

# The European Commission's science and knowledge service

## Joint Research Centre



# **EU Real Driving Emissions Regulation**

## **Overview of Concepts & Requirements**

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# RDE References

- **RDE Regulation - Concept**
- **EU-RDE Boundary Conditions**
- **Supporting elements: Guidance for testing, Data evaluation tools, PEMS instrumentation uncertainty**

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# RDE Design - Key Concepts [1]

- **[Basic] On-road test using portable equipment, vehicle to be driven normally in usual traffic conditions**
- **[Instrumentation performance and uncertainty] PEMS instruments performance specifications are nearly similar to the laboratory grade equipment. The major difference lies in the way they are utilized (e.g. subject to vibrations, temperature variations...) which increase the risk of drift**

# RDE Design - Key Concepts [2]

- **[Coverage]** Trip requirements (duration, urban, rural, motorway,...) ensure that boundary conditions are covered properly, e.g. certain vehicle/engine operating areas are covered
- **[Statistical robustness]** The test duration must be sufficient to ensure that enough data is collected to assess the vehicle emissions performance.

# RDE Design - Key Concepts [3]

- **[Boundary conditions] Boundary conditions are the ranges under which the test parameters must remain to achieve a valid test and include:**
  - Overall driving dynamics (overall)
  - Excess of driving dynamics
  - Altitude (Moderate/Extended)
  - Ambient temperature (Moderate/Extended)
  - Cumulative altitude gain
  - Some operational parameters (e.g. vehicle conditioning, payload, cold start and motorway driving, operation of auxiliary devices such as air conditioning)

# RDE Design - Key Concepts [4]

- **[Snapshot]** A single RDE test is only a “snapshot” under which the vehicle has to comply. Other snapshots with varying parameters (e.g. dynamics, temperature, altitude) may be obtained by re-testing the vehicles
- **[Representativeness]** – The parameter ranges were selected so that 90 to 95% of the EU potential driving situations may be caught in an EU-RDE test.



# RDE Design - Key Concepts [5]

- **Dynamics assessed using WLTC as reference**
- **[Overall dynamics] – CO<sub>2</sub> (~Energy) over the whole trip or sub-sections (Windows) as a metric to assess the severity of testing conditions in comparison to the WLTP reference**
- **[Excess or absence of dynamics] – Indicators meant to identify excess or absence of driving dynamics and related to the vehicle kinematics and which does not show with the CO<sub>2</sub> in the Moving Windows**

# RDE Design - Key Concepts [6]

- **[Emissions calculation] – The vehicle emissions should not be corrected, unless the testing conditions are found (ex-post) to be severe.**
- **In the EU-RDE, only 2 types of emissions corrections are currently possible:**
  - **Factor of 1.6 (applied only once when applicable) for altitude/temperature extended conditions**
  - **Total emissions if RDE CO<sub>2</sub> mass exceeds the vehicle reference CO<sub>2</sub> mass by more than a given percentage (25% for EURO6d first stage)**

# RDE Design - Key Concepts [7]

- **Pollutants currently regulated in the EU RDE: NO<sub>x</sub> and PN**
- **[Emissions Not-To-Exceed requirements]: CFs limits have to be met for any valid trip with the boundary conditions and for both the urban and the complete trip**

# RDE References

- **RDE Regulation - Concept**
- **EU-RDE Boundary Conditions**
- **Supporting elements: Guidance for testing, Data evaluation tools, PEMS instrumentation uncertainty**

# EU-RDE Structure (as of EU-RDE3 - 2017/1154)

Appendices	
1. Introduction, definitions and abbreviations	App.1: Test procedure for vehicle emissions testing with a PEMS
2. General requirements on conformity factors	App.2: Specifications and calib. of PEMS components and signals
3. RDE test to be performed	App.3: Validation of PEMS and non-traceable exhaust mass flow rate
4. General requirements	App.4: Determination of emissions
5. Boundary conditions	App.5: Verification of trip dynamic cond. with method 1 (MAW)
6. Trip requirements	App.6: Verification of trip dynamic cond. with method 2 (Power Bin.)
7. Operational requirements	App.7: Selection of vehicles for PEMS testing at initial type approval
8. Lubricating oil, fuel and reagent	App.7a: Verification of overall trip dynamics
9. Emissions and trip evaluation	App.7b: Procedure to determine the cumul. Pos. elev. gain of a trip
	App.7c: Verif. trip cond. and calc. for OVC-HEVs
	App.8/9: Data-exchange /Manufacturer's certificate of compliance

