



PEMS in the European vehicle emissions legislation: Milestones and challenges

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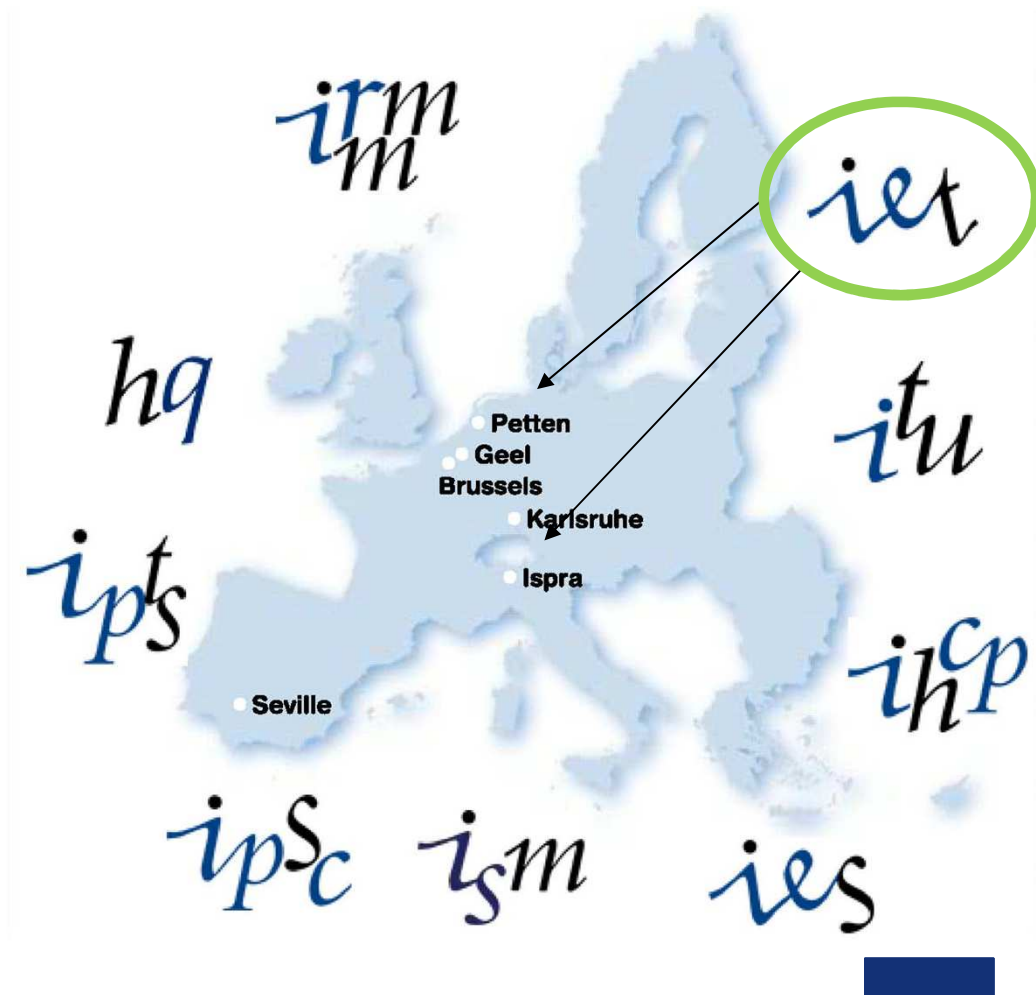
European Commission DG - Joint Research Centre (JRC)

IET - Institute for Energy and Transport

The Joint Research Centre



JRC - the European Commission's in-house science service to support EU policy making



Role of the JRC



- **Independent research and policy assessment**
- **Establishing empirical data and rationale for policy making**
- **Coordinating and guiding technical activities**
- **Cooperating with industry, member states, and research institutions**



