WORKSHOP A

SESSION TWO

Presentation 1

OBD vs Tailpipe Testing – Future test options for Emission Control System of modern in-use vehicles – extension to non-road vehicles

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2013 CITA Conference, 15-17th May, Seville, Spain

OBD vs. Tailpipe Testing - Future Test Options for Emission Control Systems of Modern In-Use Vehicles

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Content

Emission Test for Modern Vehicles Need an Update Due to:

- Report of the WHO (World Health Organisation)
- Air Quality Directives
- Results from German Emission Check 2010
- Results from German UBA Study
- Results from EU TEDDIE Study
- Results from French UTAC/OTC Study
- Further Study by German BASt
- Technological Outlook
- Summary

12 June 2012 – WHO – Press Relaese

World Health Organization

Health topics | Data and statistics | Media centre | Publications | Countries | Programmes and

Diesel engine exhaust carcinogenic

WHO/PAHO

12 June 2012 -- After a week-long meeting of international experts, the International Agency for Research on Cancer (IARC), which is part of the World Health Organization, today classified diesel engine exhaust as carcinogenic to humans (Group 1), based on sufficient evidence that exposure is associated with an increased risk for lung cancer.

Read the press release from IARC on diesel engine exhaust

PM – EU Air Quality Directives

Table 2.1 Air quality limit and target values for PM_{10} and $PM_{2.5}$ as given in the Air Quality Directive

Size fraction	Averaging period	Value	Comments
PM_{10}, limit value	One day	50 µg/m³	Not to be exceeded on more than 35 days per year. To be met by 1 January 2005
PM_{10}, limit value	Calendar year	40 µg/m³	To be met by 1 January 2005
$PM_{2.5}$, target value	Calendar year	25 µg/m³	To be met by 1 January 2010
$PM_{2.5}$, limit value	Calendar year	25 µg/m³	To be met by 1 January 2015
$PM_{2.5}$, limit value ([a])	Calendar year	20 µg/m³	To be met by 1 January 2020
$PM_{2.5}$, exposure concentration obligation ([b])		20 µg/m³	2015
$PM_{2.5}$ exposure reduction target ([b])	0–20 % reduction in exposure (depending on the average exposure indicator in the reference year) to be met by 2020		

Note: ([a]) Indicative limit value (Stage 2) to be reviewed by the Commission in 2013 in the light of further information on health and environmental effects, technical feasibility and experience of the target value in Member States.

([b]) Based on a three-year average.

Source: EU, 2008c.

Source: Air Quality in Europe – 2011 Report from European Environment Agency

European Environment Agency

NO_2 and NO_x – EU Air Quality Directives

Table 4.1 Limit and threshold values for NO_2 and NO_x as set out in the 2008 Air Quality Directive

Objective	Averaging period	Limit or threshold value	Number of allowed exceedances
Human health	One hour	200 µg/m³	18 hours per year
Human health	Calendar year	40 µg/m³	
Alert ([a])	One hour	400 µg/m³	
Vegetation ([b])	Calendar year	30 µg/m³	

Note: ([a]) To be measured over three consecutive hours at locations representative of air quality over at least 100 km² or an entire zone or agglomeration, whichever is smaller.

([b]) As oxides of nitrogen (NO_x), expressed as µg NO_2/m³.

Source: EU, 2008c.

Source: Air Quality in Europe – 2011 Report from European Environment Agency

European Environment Agency

Exposure Levels in the EU

Percentage of the urban population in the EU exposed to air pollutant **concentrations above the EU and WHO reference levels (2008–2010)**