# Changes between EU-RDE3 & RDE4

Appendices	
1. Introduction, definitions and abbreviations	App.1: Test procedure for vehicle emissions testing with a PEMS
2. General requirements on conformity factors	<b>App.2: Specifications and calib. of PEMS components and signals</b>
3. RDE test to be performed	App.3: Validation of PEMS and non-traceable exhaust mass flow rate
4. General requirements	App.4: Determination of emissions
5. Boundary conditions	<b>App.5: Verification of trip overall dynamics with MAW</b>
6. Trip requirements	<b>App.6: Calculation of final RDE emissions</b>
7. Operational requirements	App.7: Selection of vehicles for PEMS testing at initial type approval
8. Lubricating oil, fuel and reagent	<b>App.7a: Verification of overall trip dynamics</b>
9. Emissions and trip evaluation	<b>App.7b: Determination of the cumul. Pos. elev. gain of a trip</b>
	<del>App.7c: Verif. trip cond. and calc. for OVC-HEVs</del>
	<b>App.8/9: Data-exchange</b> /Manufacturer's certificate of compliance

**New or improved in RDE 4**

# EU-RDE Conformity Factors

<b>2. General requirements on conformity factors</b>	NOx conformity factor = <b>2.1</b> – applicable from Sept. 2017/2019
	NOx conformity factor = <b>1.43</b> – applicable from Jan. 2020/2021
	PN conformity factor = <b>1.5</b> – applicable from Sept. 2017/2019
	(new type approval/all new registration)
	Applicable to the <b>urban part</b> and the <b>whole trip</b>
	Temp. conformity factor <b>2.1</b> to “to allow manufacturers to gradually
	adapt to the RDE rules”
	Conformity factor of <b>1.43 (NOx)</b> to account for measurement
	uncertainty of PEMS
	CO emissions shall be measured and recorded at RDE tests

New in RDE 4

# RDE Boundary Conditions

	Test duration	90-120 min
	Ambient temperature	Moderate: $\geq 0^{\circ}\text{C}$ and $\leq 30^{\circ}\text{C}$
		Extended: $[-7; 0[$ and $]30; 35]^{\circ}\text{C}^*$
<b>5. Boundary conditions</b>	Altitude	Moderate: $\leq 700\text{m}$ above sea level
		Extended: $700 < \text{Alt} \leq 1300\text{m}$
		Difference between start and end $\leq 100\text{m}$
		Maximum cumul. Alt. gain: $1200\text{m}/100\text{km}$
	Vehicle conditioning	Driven for at least 30min in normal or extended conditions. Parked 6-56 hours
	*Derogation	<i>Moderate</i> $[3; 30]^{\circ}\text{C}$
		Extended $[-7; 3]^{\circ}\text{C}$



# RDE Boundary Conditions

5. Boundary conditions		
	Vehicle payload (shall comprise driver, witness, equipment)	<90% of the vehicle's permissible payload
	Auxiliary devices (e.g. air-conditioning)	can be operated as during real-world driving

# RDE Trip Requirements

	Test route*	Urban: $\leq 60$ km/h Rural: $> 60$ and $\leq 90$ km/h Motorway: $> 90$ km/h (and $< 145$ km/h)
	Trip composition share	Urban: $\geq 29\%$ and $\leq 44\%$ Rural: $\geq 23\%$ and $\leq 43\%$ Motorway: $\geq 23\%$ and $\leq 43\%$
<b>6. Trip requirements</b>	Trip sequence	Urban → Rural → Motorway
	Trip comp. distance	$> 16$ km for Urban, Rural and Motorway operation
	*Test route (N2 with 90km/h speed limit)	Rural: $> 60$ and $\leq 80$ km/h Motorway: $> 80$ km/h

# RDE Trip Requirements

	Cold start duration (App.4)	All data included in the evaluation
	Average speed	Urban: $\geq 15\text{km/h}$ and $\leq 40\text{km/h}$ Cold start: $\geq 15\text{km/h}$ and $\leq 40\text{km/h}$ incl. stops and maximum speed $\leq 60\text{km/h}$
<b>6. Trip requirements</b>	Stop time (speed < 1km/h)	Urban: >6% and <30% of time duration No stop shall exceed 300 seconds Cold start: $\leq 90\text{s}$

