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WLTP EU Round Robin Test

IWG #14, Paris

24th of April – 26th of April 2016

Objectives

- Check the understanding and the application of the <u>GTR15 (based on phase 1a text)</u> in different labs

- Estimate the repeatability and reproducibility of the GTR15 test procedure in type approval conditions

Schedule

↗ **Tests carried out from Sept 2014 to Nov 2015 (11 labs)**
  - ↗ Initially 9 labs planned
  - ↗ 2 were added and 1 was doubled (to take advantage of an update of the test facilities)
  - ↗ Tests were planned to be tested at the end of the program in their "home" lab, but that was eventually not possible

↗ **Supplemental testing from**
  - ↗ NEDC testing added by JRC but w/o interfering w/ the initial schedule (WLTP/NEDC correlation)

↗ **List of participants**

Date	V1	V2	Golden Engineer
22-24 Sept. 2014	BMW		Yes
27-29 Oct. 2014	FIAT	FIAT	Yes for V2
24-26 Nov. 2014	UTAC	UTAC	Yes
19-20 Jan. 2015	PSA	PSA	Yes
16-18 Feb 2015	Daimler	Daimler	Yes
16-18 March 2015	Bosmal	Bosmal	Yes
April 2015	Horiba	Horiba	JRC
26-27 May 2015	DEKRA	DEKRA	Yes
22-23 June 2015	VW	VW	Yes
20-21 July 2015	TÜEV Nord	TÜEV Nord	JRC
August 2015	Bosmal	Bosmal	-
14-15 Sept 2015	JRC	JRC	Yes
Nov 2015		BMW	-

Test Equipment

- **Lab Equipment, were not strictly WLTP compliant. e.g. (note that test started in Sept 2014):**

  - Soaking areas => impossibility be set to 23°C because of other on going programs
  - RCB measurement equipment => existing equipment not yet always compliant
  - Dynosetting iterative method, test benches are not set to have the vehicle accelerated by its own power before dynosetting or have the rotating inertia taken into account

- **Input data**

  - Gear shift calculation => could not be checked during the RRT

  Due to improvements of the tool since beginning of the RRT, labs have different versions + most labs have not developed their own calculation tool

Test Results – Overview

- **11 labs, 79 tests**
  - <u>V1 (gasoline)</u> : 11 test series
    - Minimum of 3 tests per lab => 43 tests

  - <u>V2 (diesel)</u> : 10 test series
   - Minimum of 3 tests per lab => 36 tests

- **Results have been statistically processed**
  - Calculation of the **uncertainty of the measurement in repeatability and reproducibility** conditions
    - => for simplicity in this presentation only standard deviation (σ) are shown on the graphs (uncertainty being $2 \times \sigma$)
  - Excluding **outliers** (reminder: labs can be considered as outliers, if their dispersion is too high or if their mean value is too biased compared to the other labs)
    - Outliers are excluded from the final calculations to prevent "isolated effects" to interfere with the global evaluation of the uncertainty of the method

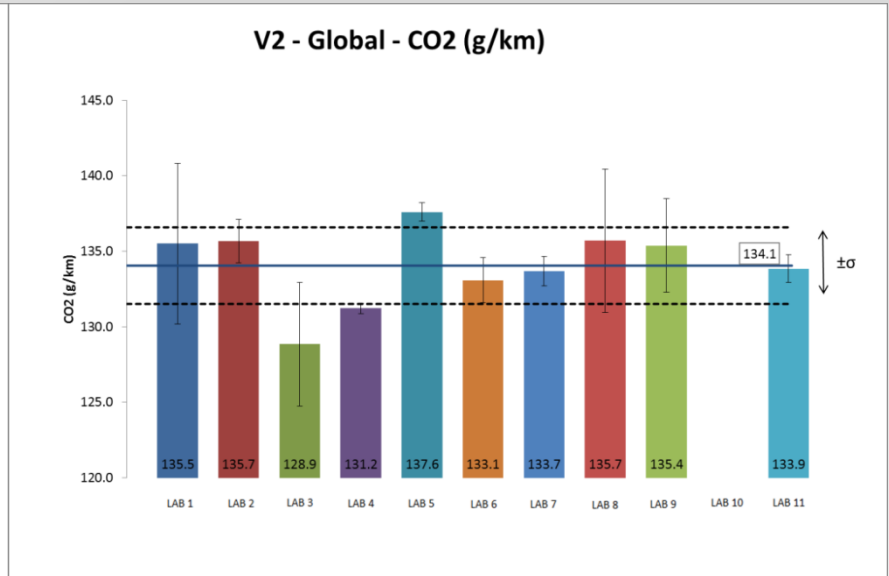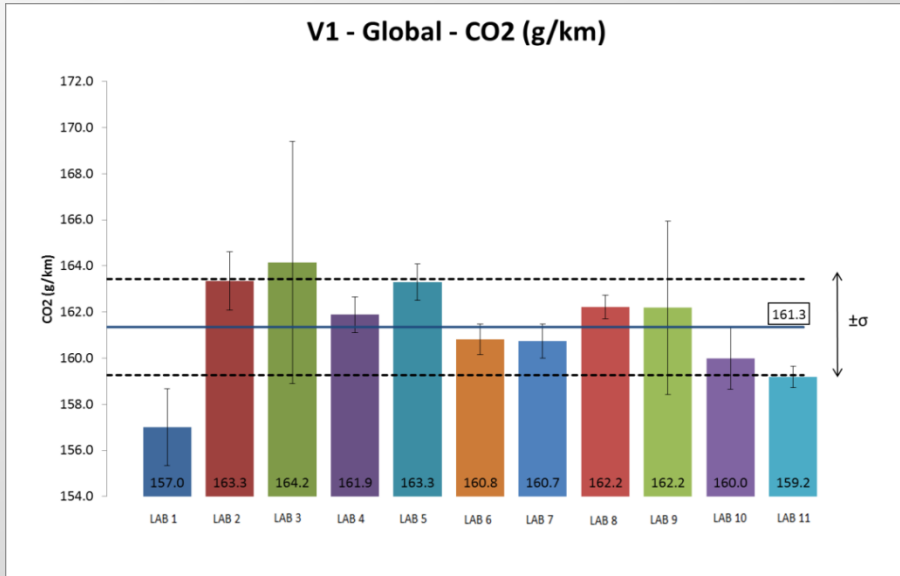- **All the results can be found in annex of this presentation**
  - The results are not presented in chronological order

