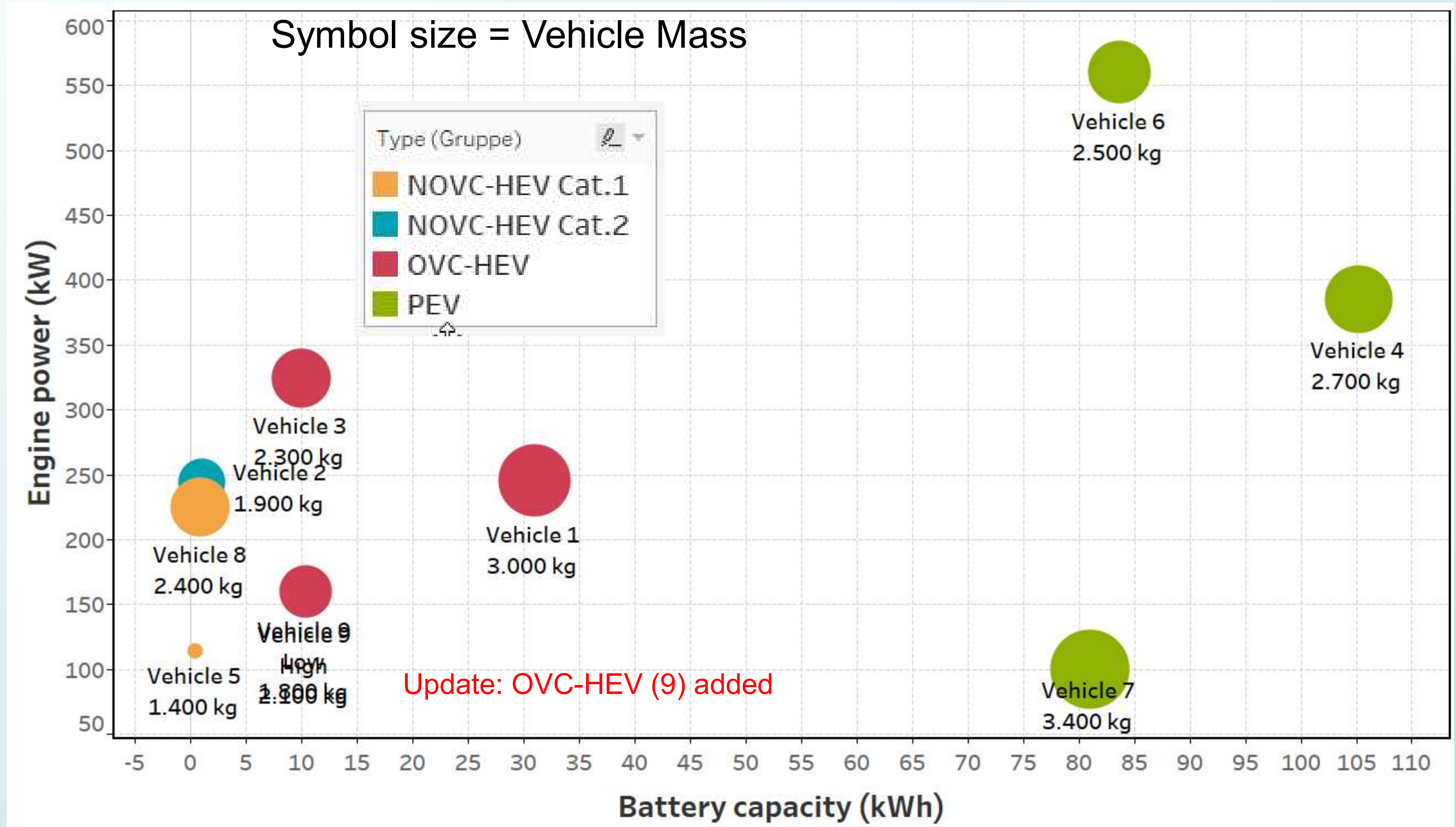
potential technical reason:

higher average speed (evaluated with energetic weighting)