# EU-RDE Operational Requirements

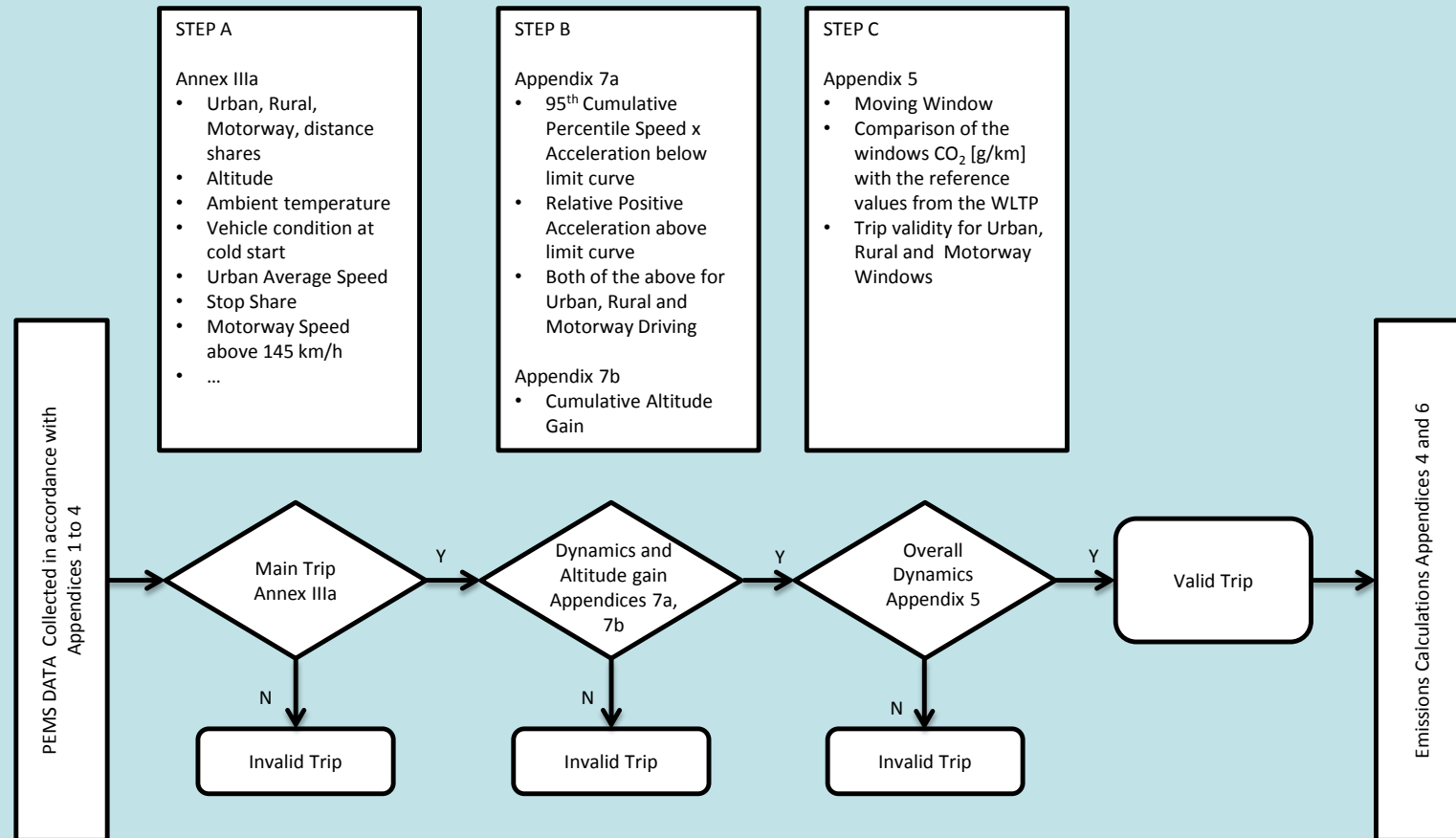
	Road conditions	Paved roads and streets
	Driving time	Working days
	PEMS installation	<ul style="list-style-type: none"><li>- Minimize the mass of the equipment</li><li>- Minimize the potential aerodynamic modifications</li></ul>
<b>7. Operational requirements</b>	<i>Other elements</i>	<div style="border: 1px solid blue; border-radius: 50%; background-color: #c8e6c9; padding: 20px; text-align: center;">Subject to variations in the practices =&gt; Guidance</div>