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Test results – Focus on CO2
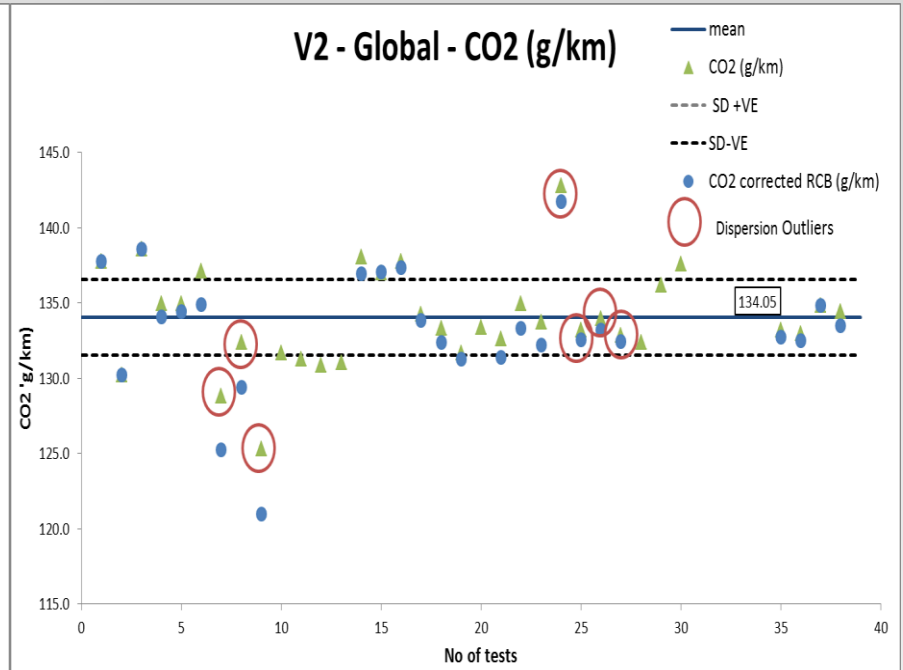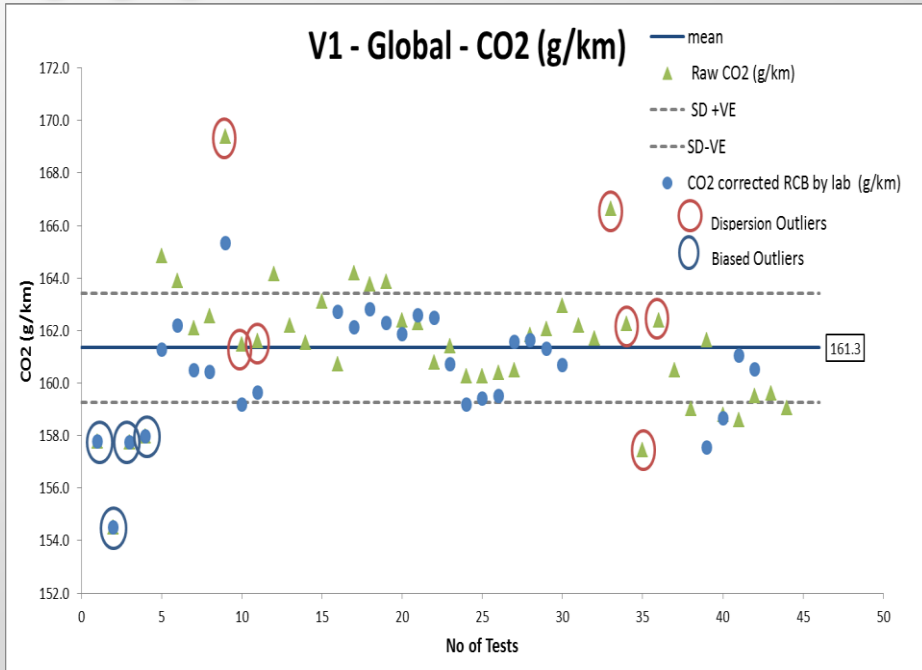
- Dispersion can occur intra-lab (for V1 and V2)
- Biased results inter-lab (for V1 only)

Test Results - Focus on CO2

V1 - Global - CO2 (g/km)

V2 - Global - CO2 (g/km)

All labs	WLTC	CO2	w/o outliers	WLTC	CO2
V1	Mean	161.3	V1	Mean	161.5
	σRepeat	1.9(1.2%)		σRepeat	0.9(0.6%)
	σRepro	2.6(1.6%)		σRepro	1.7(1.1%)
V2	Mean	134.5	V2	Mean	133.7
	σRepeat	2.8(2.1%)		σRepeat	1.3(1.0%)
	σRepro	4.1(3.1%)		σRepro	2.0(1.5%)

