Scientific expert workshop on CO2 emissions from light duty vehicle Lisbon 7-8 June 2016

Session 3: challenges of measuring real driving emissions

DIRECTION RECHERCHE ET DEVELOPPEMENT
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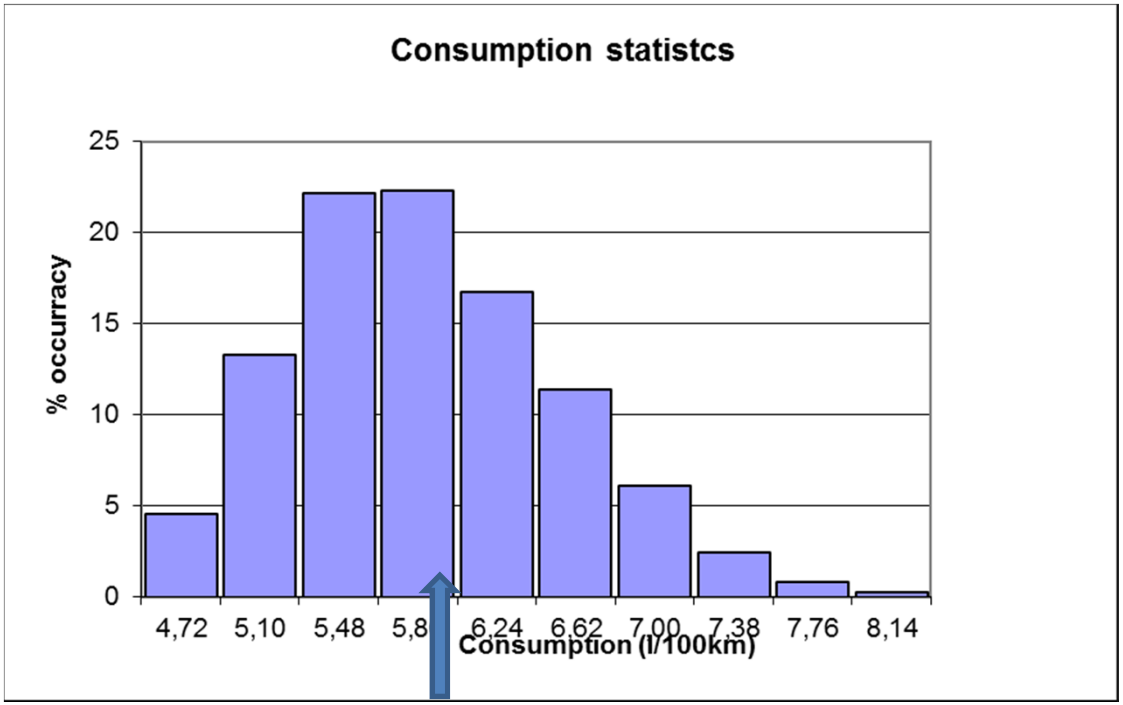
Real driving consumption challenges…