# EU-RDE-LDV Trip Evaluation and Emissions

	Overall Dynamics (Appendix 5)	Moving Averaging Window Different tolerances for ICEs, NOVCs-HEVs and OVC-HEVs
	Excess or absence of driving dynamics (Appendix 7a)	$V \cdot a_{\text{pos}_{95}}$ // RPA
	Calculation of emissions (Appendix 6)	RDE emissions corrected only when the RDE CO <sub>2</sub> mass exceeds the vehicle reference CO <sub>2</sub> mass by more than a given percentage (25% for EURO6d first stage)
<b>9. Emissions and trip evaluation</b>	Extended ambient conditions	Pollutant emissions divided by <b>1.6</b> (except CO <sub>2</sub> )

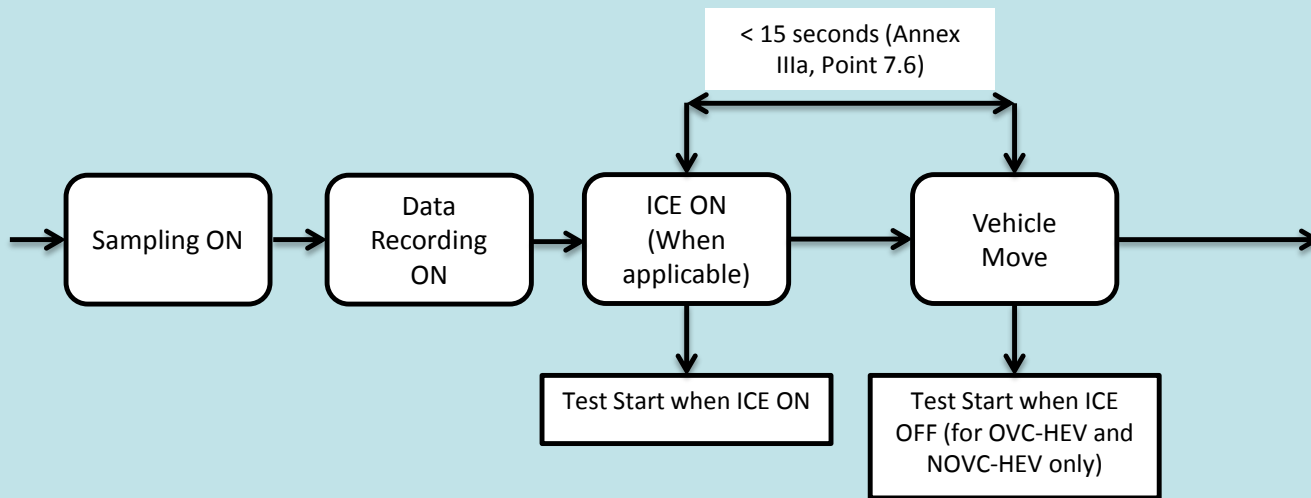
New in RDE 4