- **Higher dispersion on V2 results**
  - Generally more difficult to carry out the dynosetting

- **As none of the tests require RCB correction according to GTR15**
 - for this program the mean value and the dispersion of the GTR15 procedure are equivalent to the raw CO2 results

Test Results – Focus on CO2 – STT

V1 - Start stop variation

V2 - Start Stop Variation
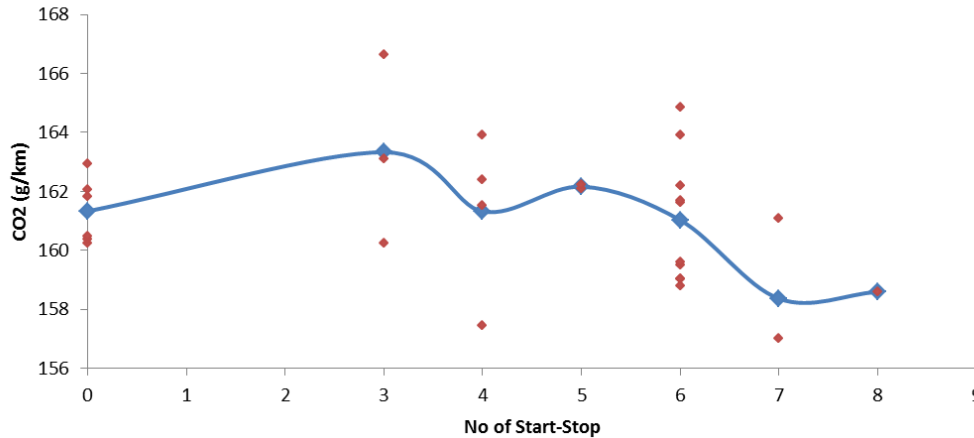
The STT system did not always work with he same efficiency. A logical trend can be seen on the CO_2 level vs the n° of stops, but the dispersion did not allow to take this parameter into account.
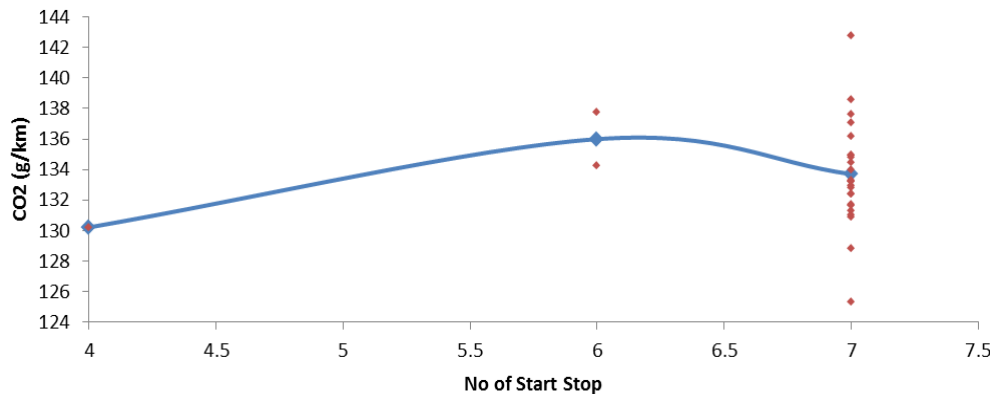
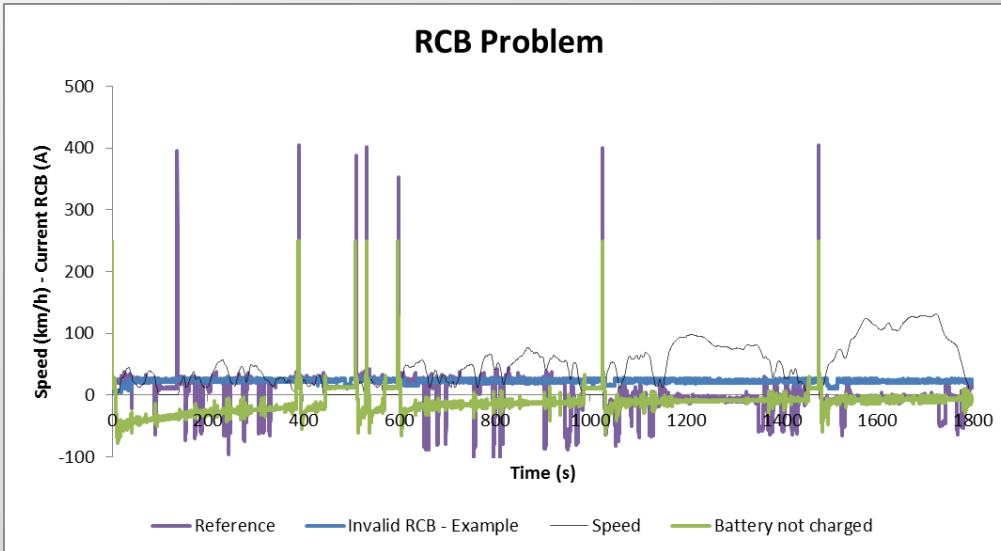Nevertheless the test proc was decided to leave it free to the lab to charge the battery => increases the dispersion
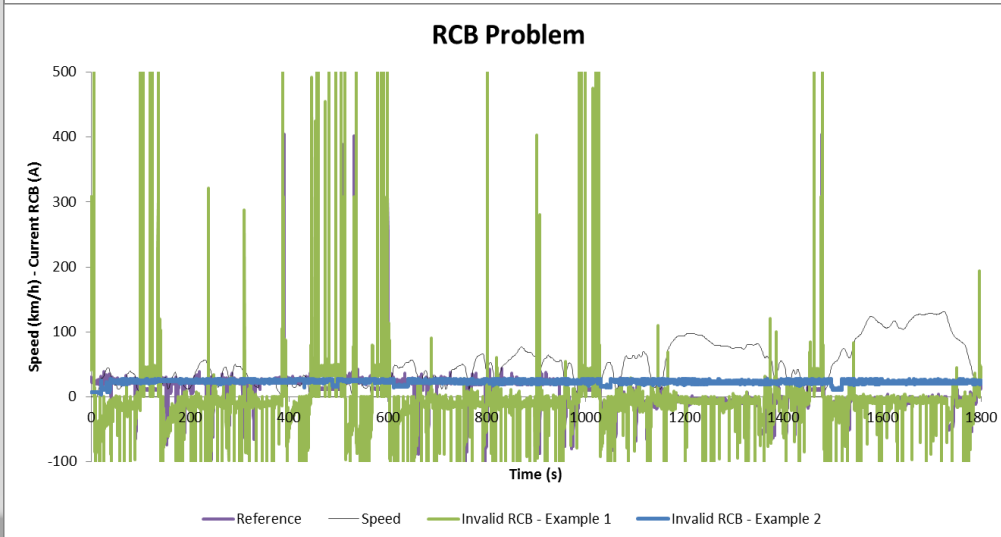
Test Results – Focus on RCB correction