→ friction coefficient sightly reduced with higher speed

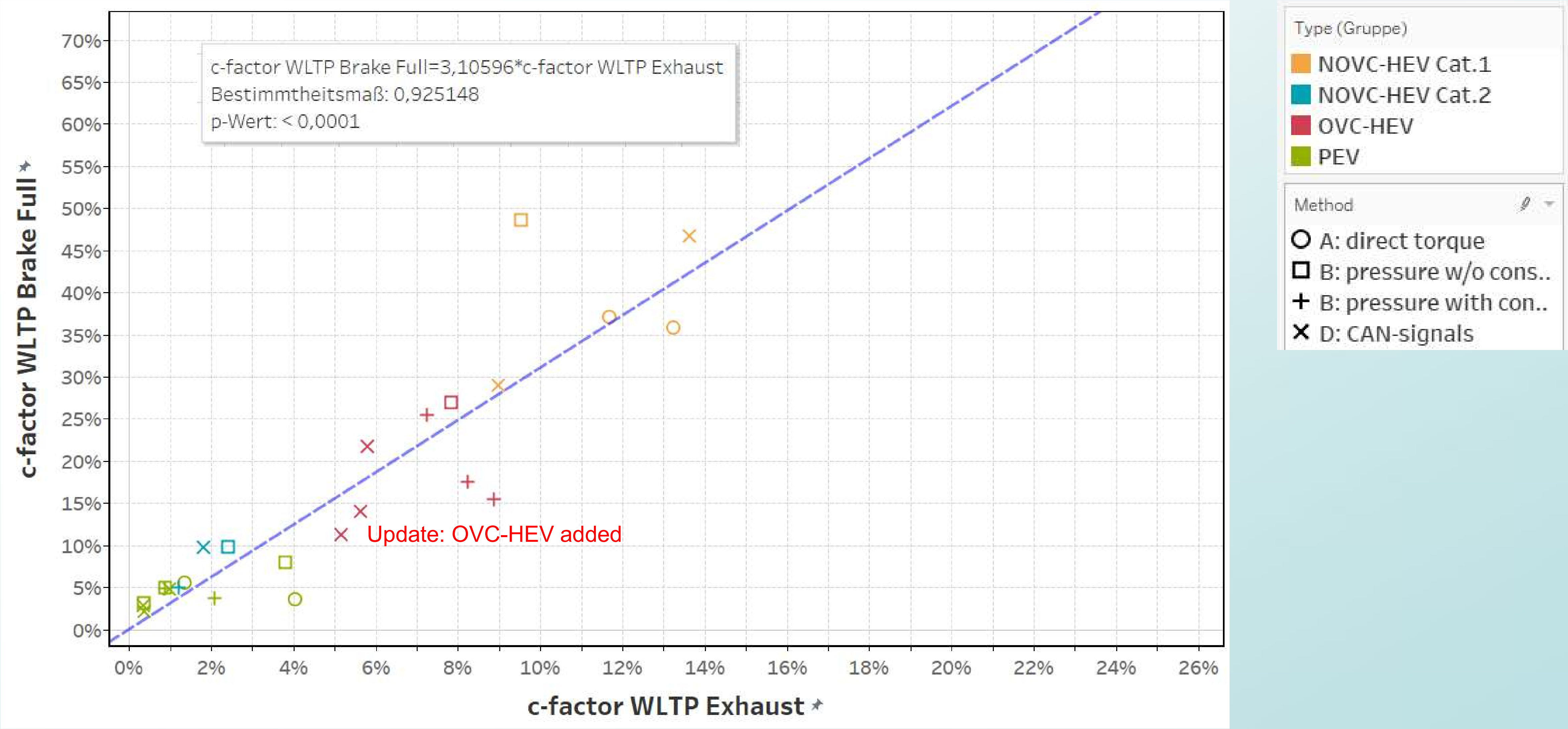
Data comparison Method B

Vehicle	Type	Engine power (kW)	Battery capacity (kWh)
Vehicle 1	OVC-HEV	245	31
Vehicle 2	NOV-HEV Cat2	244	1,1
Vehicle 3	OVC-HEV	324	10
Vehicle 4	PEV	385	105,2
Vehicle 5	NOVC-HEV Cat.1	114	0,45
Vehicle 6	PEV	560	83,7
Vehicle 7	PEV	100	81
Vehicle 8	48V	225	0,92
Vehicle 9 High	OVC-HEV	160	10,4
Vehicle 9 Low	OVC-HEV	160	10,4