# Trip verification and emissions calculation

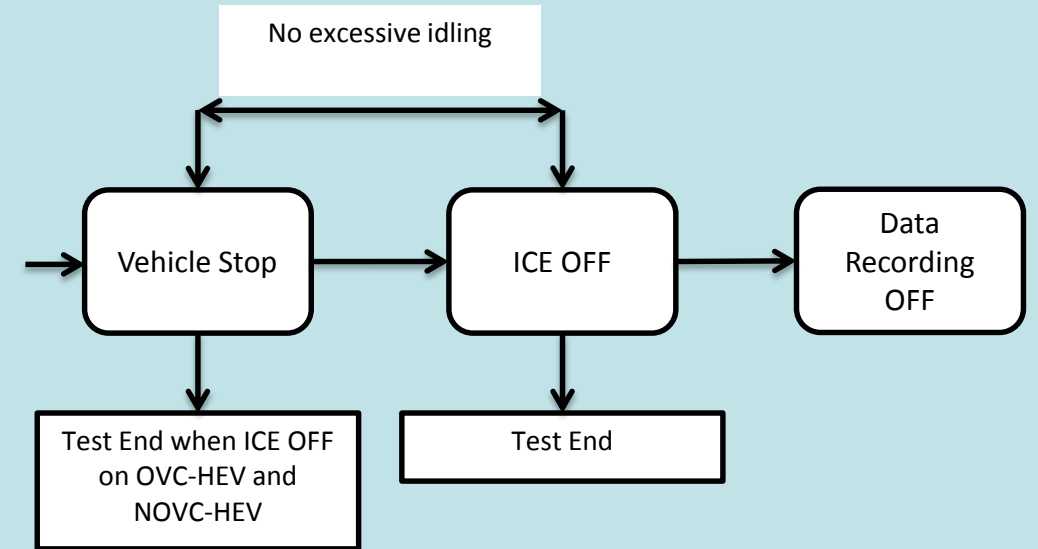


# Test start and test end

## Start

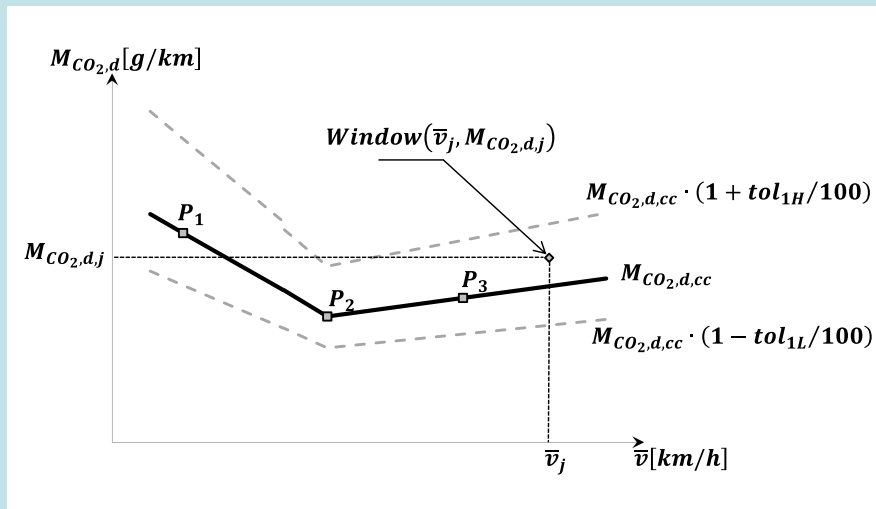


## End

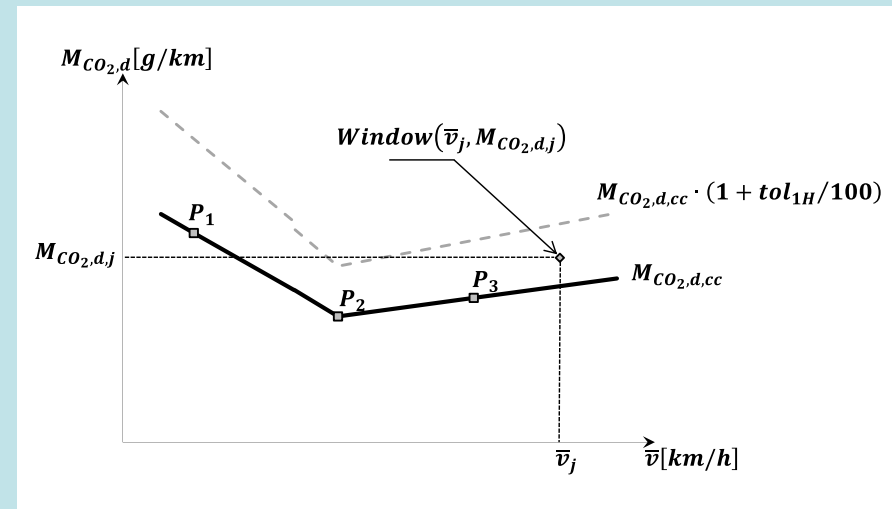


# Trip Evaluation (Moving Window)

## ICE and NOVC-HEV



## OVC-HEV



**Tolerances around the vehicle CO2 characteristic curve:** The upper tolerance of the vehicle CO2 characteristic curve is  $tol_{1H}=45\%$  for urban driving and  $tol_{1H}=40\%$  for rural and motorway driving. The lower tolerance of the vehicle CO2 characteristic curve is  $tol_{1L}=25\%$  for ICE and NOVC-HEV vehicles and  $tol_{1L}=100\%$  for OVC-HEV vehicles.