RCB measurement

- New in the test procedure => was the tough spot of the tests
- Measurements had to be unvalidated
- => to study the correction effect, only the labs with valid RCB measuremenst were kept in

	Vehicle 1	Vehicle 2	Total
Objective (valid test)	3-4	3-4	**6 – 8**
Total valid tests carried out	43	36	**79**
Test with valid RCB meas.	**24 (56%)**	**23 (64%)**	**47 (59%)**

RCB – Measured results - Examples

RCB Problem (top chart)
Y-axis: Speed (km/h) - Current RCB (A), range -100 to 500
X-axis: Time (s), range 0 to 1800
Legend: Reference, Invalid RCB - Example, Speed, Battery not charged

RCB Problem (bottom chart)
Y-axis: Speed (km/h) - Current RCB (A), range -100 to 500
X-axis: Time (s), range 0 to 1800
Legend: Reference, Speed, Invalid RCB - Example 1, Invalid RCB - Example 2

- **Frequency of the signal**
- **Noisy**
- **Amplitude**

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RCB – Measured results - Examples
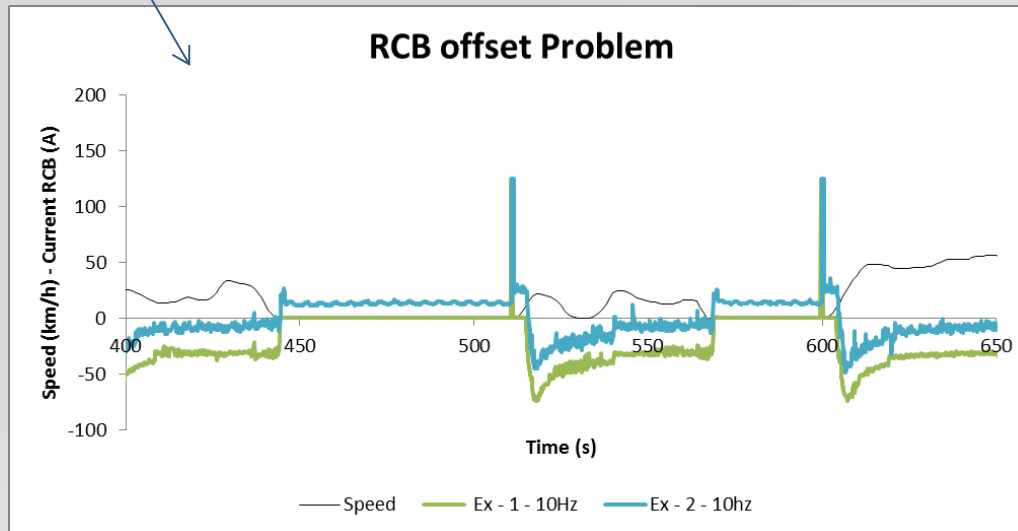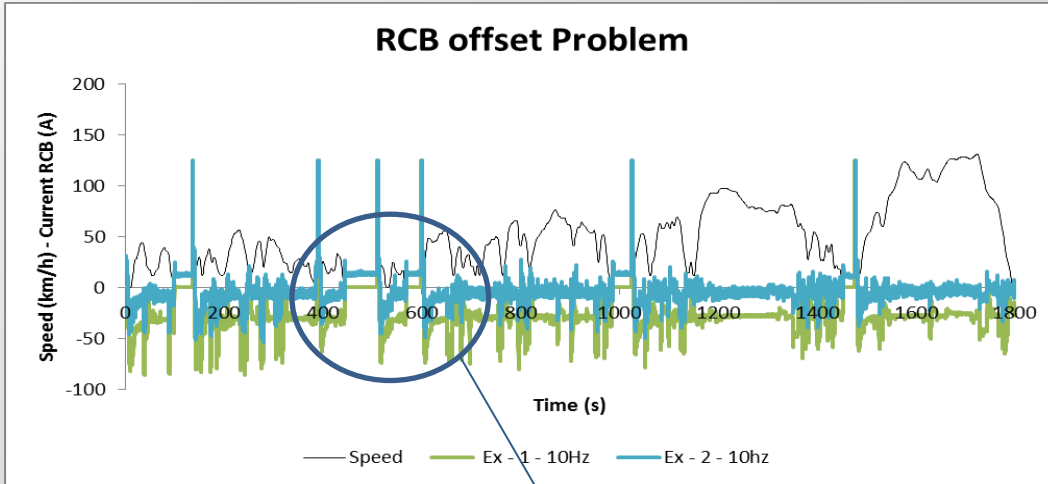
Test Results – Focus on RCB correction