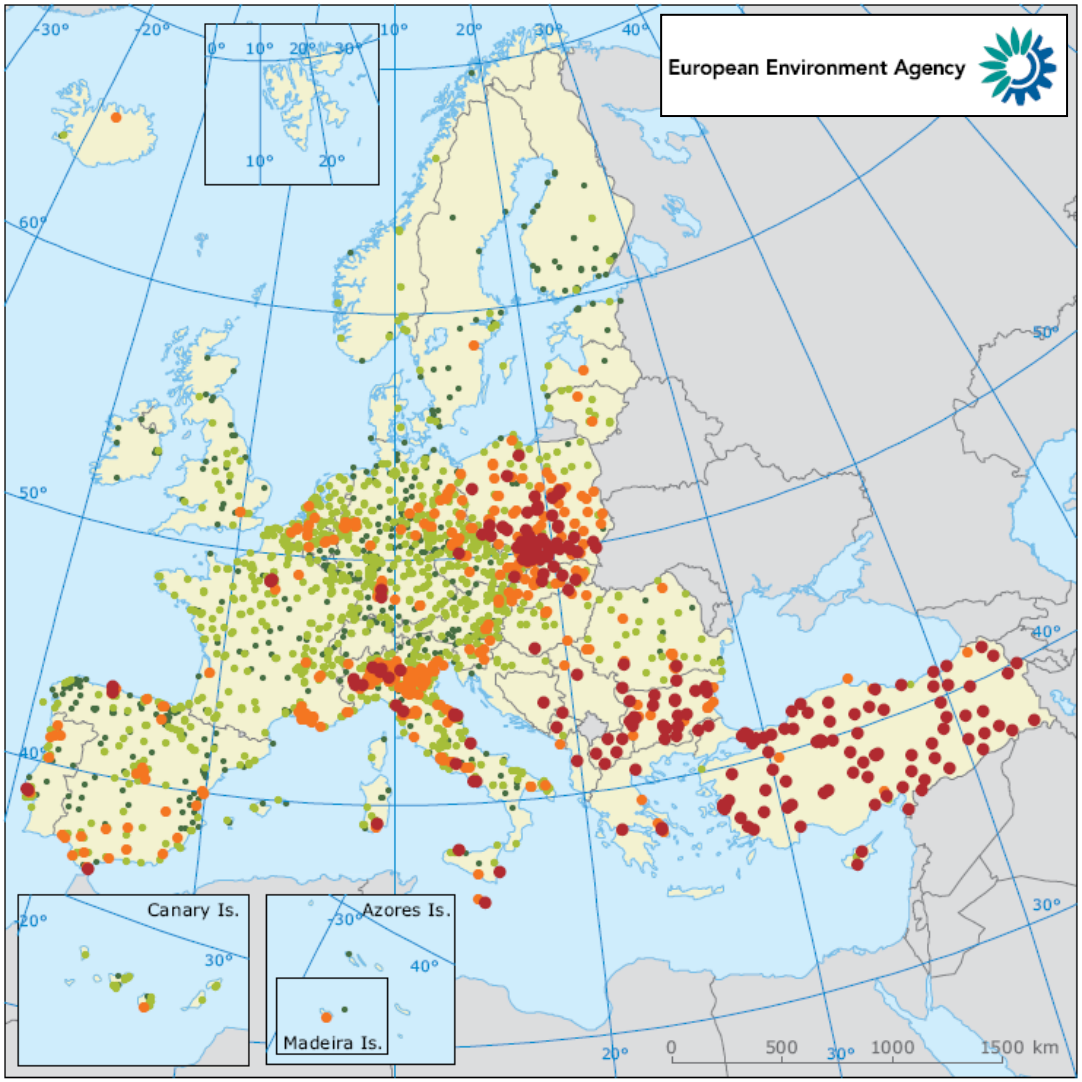
Pollutant	EU reference value	Exposure estimate (%)	WHO reference level	Exposure estimate (%)
$PM_{2.5}$	Year (20)	**16–30**	Year (10)	**90–95**
PM_{10}	Day (50)	**18–21**	Year (20)	**80–81**
O_3	8-hour (120)	**15–17**	8-hour (100)	**> 97**
NO_2	Year (40)	**6–12**	Year (40)	**6–12**
BaP	Year (1 ng/m³)	**20–29**	Year (0.12 ng/m³)	**93–94**
SO_2	Day (125)	**< 1**	Day (20)	**58–61**
CO	8-hour (10 mg/m³)	**0–2**	8-hour (10 mg/m³)	**0–2**
Pb	Year (0.5)	**< 1**	Year (0.5)	**< 1**
C_6H_6	Year (5)	**< 1**	Year (1.7)	**7–8**

Colour coding of exposure estimates fraction of urban population exposed to concentrations above the reference levels:			
< 10 %	10–50 %	50–90 %	> 90 %

Source: Air Quality in Europe – 2011 Report from European Environment Agency

European Environment Agency

Exceeding PM_{10} Limits in Europe



Source: Air Quality in Europe – 2012 Report from European Environment Agency

Annual mean particulate matter (PM_{10}) 2010, based on daily average with percentage of valid measurements ≥ 75 % in µg/m³

- ≤ 20
- 20–31
- 31–40
- > 40
- Countries/regions not included in the data exchange process