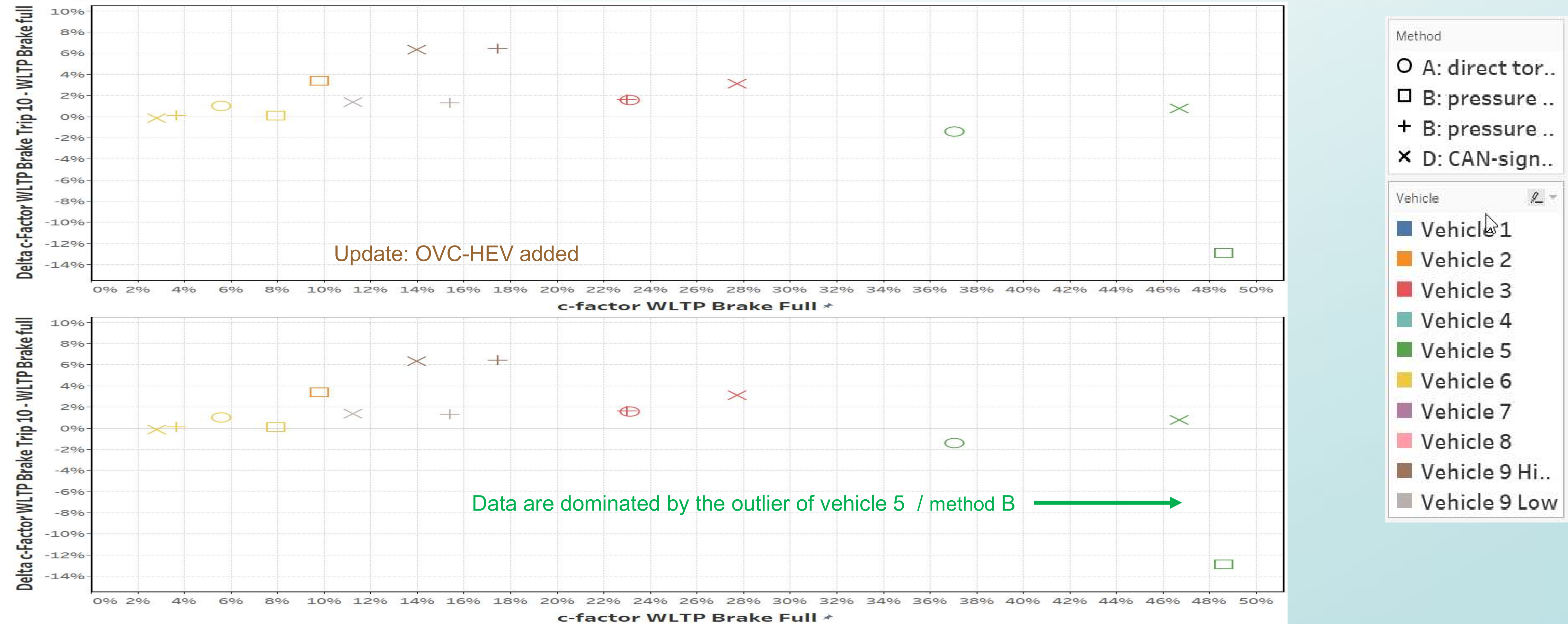
- All electrification types were tested: 3x PEVs, 4x OVC-HEV, 2x NOVC-HEV-cat-1, 1x NOVC-HEV cat-2
- More vehicles to be tested