	All Labs w/valid RCB meas.			w/o Outliers		
	Mean	**σRepeat**	**σRepro**	**Mean**	**σRepeat**	**σRepro**
Raw CO2 g/km						
Vehicle 1	161.1	1.9(1.2%)	2.7(1.7%)	161.9	1.1(0.7%)	**1.4(1.1%)**
Vehicle 2	134.1	2.5(1.8%)	2.8(2.1%)	134.5	1.6(1.2%)	**1.8(1.3%)**
RCB corrected CO2 g/km (all tests regardless of GTR15 criteria)						
Vehicle 1	161.7	2.0(1.2%)	3.2(2.0%)	161.7	2.0(1.2%)	**3.2(2.0%)**
Vehicle 2	133.4	2.4(1.8%)	2.7(2.0%)	133.4	2.4(1._%)	**2.7(2.0%)**

RCB correction would tend to increase the dispersion of the results.

Discrepancies between the RCB measurement (not all comply with GTR15: frequency, equipment)

RCB Issues found during RRT

Issue	Clarified in GTR15 Phase 1B
Calculation misunderstood	Yes, calculation is clarified
Frequency measurement not properly followed as per regulation	=> 20Hz
Noisy, and amplitude pb Not all equipment were compliant	Equipment, accuracy
Offset not done properly before starting the tests	No, should the zero procedure be specified?