Setting the stage



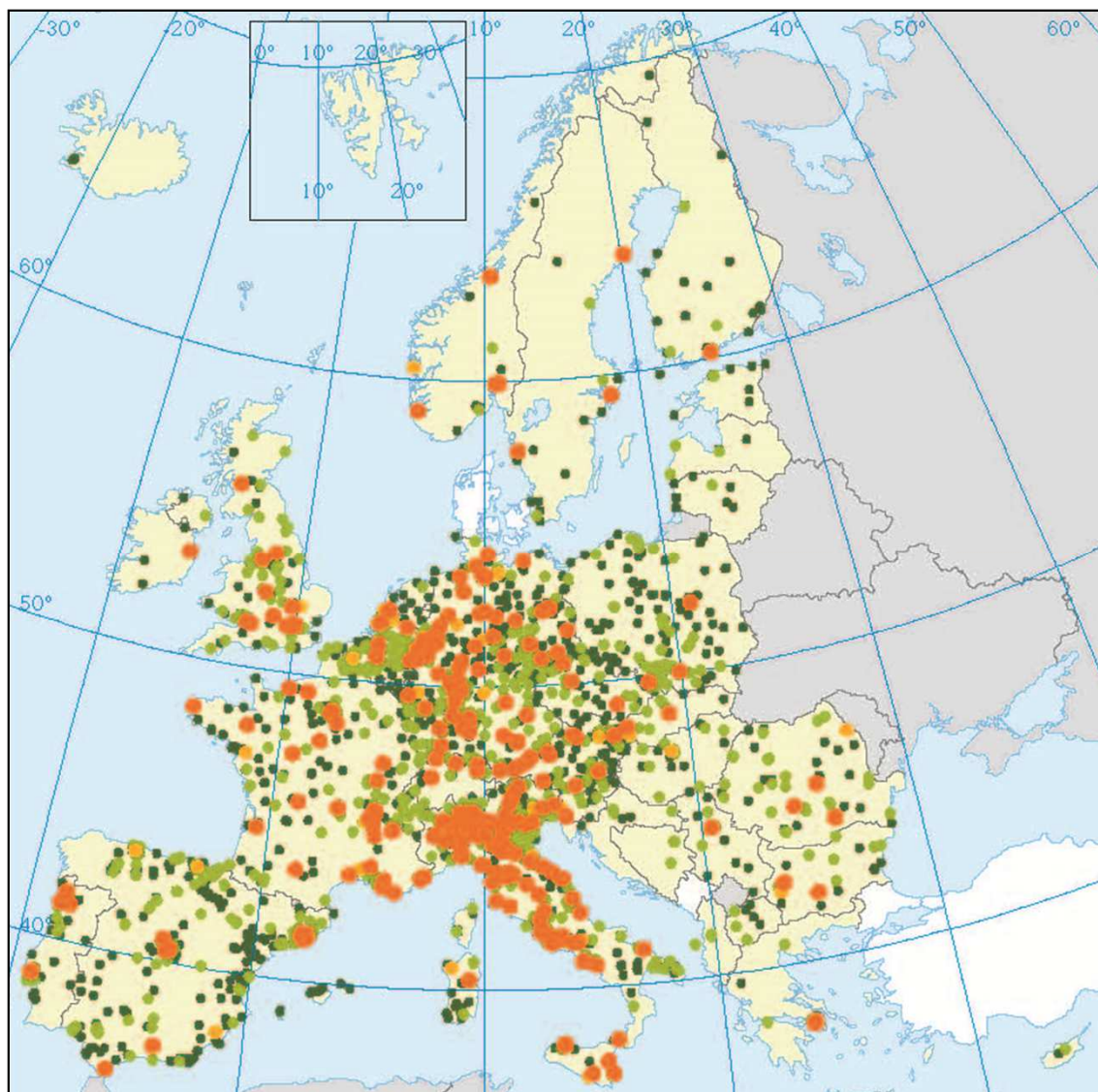
- **EU Air Quality Directive 2008/50/EU**
 - **Persisting NO₂ exceedance in urban areas**



PEMS - Light-duty vehicles



- **Environmental background**



Annual mean, nitrogen dioxide, 2009, based on daily averages with percentage of valid measurements 75 % in $\mu\text{g}/\text{m}^3$

- ≤ 20
- 20-40
- 40-42
- ≥ 42

- No data
- Outside data coverage

Source: Copyright EEA (2011)