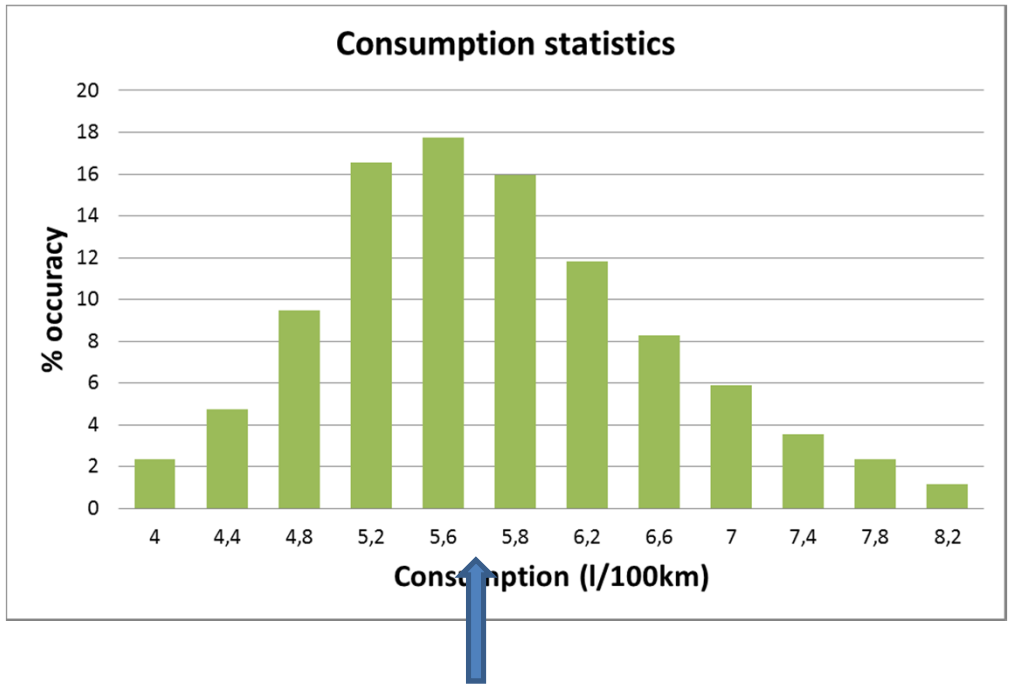


Average consumption

- What real driving consumption are we talking about? A user value?
- User survey=> not a unique value but a distribution
- Many reasons to have a wide spread consumption repartition (see session 2)
  - Urban/ Road / highway %
  - Driver sportiness
  - Auxiliary use
  -

Challenge : measurement of the x% (=50% for PSA) consumption value

Real driving consumption challenges…

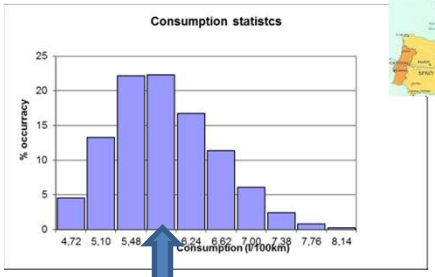


Average consumption

- What real driving consumption are we talking about? A 50% user?
- Statistics for a given user=> not one value!
  - Holidays/working weeks
  - Summer/winter
  - …
- =>consumption should be evaluated on a yearly basis

Challenge : measurement of the 50% user yearly consumption value with simple and short test

Real driving consumption challenges…



Vehicle data

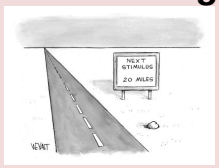
Mass (load, tank level..)

Tyre resistance

Drag

Vehicle Use

Urban/Road/highway%



Trip distances, stop duration

Plug frequency

Auxiliary use (A/C ..)