**Verification of test validity:** The test is valid when it comprises at least 50% of the urban, rural and motorway windows that are within the tolerances defined for the CO2 characteristic curve.



# RDE References

- RDE Regulation - Concept
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- **Supporting elements: Guidance for testing, Data evaluation tools, PEMS instrumentation uncertainty**

# Supporting documents and tools

## - Guidance

- Guidance: practical recommendations for the execution of real-driving emissions (EU-RDE) tests with Portable Emissions Measurement Systems (PEMS) on board of light-duty vehicles (LDV)
- Best practices contained in this guidance note aim at obtaining valid PEMS tests and to prevent wrongdoings in the preparation, execution, and follow up of emissions testing with PEMS
- Types of PEMS tests: EU-RDE & research
- <http://skp.jrc.cec.eu.int/skp/showPub?id=JRC109812>



JRC TECHNICAL REPORTS

## On-road testing with Portable Emissions Measurement Systems (PEMS)

*Guidance note  
for light-duty vehicles*

Valverde Morales, V., Bommel, P.

# Supporting documents and tools

## - Guidance

- In-use emissions test with PEMS [What shall I measure and how?]
- Instrumentation performance requirements [Which instruments shall I use?]
- Test preparation [How do I select and prepare the vehicle for the test?]
- Test conditions [Under which conditions shall I test the vehicle?]
- Test Protocol [How shall I conduct the test?]
- Data screening [How shall I evaluate the quality of the measurements?]



**Figure 1. Installation of PEMS main units (left) inside the vehicle (right) outside the vehicle**



**Figure 2. Vehicles equipped with a roof box (left) or loaders that modify the aerodynamic characteristics of a vehicle (right) are not eligible for RDE-TA and RDE-ISC testing.**

# Supporting documents and tools

## - EMROAD

- The tool is available in the CIRCABC group "New light duty test procedures: WLTP, MAC, ...", in the section "RDE-LDV Reference documents and tools".
- Access to this section is open to all and does not require any registration or membership: <https://circabc.europa.eu/w/browse/79a4a9b6-4003-4e02-956d-048dcef1a169>



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Soon a new CIRCABC User Interface will be released. Please try it by requesting to join the following group: CIRCABC

### New light duty test procedures: WLTP, MAC, ...

- Information
- Library**
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#### Main Menu

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- CIRCABC online training course

Library > RDE-LDV > rde-ldv\_reference

### Library

The Library is the space where content is stored.

#### Spaces

Title ▾

- Old

#### Content

Title ▾

- EMROAD\_5\_96B3.zip
- EMROAD\_Release\_Notes\_5\_96B3.pdf
- EMROAD Data Sample#1

# EMROAD

- EMROAD is a Microsoft Excel add-in for analyzing vehicle emissions data recorded with Portable Emissions Measurement Systems (PEMS). In the frame of the European legislative PEMS programs for heavy-duty vehicles (HDV), non-road mobile machinery (NRMM), and light-duty vehicles (LDV), EMROAD was developed as a research tool, primarily used to support the development of PEMS data evaluation methods for the EU emissions legislation.
- These legislative developments being completed, EMROAD is updated by the JRC on a regular basis to meet:
  - - For light-duty vehicles, the applicable methods and requirements are laid down in EU Regulations 2016/427 (except for the Power Binning Method in Appendix 6), 2016/646 and 2017/1154 on Real Driving Emissions (RDE). **The "4th RDE package" (currently under development) will be shortly part of EMROAD).**
  - - For heavy-duty vehicles, the applicable methods and requirements are laid down in Regulations 582/2011 and 2016/1718.

# RDE-PEMS Measurement uncertainty

- The RDE additional measurement uncertainty is included in the Conformity Factors and assessed on a regular basis using an agreed framework
- The main source is the risk of drift for the PEMS analysers)
- 2017-18 revision:  
<https://ec.europa.eu/jrc/en/publication/real-driving-emissions-2017-assessment-pems-measurement-uncertainty>



JRC TECHNICAL REPORTS

## Real driving emissions: 2017 assessment of Portable Emissions Measurement Systems (PEMS) measurement uncertainty

Giechaskiel B., Clairotte M.,  
Valverde V., Bonnel P.