Setting the stage



- **EU Air Quality Directive 2008/50/EU**
 - **Persisting NO₂ exceedance in urban areas**
 - **Main contributor is road transport**
- **GHG emissions reductions of 20% – Europe 2020 Strategy**
- **Long-term vision for transport in Europe - 2011 Transport White Paper:**
 - **60% CO₂ reduction by 2050**
 - **Halving the use of conventionally-fuelled cars in cities by 2030; phase them out in cities by 2050**



Expectations



- **Balancing environmental objectives with societal (mobility) and economic (competitiveness, jobs) objectives**
- **Emissions legislation and vehicle tests should be:**
 - **practical: technically feasible, simple, transparent, and cheap for manufacturers**
 - **effective: to ensure clean vehicles during use (not only in the test cell)**
 - **flexible: to accommodate future developments (vehicle technologies, state of knowledge, societal demands)**
- **PEMS offers multiple advantages over conventional vehicle testing in the laboratory**



Practicality and costs

- **In-use conformity testing of heavy-duty engines and NRMM: PEMS avoids extracting engines from vehicles**

Effectiveness

- **Vehicle testing (mainly light-duty vehicles):**
 - **PEMS allows quantify real-world on-road emissions**
 - **PEMS forces an optimized design of increasingly complex emissions control technologies**
 - **PEMS can limit the use of defeat strategies**
 - **PEMS can ensure clean vehicles on the road**



Regulations & Activities



**Heavy-duty vehicles
(type approval of the
engine)**

**NRMM
(type approval of
the engine)**

**Light-duty vehicles
(type approval of the
vehicle)**



Regulations & Activities



Heavy-duty vehicles

- Regulations 582/2011 & 64/2012: Type approval and in-service conformity testing based on on-road testing with PEMS
- Verifying the conformity of engines on vehicles during normal use
- 'Real-world' emissions not explicitly addressed; aim is a functional and performance check of emissions control technologies
- Review of current procedures until the end of 2014
- PEMS-PM instrumentation evaluation completed; industry-run Pilot Program
- Until 2014, assessment of requirements for EURO VI+ engines under urban and low-load operation

NRMM

Light-duty vehicles

Regulations & Activities



Heavy-duty vehicles

NRMM

- **Industry-run Pilot Program for in-service conformity testing completed in 2012**
- **PEMS implementation for Stage IV or V under discussion**
- **Likely adaptation of heavy-duty procedures to NRMM**

Light-duty vehicles

Regulations & Activities



Heavy-duty vehicles

NRMM

Light-duty vehicles

- Regulation 715/2007 on Euro 5/6 limits aims "to ensure that real world emissions correspond to those measured at type approval. The use of portable emission measurement systems and the introduction of the 'not-to-exceed' regulatory concept should also be considered."
- Establishment on-road emissions in 2010
- Real-driving emissions (RDE) working group since 2011; development of a complementary test procedure since 2012
- Introduction of the complementary test procedure 2014/2017
- Feasibility of PEMS-PN under investigation (alternative: random cycles)