Driver driving behavior

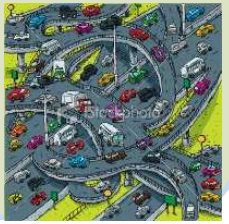
Gear shiftings

Sportiness

External conditions

Temperature

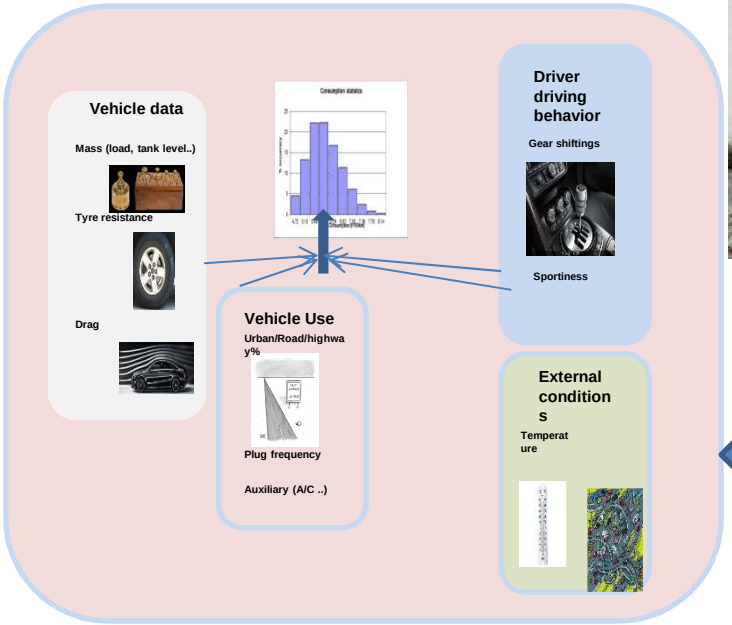
Traffic density



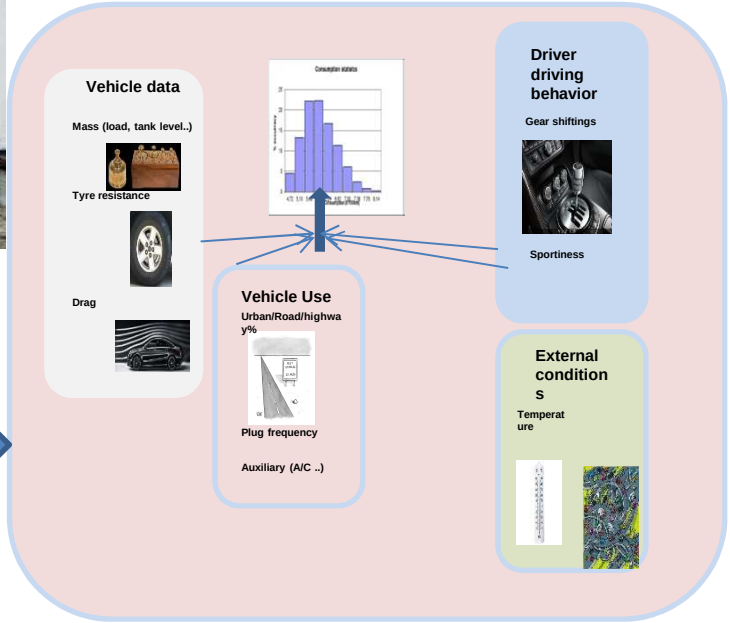
Challenge : try to find conditions leading to the average consumption of the average driver

Real driving consumption challenges…

Average consumption conditions



Real test conditions



Challenge : try to stick to average conditions and be able to correct difference impacts

A method to measure consumption?

- An initiative for transparency from PSA, with two NGOs (T&E, FNE)*, and a certification body (Bureau Veritas) working together to offer better information to customers

**Transport & Environment, France Nature Environnement*

A method to measure consumption?

- PSA Groupe took the initiative to announce the publication of customer fuel consumption for their principal vehicles, under the control of an independent parties (T&E, FNE and BV)
- A Protocol has been developed to measure the average customer fuel economy
- PSA, presented at the 2016 Geneva motor show the validated protocol with the 3 first results
- Before summer 2016: PSA will publish the measurements of average fuel consumption for 30 Peugeot, Citroën and DS models

Following elements on real driving consumption measurement comes from this working group

The different steps of the protocol

Step 1 :

Vehicle data

Mass (load, tank level..)

Tyre resistance

Drag

- **Selection of the vehicle**
- **Verification of the vehicle**

The different steps of the protocol

Step 1 : Selection and verification of the vehicle

Vehicle data

Mass (load, tank level..)

Tyre resistance

Drag

Step2: driving and measurement

Driver driving behavior

Gear shiftings

Sportiness

External conditions

Temperature

The different steps of the protocol

Average Real driving consumption

<u>Step 1</u> : Selection and verification of the vehicle

Vehicle data

Mass (load, tank level..)