Test results – Comparison w/ R83

CO2 (g/km) - σRepro- w/o outliers

NOx (mg/km) - σRepro - w/o outliers

CO (mg/km) - σRepro - w/o outliers

PN (#/km) - σRepro - w/o outliers

Legend: V1, V2, VA, VB

WLTC / NEDC

- Comparison with ACEA PN RRT program (2009)
- The uncertainties of both procedures are equivalent apart from the NOx for which there is an increase in absolute value, less in
- To define whether it is due to vehicle or procedure => JRC NEDC program
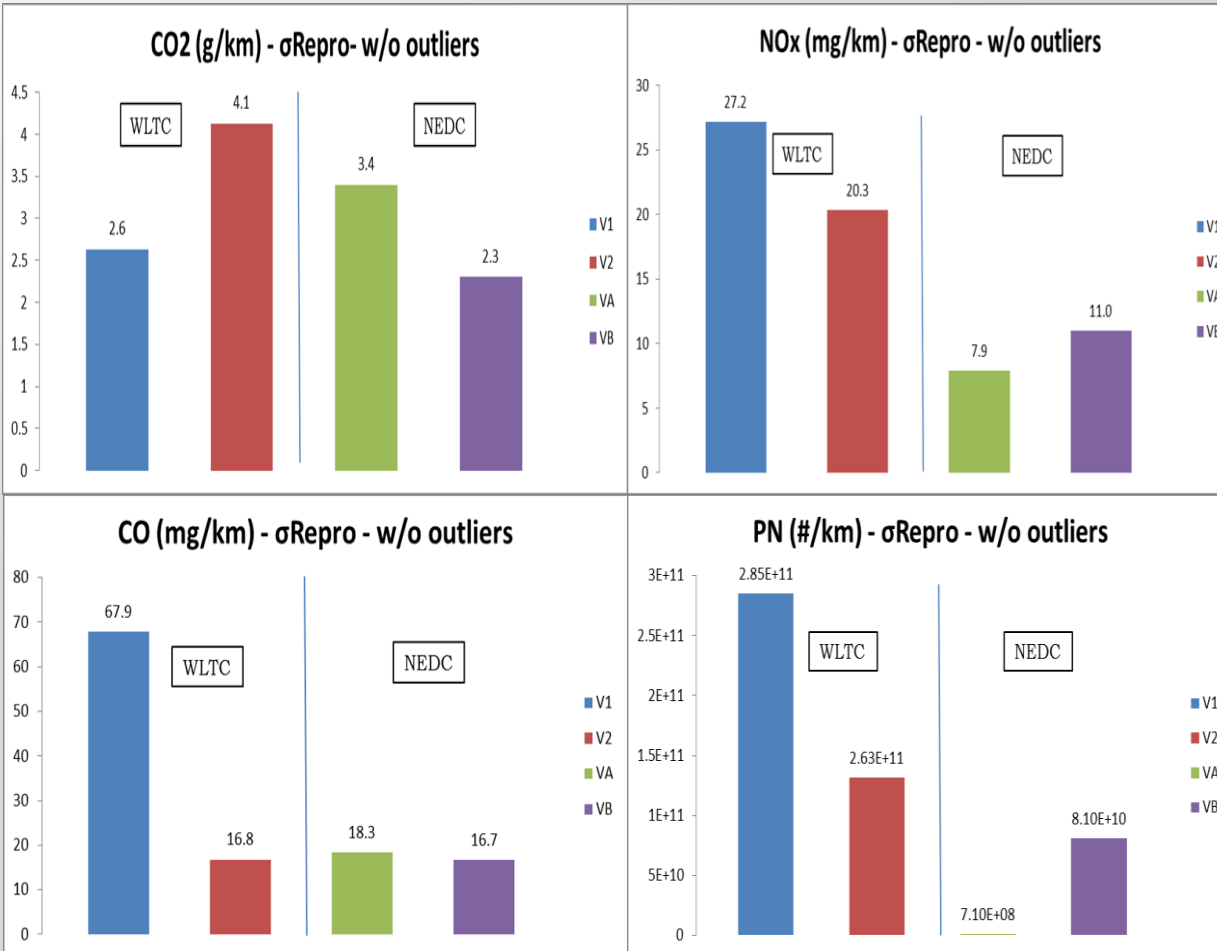
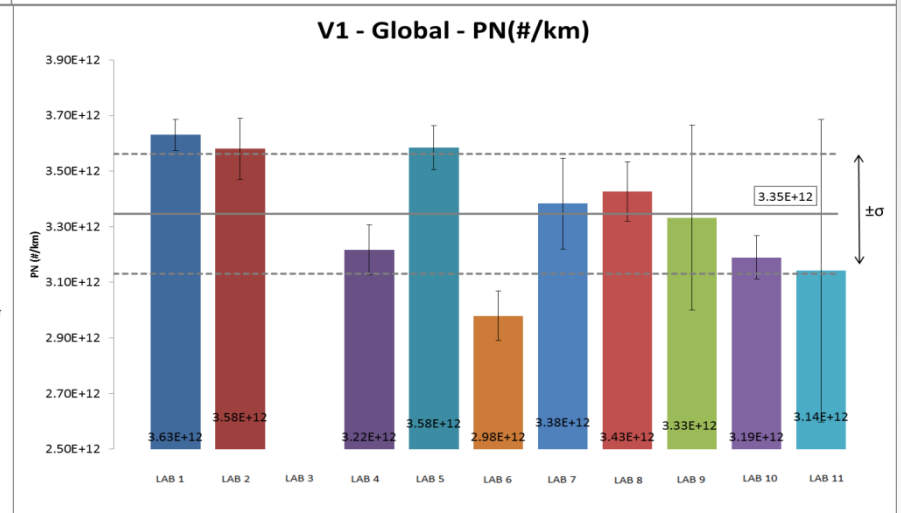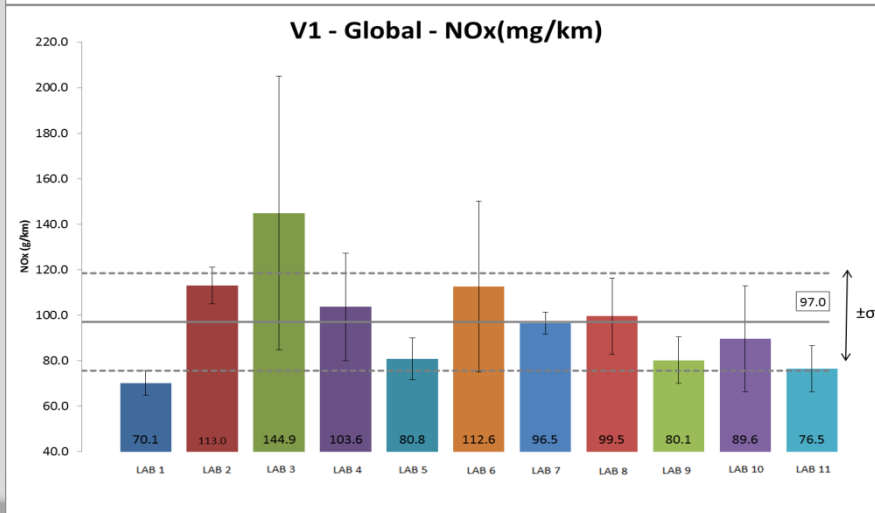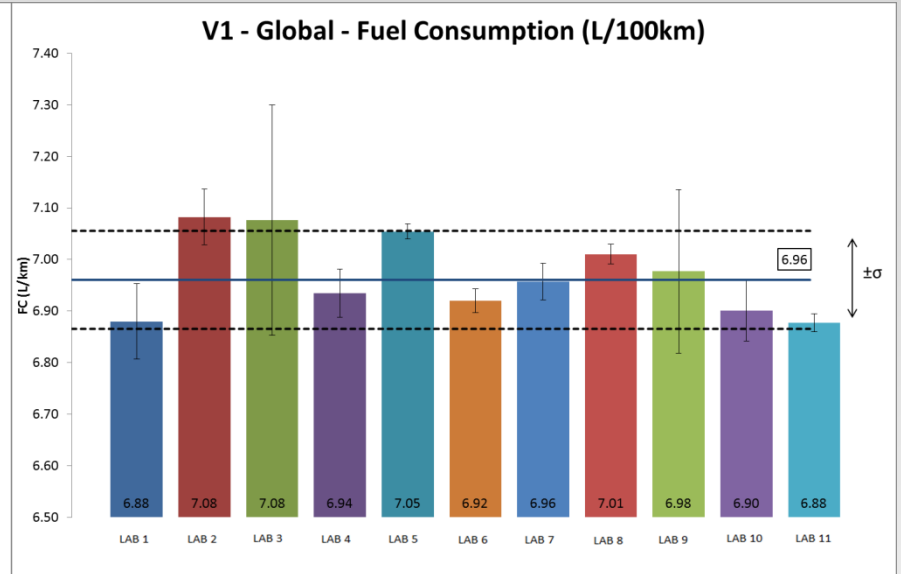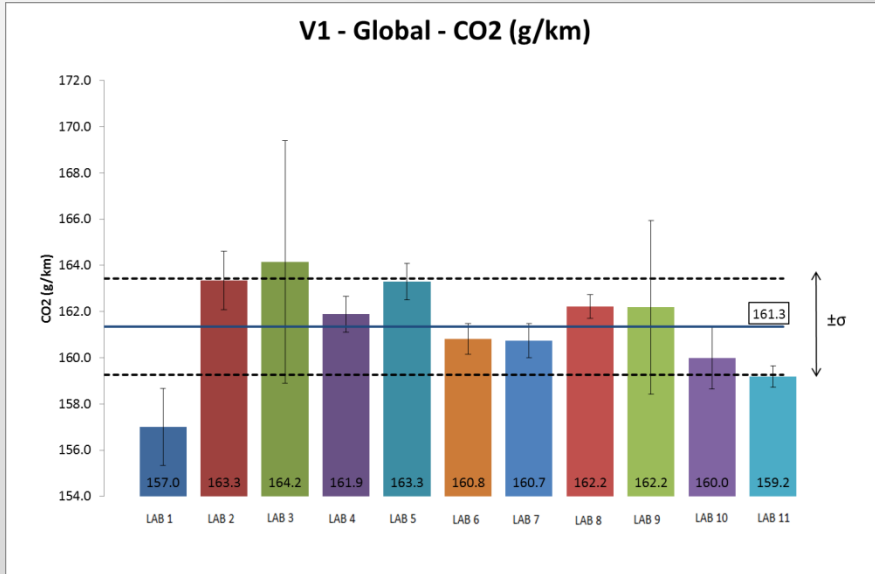Vehicle 1 - Gasoline & Vehicle 2, A & B - Diesel