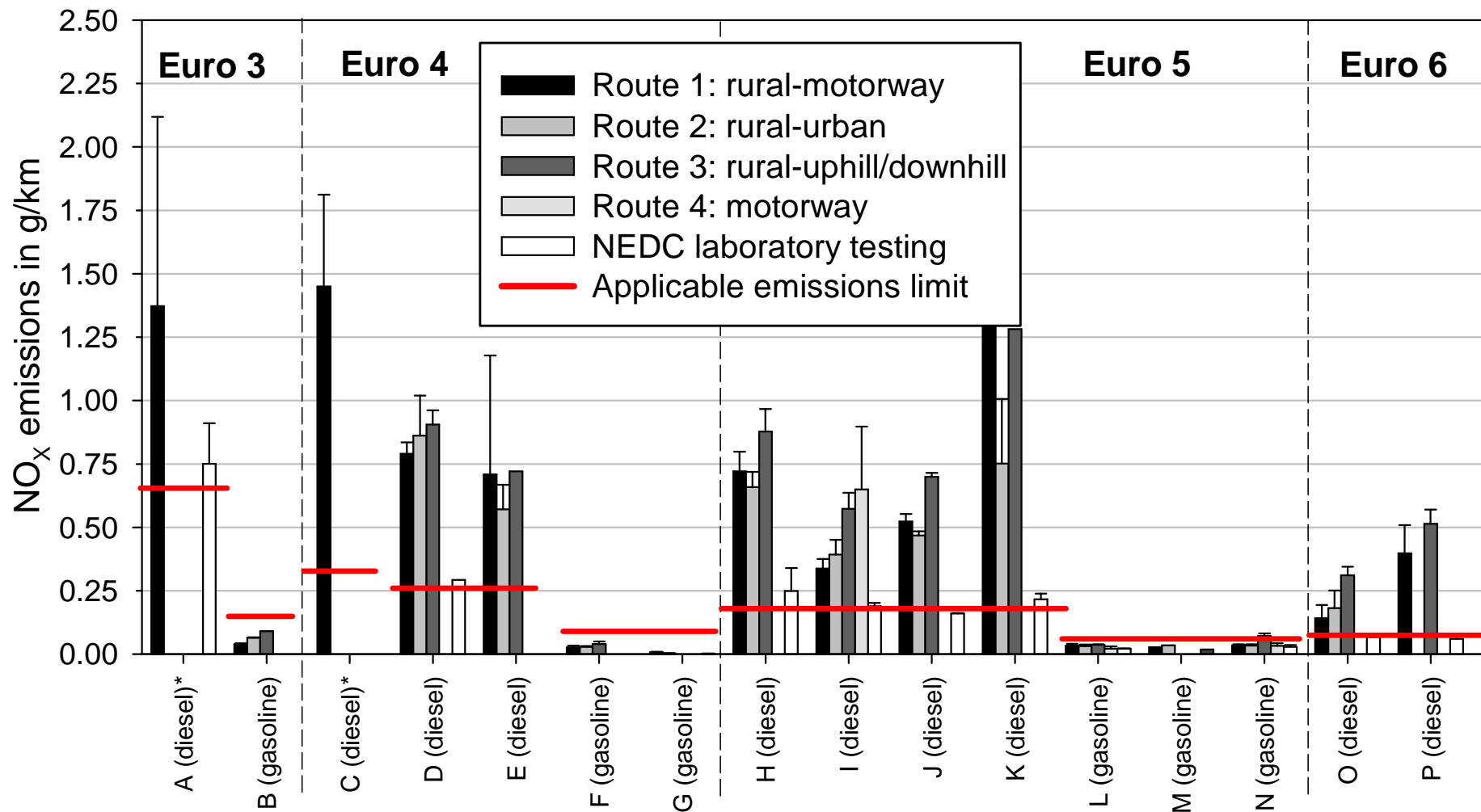
PEMS - Light-duty vehicles



- **Establishing on-road emission values**
- **JRC has tested 26 light-duty vehicles with PEMS until September 2013**
- **4 standard test routes – covering a wide range of driving conditions**



PEMS - Light-duty vehicles



PEMS - Light-duty vehicles



- **Real-driving emissions (RDE) working group to establish a complementary test procedure**
- **JRC coordinates the technical work**
- **Candidate procedures:**
 - Fixed test cycles**
 - Random test cycles**
 - PEMS on-road testing**
 - Vehicle modeling**



PEMS - Light-duty vehicles



- Real-driving emissions (RDE) working group to establish a complementary test procedure
- JRC coordinates the technical work
- Candidate procedures: ~~Fixed test cycles~~
Random test cycles
PEMS on-road testing
~~Vehicle modeling~~



PEMS - Light-duty vehicles



| Random cycles | PEMS |
|--|--|
| + less sensitive to changes in driver's behavior | + wider coverage of driving conditions |
| + less sensitive to climatic variability | + test difficult to detect |
| + long-term experience | + prevents defeat strategies |

- **RDE working group develops on-road testing with PEMS as complementary test procedure until mid 2014**



PEMS - Light-duty vehicles



Key issues – Test route

- coverage of normal driving conditions
- special attention to urban driving
- 30/30/30 split on low/medium/high (extra-high speed) defined *a priori*
- Definition of maximum speed and idling shares

Key issues – Ambient conditions

- larger temperature range than current type approval
- Applying PEMS regulation on heavy-duty vehicles (?)