Correlation: WLTP Brake / WLTP-Exhaust



- Raw OICA data – outliers need to be investigated
- WLTP Brake / WLTP Exhaust correlation factor needs to be determined by further data

Correlation plot c-Factor WLTP Brake Full vs Trip 10

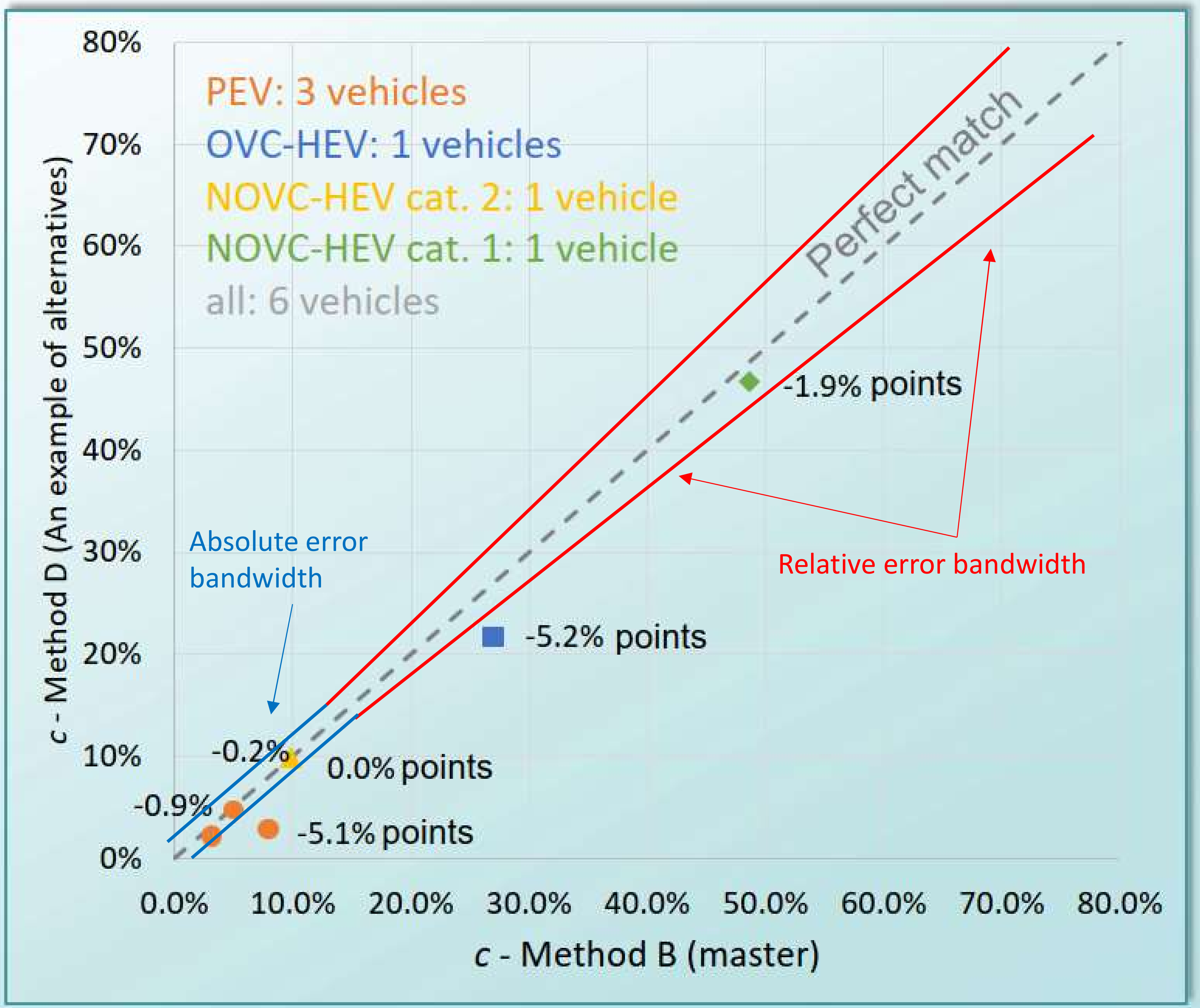


- c-factor determined on Trip 10 tends to show somewhat higher values ➔ Δ (WLTP Brake Trip10 – Full) > 0
- reconfirmed by further data (vehicles 9 high and low mass)