Thank you for attention

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Test Results

All labs	WLTC	CO2	CO2 corr	FC	NOx	CO	HCT	PN	PM
V1	Mean	161.3	161.5	6.96	95.17	456.25	40.60	3.36E+12	3.94
	σRepeat	1.9(1.2%)	2.0(1.2%)	0.08(1.1%)	20.32(21.4%)	54.13(11.9%)	6.43(15.8%)	2.2E+11(6.6%)	0.80(20.3%)
	σRepro	2.6(1.6%)	2.7(1.7%)	0.11(1.7%)	27.17(28.6%)	67.94(14.9%)	9.14(22.5%)	2.9E+11(8.5%)	1.48(37.7%)
V2	Mean	134.5	134.1	5.07	282.15	40.26	7.72	5.25E+11	0.21
	σRepeat	2.8(2.1%)	2.36(1.8%)	0.05(1.0%)	26.50(9.1%)	7.65(19.0%)	2.28(15.8%)	1.30E+11(24.7%)	0.11(54.7%)
	σRepro	4.1(3.1%)	2.77(2.1%)	0.07(1.4%)	35.72(12.3%)	16.78(41.7%)	3.52(45.6%)	1.32E+11(25.0%)	0.16(77.4%)

w/o outliers	WLTC	CO2	CO2 corr	FC	NOx	CO	HCT	PN	PM
V1	Mean	161.5	160.5	6.97	95.17	5.49	39.98	3.42E+12	3.84
	σRepeat	0.9(0.6%)	1.3(0.9%)	0.04(0.6%)	20.32(21.4%)	0.39(7.2%)	3.62(9.1%)	1.5E+11(4.4%)	0.35(9.3%)
	σRepro	1.7(1.1%)	2.0(1.3%)	0.08(1.2%)	27.17(22.3%)	0.62(11.3%)	6.33(15.8%)	2.1E+11(6.2%)	0.72(18.9%)
V2	Mean	133.7	133.4	5.06	282.15	2.22	7.51	5.24E+11	0.22
	σRepeat	1.3(1.0%)	1.61(1.2%)	0.04(0.8%)	10.11(3.6%)	0.22(10.0%)	0.708(9.4%)	5.24E+10(10%)	0.09(39.9%)
	σRepro	2.0(1.5%)	1.80(1.3%)	0.06(1.1%)	20.33(7.2%)	1.01(45.4%)	1.53(20.4%)	9.5E+10(18.0%)	0.09(39.9%)

Tests Results – Graphs – V1

V1 - Global - CO2 (g/km)

V1 - Global - Fuel Consumption (L/100km)

V1 - Global - NOx(mg/km)

V1 - Global - PN(#/km)

Tests Results – Graphs – V1

V1 - Global - THC(mg/km)

LAB	Value
LAB 1	33.9
LAB 2	54.8
LAB 3	39.2
LAB 4	41.9
LAB 5	38.9
LAB 6	32.6
LAB 7	50.9
LAB 8	40.5
LAB 9	37.8
LAB 10	43.1
LAB 11	31.8

40.5 ±σ

V1 - Global - CO(mg/km)