Tyre resistance

Drag

<u>Step3</u>: Data post treatment

Vehicle Use
Urban/Road/highway%

Trip distances, stop duration
Auxiliary (A/C ..)
Plug frequency

Driver driving behavior
Gear shiftings

Sportiness

External conditions

Temperature

<u>Step2</u>: driving and measurement

3 steps to determine the average real driving consumption

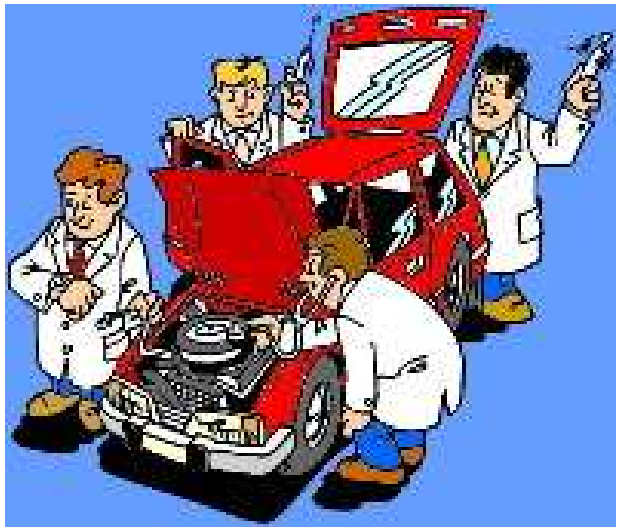
Step 1 of the protocol : selection and verification of the vehicle

Selection of the vehicle

- Selection of vehicle to fit to average user vehicle
  - With mainstream options which have an impact on consumption (AC, tyre size, ..)
  - Above 1000km vehicle

Verification/ Preparation of the vehicle

- Check list verification
  - Oil level
  - Battery SOC
  - Tire pressure and wear
  - Service manual check



Real Driving Consumption value Measurement: 4 different ways

- Information from Engine Computer :
  - No accuracy requirement on OBD signal. Accuracy on low load situation not good
  - Need to be connected to the Engine Computer

- Fuel Flowmeter:
  - Need to modify the fuel circuit

- With the fuel pump value (using fueling gun stop)
  - Poor precision >> 5 %
  - Need lot of km
  - Do not give access to urban/road/ highway consumption independently

- PEMS (Portable Emission measurement system)
  - Need an exhaust pipe modification
  - Aero drag impact
  - Same tool as for RDE
  - Precision: See PEMS Precision slide

Step 2 of the protocol : driving the vehicle and measurement

Step 1 : Vehicle ready for measurement

Vehicle data

Mass (load, tank level..)

Tyre resistance

Drag

Average Real driving consumption

Step3: Data post treatment

Vehicle Use
Urban/Road/highway%

Plug frequency

Auxiliary (A/C ..)

Driver driving behavior
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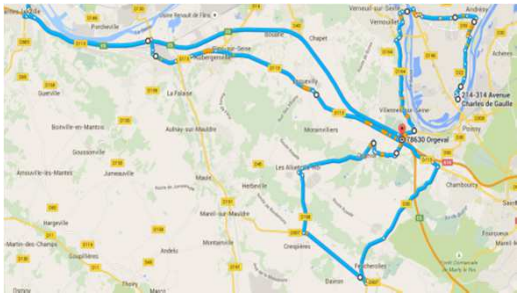
Temperature

Step2: driving and measurment

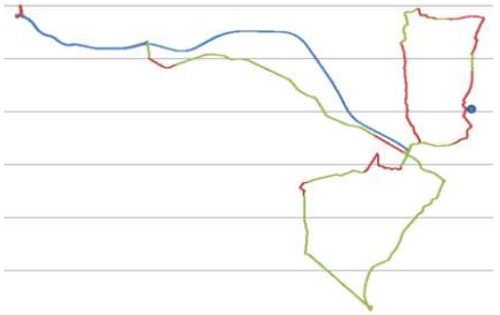
3 steps to determine the average real driving consumption

Circuit and Driving instructions

- Definition of a circuit with diversified driving conditions (city, road, motorway)
- City / Road / Motorway mix