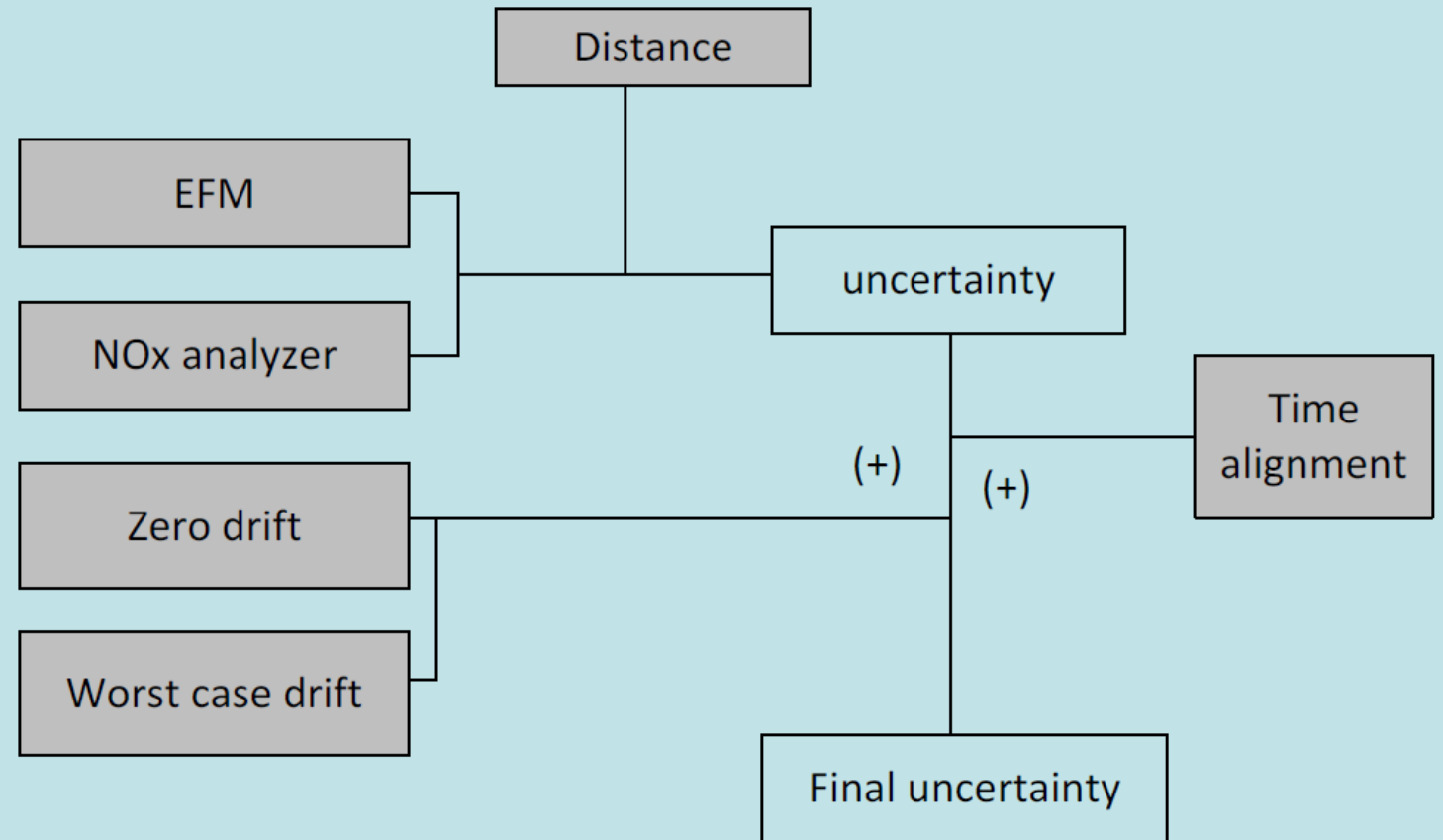
2018



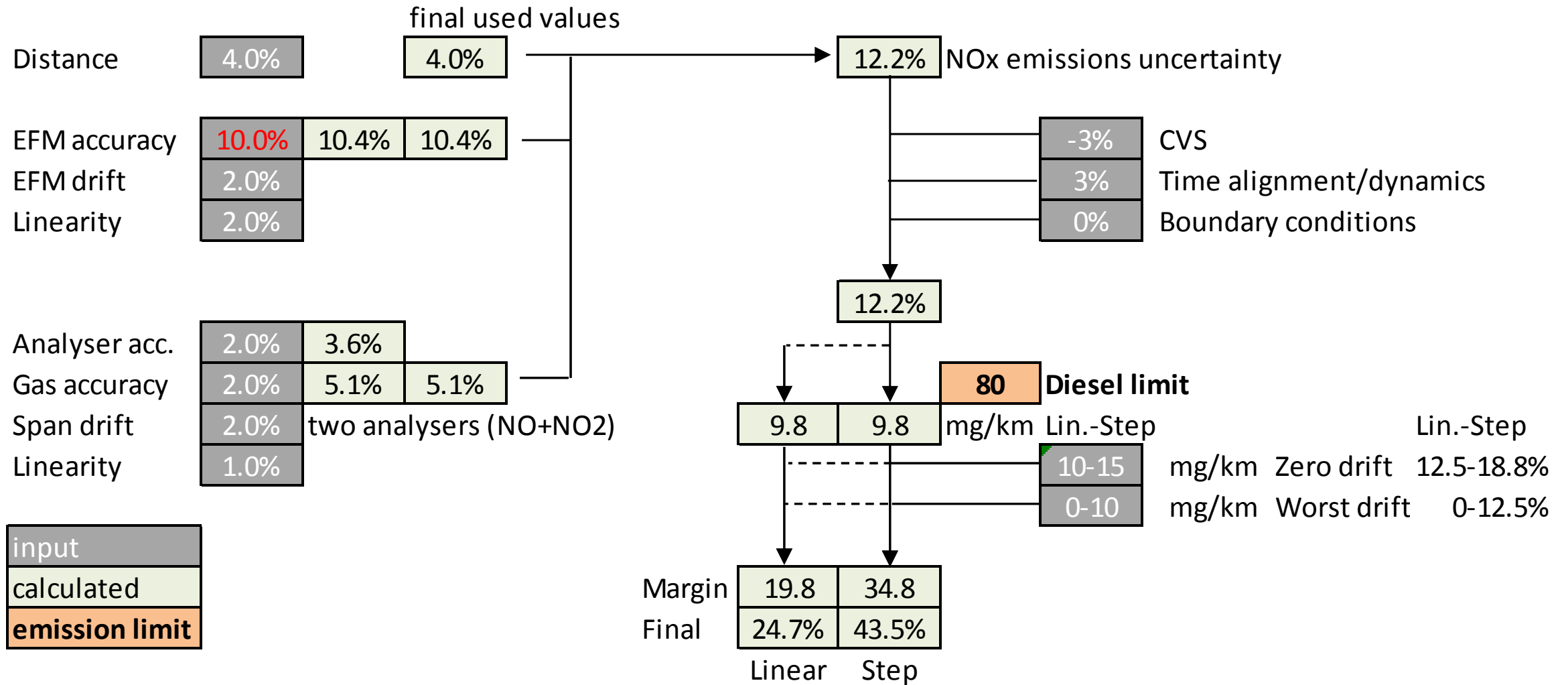
# PEMS uncertainties - revision framework

- Error propagation
- (+) = addition

Relative uncertainty  
Absolute uncertainty



# Estimation of measurement uncertainty (Example)





		RDE regulation (in lab checks)	2015	2017 experiments (real conditions)
EFM	Accuracy	3%	2%	10%
	Drift	2%	2%	2%
	Linearity	2%	2%	2%
Analyzers	Accuracy	2%	5%	2%
	Linearity	1%	1%	1%
	Span drift	2%	2%	5%
	Gas accuracy	2%	2%	(2%)
	Distance	4%	4%	(4%)
Additional	Dynamics	-	3%	3%
	Boundaries	-	0%	0%
	Zero drift (Analyzer)	5 ppm	20%	10-15 mg/km
	Worst case drift	-	20%	0-10 mg/km

In brackets ( %) not studied in 2017