Alternative Method(s)

- An alternative method shall be tested in comparison to the Master Method (B) and demonstrated to the Technical Service
- Drive cycle shall be WLTP Brake
- Alternative method is valid if one of the following conditions is fulfilled
  - $\left|\frac{c_{alternative} - c_{method\ B}}{c_{method\ B}}\right| \leq [10\%]\ ;\ or$
  - $|c_{alternative} - c_{method\ B}| \leq [x\%]$ *
- TF-4 work shows tests for each electrification concept (PEV, NOVC-HEV I II, OVC-HEV)

(*) An absolute error is necessary to cover the inaccuracies for the low values of the c-factor



Alternative use of individual method or Tab 5.1.

- In order to avoid excessive testing requirements and due to the very strict timeline OICA needs clarity on the continuation of Table 5.1 (fall back solution)
- individual friction share method or values in Table 5.1. may be used
- in case the individual friction share would be higher than Table 5.1., the individual value counts
- With this proposal, no cherry picking is possible with current Table 5.1 values
- The following text is proposed for the GTR revision:

> 5.2.2. Brake Emissions Family Parent
>
> ….
>
> [Manufacturers can use the assigned friction braking share co-efficient from Table 5.1, or as an option may demonstrate own tests to determine the vehicle specific friction braking share co-efficient via the methodology described in Annex C. If the vehicle specific friction braking share determined by Annex C is higher than Table 5.1, the individual number of Annex C is used to determine the vehicle's emission as described in paragraph 12.1.5 and paragraph 12.2.4.
>
> A detailed testing methodology to determine vehicle-specific friction braking share coefficients is described in Annex C.]

A further increase of Table 5.1 default values is not justified, To be beneficial the table should represent industry data

From OICA perspective the proposal to increase the friction braking share coefficient values in table 5.1 is **not justified.** There is **no measurement data available** which demonstrates that the old table would not represent the industry values well enough.

In addition, OICA wants to underline that the manufacturer must be able to demonstrate compliance with the data of this table if any measurement is requested. In case that the specific value of the vehicle is worse than the default value, the table cannot be used. **Therefore, OICA clearly wants to mention that there is no option for any „Cherry Picking approach" by using default values.**

The current proposal from JRC to further increase the default friction share **would result in an additional testing/homologation effort** for manufacturers to demonstrate lower friction values. From OICA perspective this is not justified as the chassis dyno capacities are limited.

→ To be beneficial the table should represent industry data.

Development/Homologation Flow

Development

Determination of the specific recuperation share by OEM

1. Chassis Dyno
   - WLTC Exhaust
   - WLTP Brake
   - WLTP Brake Trip10

OR

2. Simulation
   - WLTC Exhaust
   - WLTP Brake
   - WLTP Brake Trip10

…

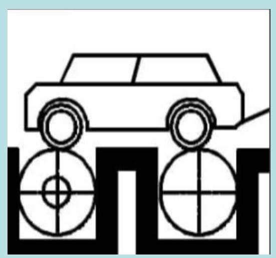
Certification (Recuperation - Family Head)

1. Default Table-Value

Brake type	Vehicle Type	Friction Braking Share Coefficient (c)
Full-friction braking	ICE and other vehicle types not covered in this Table	1.0
Non-friction braking	NOVC-HEV Cat.1	0.63
	NOVC-HEV Cat.2	0.45
	OVC-HEV	0.30
	PEV	0.15

OR

2. Chassis Dyno: (Master method or alternative method)



- WLTC Exhaust
- WLTP Brake
- WLTP Brake Trip10

?

Verification

1. Chassis Dyno:
(Master method or alternative method)
   - WLTP Brake