City : 22,8 km
Road : 39,6 km
Motorway : 29,9 km
Total: 92,3 km



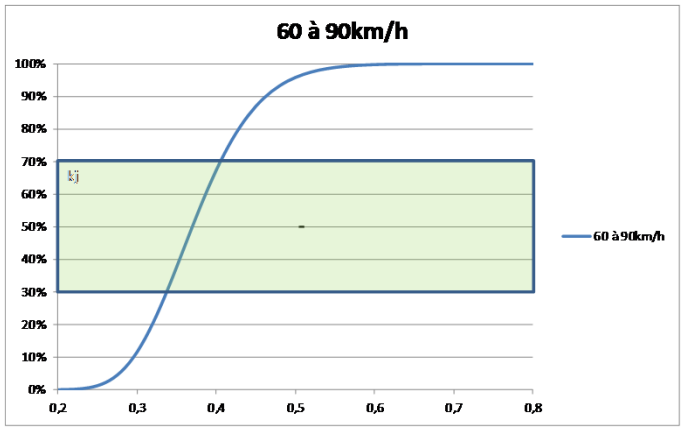
- Driving instructions:
  - No obligation to follow Gear Shifting Indicator (GSI)
  - Use of auxiliaries (HVAC, lights…): as needed depending on conditions
  - Be as close as possible to average customer driving dynamics
  - Only rules: follow road traffic code, especially speed limits

One circuit to have 3 consumption values.

Validation of each drive

- Comparison to “driver 50%” statistics driving dynamics
  - average speed in Urban/Road/HighWay
  - average positive acceleration in U/R/HW
- These statistics are
  - deduced from Customer database
  - segment and fuel type dependent
  - for each U/R/HW use

		Vehicle speed [km/h]		
		0 à 60	60 à 90	90 à 250
average speed			75.0 km/h	
average longitudinal acceleration	< -0,1			
	-0,1 à 0,1			
	> 0,1		Distance : 9,78% average acceleration : 0,37 m/s^2	



Comparison to “driver 50%”

Validation of each drive

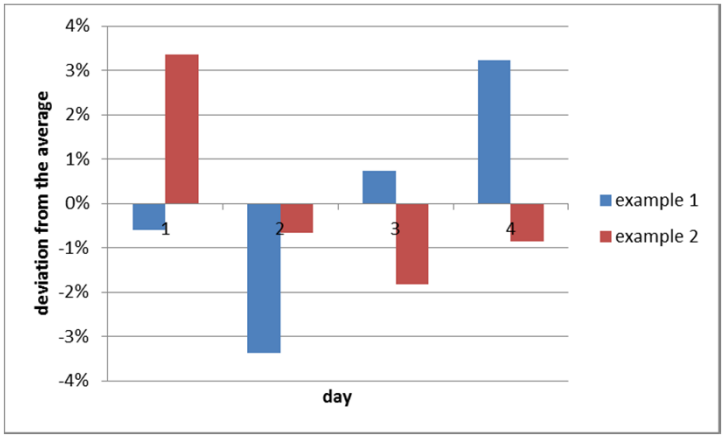
- A trip is accepted if
  - The average speed for U/R/HW is within ± 3 km/h of the “driver 50%”
  - The average positive acceleration for U/R/HW is included between the customer 30% and customer 70% values.
  - Tolerances are defined to have :
    - Little consumption difference within tolerances
    - Easiness to have a valid test
- Others are rejected (too much or not enough dynamical driving)

Each test should be in a velocity/acceleration windows to be accepted

Measurement: number of tests

- On a given circuit with the same driver=> some variations
  - wind, rain, road traffic, use of auxiliaries, dynamics conditions…
- On a given circuit average consumption depend of driver

=> At least 3 valid measurements with minimum 2 different drivers should be performed



- At the end: completion with
  - Correlation test with test bench
  - Cold start effect measurement