PEMS - Light-duty vehicles



Key issues - Driving style, (micro) coverage of driving conditions, averaging of tests

- **three data evaluation tools (TU Graz, TNO, JRC)**
- **weighing of driving data (TU Graz)**
- **binning/zoning of driving data (TNO, JRC)**

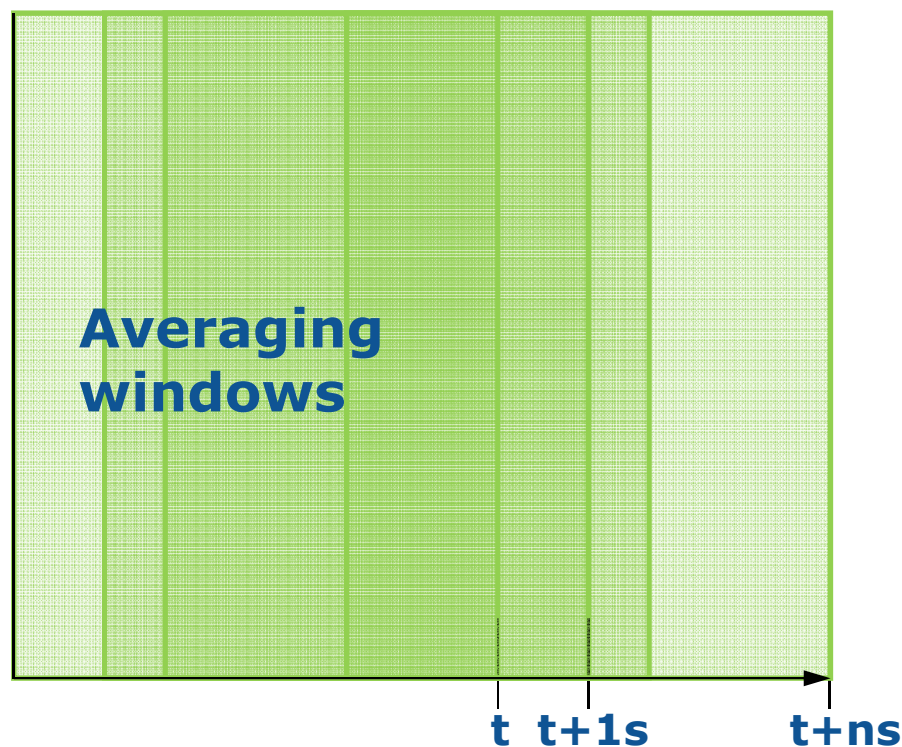
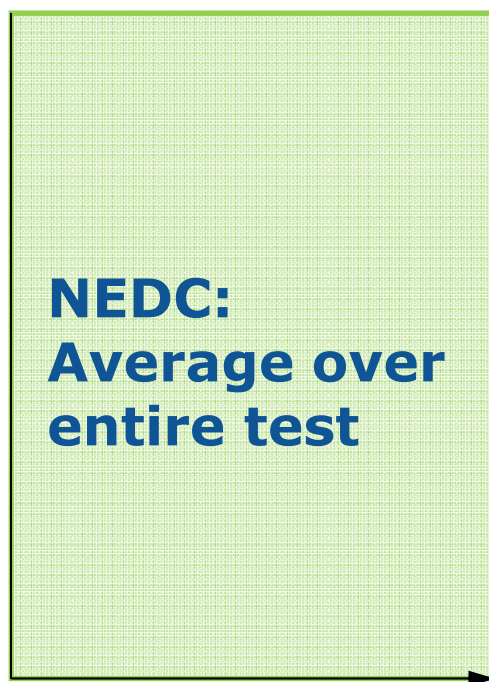