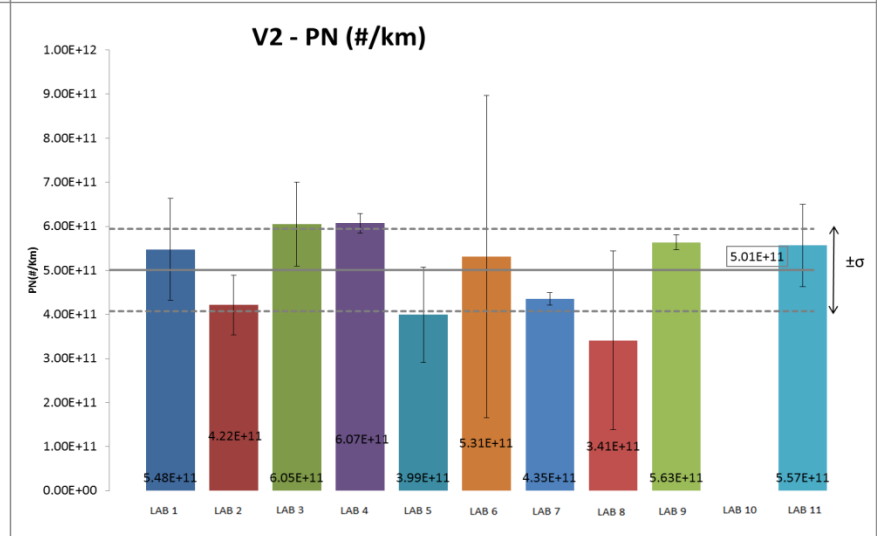| LAB	Value
LAB 1	444.3
LAB 2	453.6
LAB 3	443.9
LAB 4	464.7
LAB 5	524.0
LAB 6	396.5
LAB 7	385.6
LAB 8	413.8
LAB 9	486.9
LAB 10	501.8
LAB 11	387.7

445.7 ±σ
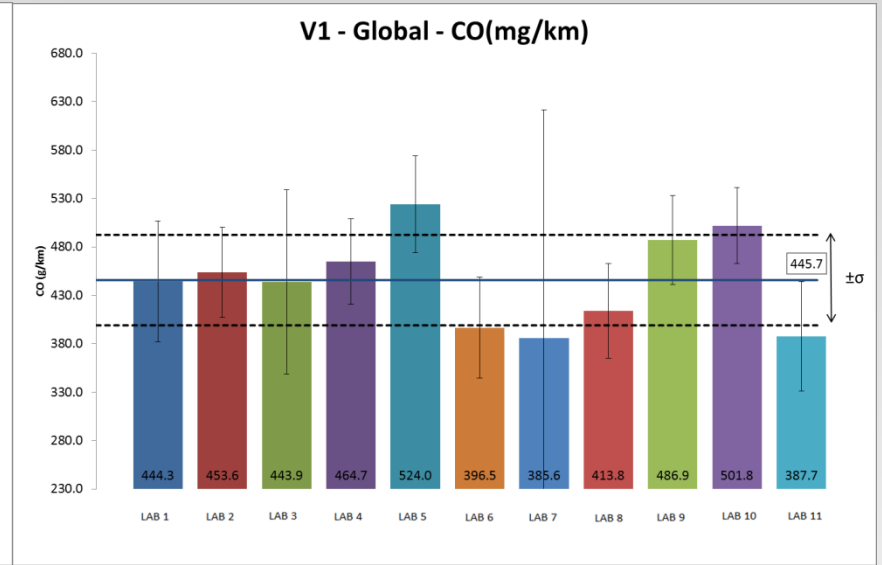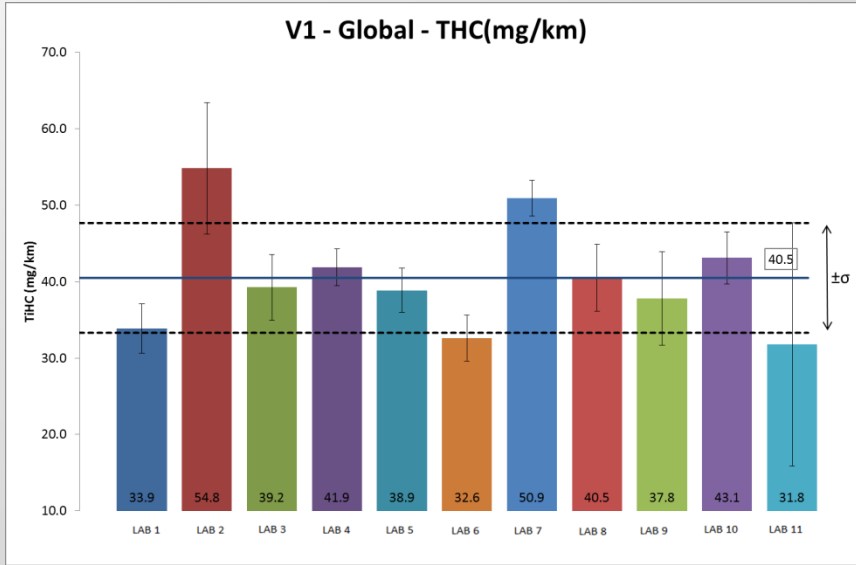
Tests Results – Graphs – V2

Tests Results – Graphs – V2

V2 - THC (mg/km)

Values (LAB 1 to LAB 11): 11.4, 9.3, 7.0, 6.1, 10.3, 8.8, 8.2, 7.4, 6.7, (LAB 10), 2.1

Reference line: 7.7, ±σ

CO (mg/km)

Values (LAB 1 to LAB 11): 39.4, 37.7, 27.1, 30.4, 69.6, 49.7, 36.7, 26.2, 46.6, (LAB 10), 26.6

Reference line: 39.0, ±σ