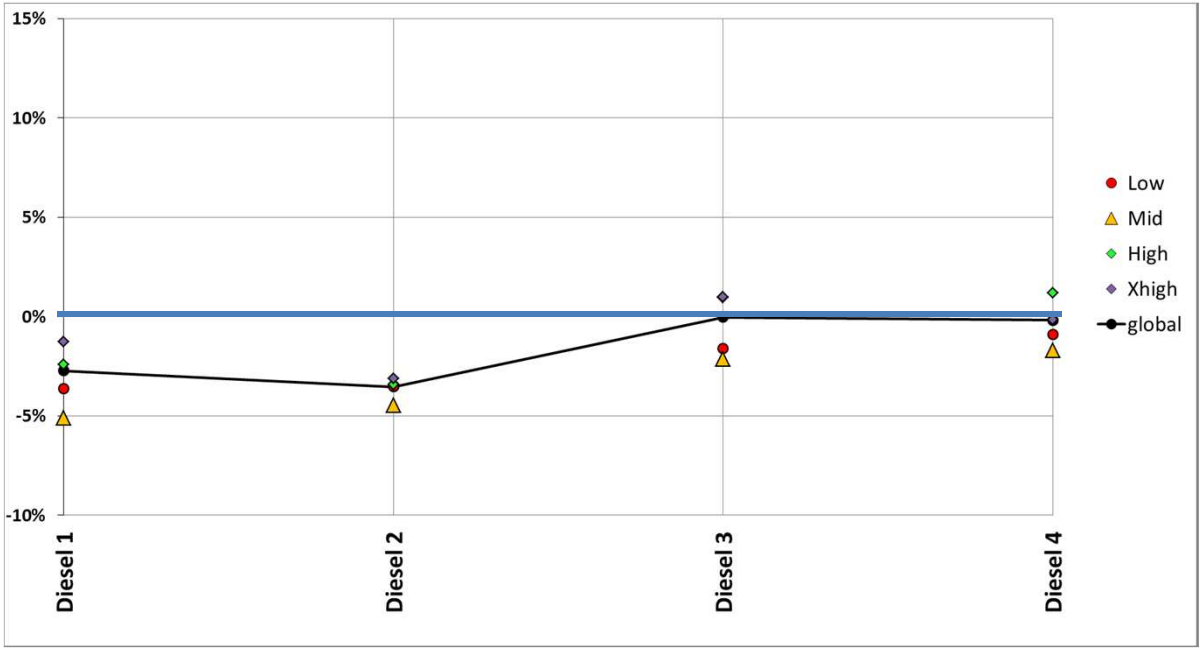
Measurement: PSA experience from 01/01/16 to 31/05/16

- 130 tests on the road
- 60 correlation tests on the bench
- To get an accurate fuel consumption result, it is necessary to correct the PEMs measurement by the correlation factor PEMS / bench

A correction of PEMs measurement should be performed

Measurement: PEMS uncertainty

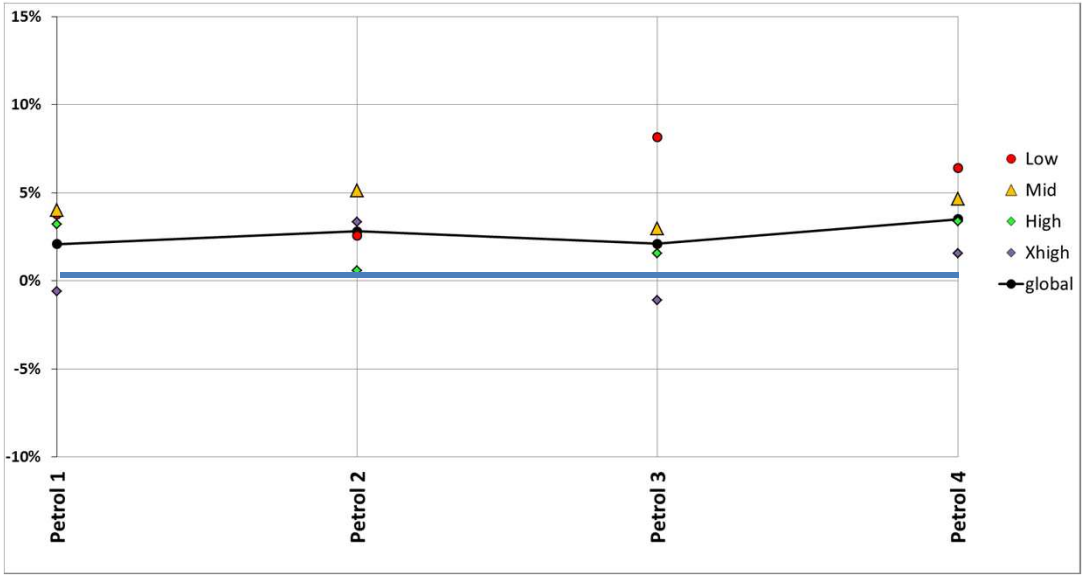
- For diesel engine (1.6 and 2.0 displacement)
  - Use of a 2'' flowmeter
  - The uncertainty quite low and constant for the 4 phases of the WLTP