PEMS - Light-duty vehicles



Moving averaging window approach

- Implemented for heavy-duty vehicles



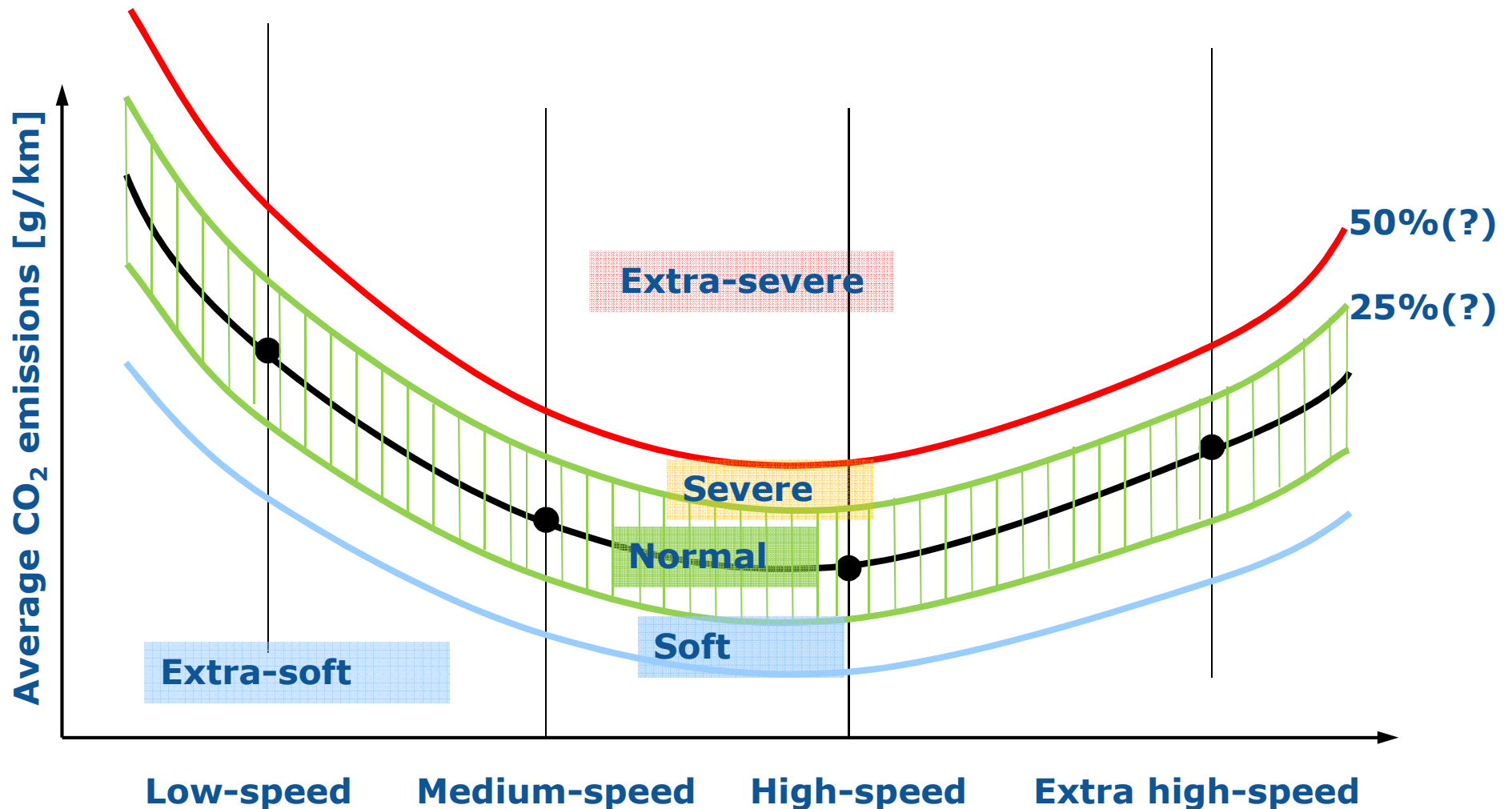
How to determine the severity of on-road driving?



PEMS - Light-duty vehicles



Moving averaging window approach



PEMS - Light-duty vehicles



Key issues - Not-to-exceed (NTE) principle

- **Aim is not to reproduce average driving but to cover the range of driving conditions**
- **Under permissible conditions, vehicles should be clean**
- **Accounting for statistical uncertainty:
NTE > Euro 6**
- **Accounting for severity and variability in ambient conditions**



Tentative time schedule



- **Structured data base of PEMS tests from 10/2013**
- **One tool for data analysis chosen by end 2013/early 2014**
- **Fine tuning and vehicle testing until mid 2014**
- **Procedure drafting until mid 2014**
- **Implementation end 2014**
- **Binding NTE limits Euro 6c 2017**





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Moving averaging window approach