Diesel engine: PEMS uncertainty OK

Measurement: PEMS uncertainty

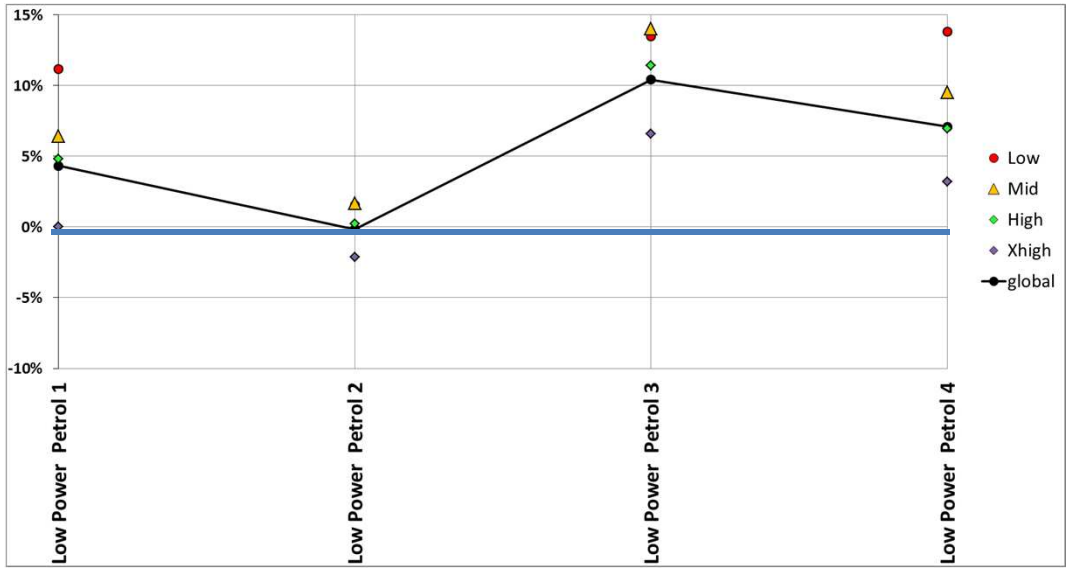
- For petrol engine (1.2 TC and 1,6 TC displacement)
  - Use of a 1,5'' flowmeter
  - The uncertainty is just sufficient and not constant for the 4 phases of the WLTP
  - Need to be improved



High power petrol engine: PEMS uncertainty quite OK, need be improved

Measurement: PEMS uncertainty

- For petrol engine (1.0 NA and 1.2 NA displacement)
  - Use of a 1,5'' flowmeter
  - The uncertainty is not OK and not constant for the 4 phases of the WLTP
  - The 1'' flowmeter is not suitable for the 1.0 NA and 1.2 NA
  - Validation of the 1,25'' flowmeter once available



Low power petrol engine: PEMS uncertainty not OK, must be modified

Step 3 of the protocol : Data post treatment

Step 1 : Vehicle ready for measurement

Vehicle data

Mass (load, tank level..)

Tyre resistance

Drag

Average Real driving consumption

Step3: Data post treatment

Vehicle Use

Urban/Road/highway%

Plug frequency

Auxiliary (A/C ..)

Driver driving behavior

Gear shiftings

Sportiness

External conditions

Temperature

Step2: driving and measurment

Post treatment

- Why a post treatment? To be as close as possible to the « driver 50% »
- => Correction of the fuel consumption to better match real average uses
  - Normalisation to “driver 50%” use conditions.

Correction of the fuel consumption

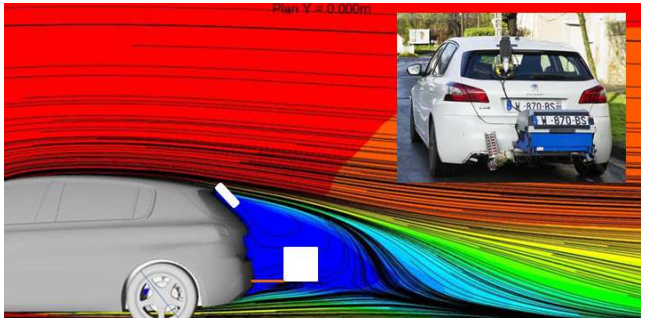
- Consumption test result corrections by calculation to bring them to the “driver 50%” use
  - 1. Correction for mass and weather conditions
  - 2. Aerodynamic impact of the PEMS
  - 3. Correction for the mix City, Road, Motorway
  - 4. Weighting of the cold phase
  - 5. Taking into account not continuously working devices (eg. DPF (diesel particulate filter) regeneration)

Correction of the fuel consumption

- 1. Correction for mass and weather conditions
  - Using coast-down values and WLTP formula to bring back rolling resistance to standard conditions
    - 14°C
    - 100 kPa
    - Average « target » mass as driven by the customer
  - Target mass is the sum of
    - Empty weight for the vehicle equipment level tested
    - Average options mass for the vehicle equipment level considered
    - Average occupants' mass
    - Luggage mass
  - Occupants mass and luggage mass from customer database

Correction of the fuel consumption

- 2. Aerodynamic impact of the PEMS
  - 3 rear body styles considered
  - Fuel penalties substracted



- 3. Correction for the mix Urban, Road, Highway
  - Bringing back to the average customer mix
  - Average customer mix depends on segment and fuel type, from customer database

Correction of the fuel consumption

- 4. Weighting of the cold phase
  - The trip begin by a cold start (at workshop temperature), the measurement already includes a cold penalty
  - The trip is approximately 92 km whilst the average customer trip is shorter.
  - Cold start phase during which Fuel Consumption is higher is therefore under estimated. A weighting of the cold phase is necessary by adding a fixed extra fuel consumption to be representative of the customer average use
  - Correction principle
    - Identification of cold start overconsumption
    - Identification of cold start impact duration
    - weight the overconsumption using statistics of customer trips (customer surveys).

Correction of the fuel consumption

- 5. Taking into account the possible DPF regeneration (diesel particulate filter)
  - Looking at PEMS exhaust temp, regeneration can be easily identified
  - Trip rejected when regeneration occurs
  - Trip valid if no regeneration occur
  - We add a fixed penalty with the real life Ki Factor, based on real regeneration intervals

First results shown at Geneva

3 vehicle tested on the 1rst of March

Vehicle tested Consumption measurement (l/100km)	**PEUGEOT 308** 1.6l BlueHDi 120 S&S BVM6	**CITROËN C4 GRAND PICASSO** 1.6l BlueHDi 120 S&S BVM6	**DS 3** 1,6l BlueHDi 120 S&S BVM6
T&E Customer use protocol	**5,0**	**5,6**	**4,9**
Customer consumption (Customers survey / Spritmonitor)	5,0 / 5,1	5,5 / 5,7	5,1 / 5,3
Homologated consumption (NEDC)	3,2	4,0	3,6

Results consistent with the average costumer consumption

Next Steps

Next Steps

- Before summer 2016: target of 30 vehicles tested. 24 already done
- Adapt the protocol for
  - Hybrids
  - LCVs
- Working with Sensors (our PEMS provider) to identify best flowmeter for all engine types

Conclusion

Conclusion

- Measuring Real driving consumption on road is a challenge
  - To know the average consumption conditions:
    - Reduce all drivers to an average one
    - Reduce all uses to an average one
    - Reduce all driving conditions to an average one
  - To measure this average consumption value
    - Have tests with as low variability as possible
    - deduce average consumption from real tests performed in non average conditions

- A methodology is proposed
  - Still remain a noticeable uncertainty
  - Some improvement still needed on PEMS (especially for small displacement petrol engines)
  - Need adjustments for HEV/PHEV and LCV