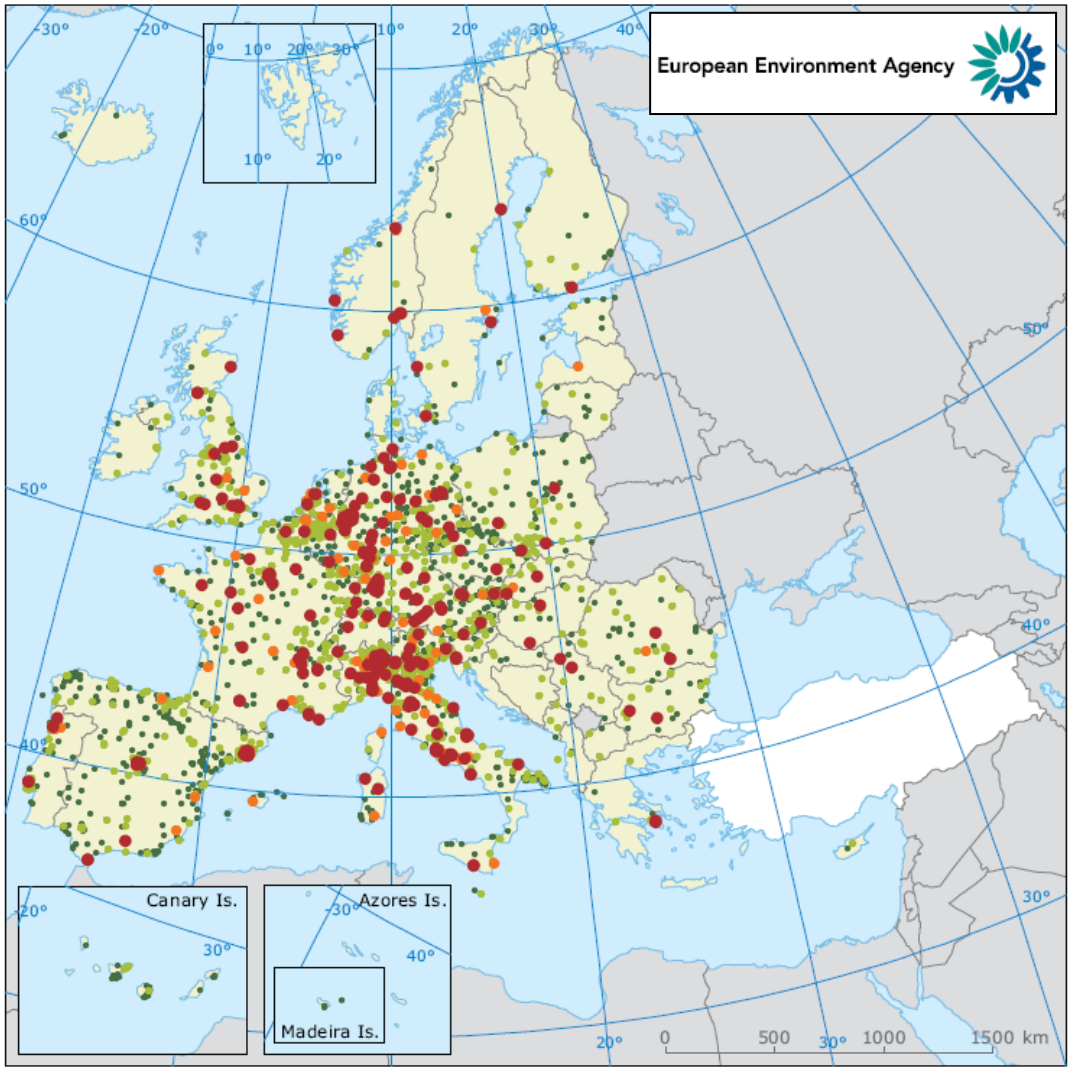
● The red dots indicate stations reporting exceedances of the 2005 annual limit value (40 µg/m³), as set out in the Air Quality Directive (EU, 2008c).

● The orange dots indicate stations reporting exceedances of a statistically derived level (31 µg/m³) corresponding to the 24-hour limit value, as set out in the Air Quality Directive (EU, 2008c).

● The pale green dots indicate stations reporting exceedances of the WHO air quality guideline for PM_{10} of less than 20 µg/m³ but not in exceedance of limit values as set out in the Air Quality Directive (EU, 2008c).

● The dark green dots indicate stations reporting concentrations below the WHO air quality guideline for PM_{10} and implicitly below the limit values as set out in the Air Quality Directive (EU, 2008c).

Exceeding NO_2 (Nitrogen Dioxide) Limits in Europe



Annual mean nitrogen dioxide 2010, based on daily averages with percentage of valid measurements ≥ 75 % in µg/m³

- ≤ 20
- 20–40
- 40–45
- > 45
- No data
- Countries/regions not included in the data exchange process

● Red dots correspond to exceedances of the annual limit value + 5 µg/m³.

● Orange and red dots correspond to exceedances of the annual limit value (40 µg/m³).

● The pale green dots indicate stations reporting exceedances of the WHO air quality guideline for NO_2 but not in exceedance of limit values as set out in the Air Quality Directive (EU, 2008c).

● The dark green dots indicate stations reporting concentrations below the WHO air quality guideline for PM_{10} and implicitly below the limit values as set out in the Air Quality Directive (EU, 2008c).

Source: Air Quality in Europe – 2012 Report from European Environment Agency

Results of the Studies

German Project Emission Check 2010 (2009-2010):

- OBD specially on diesel engines is not covering all emission aspects
- Present limit (k 1.5 m^{-1} / k 3.0 m^{-1}) values used during PTI are too high
- Second generations of opacimeter and light scattering measurement devices are much more sensitive and precise

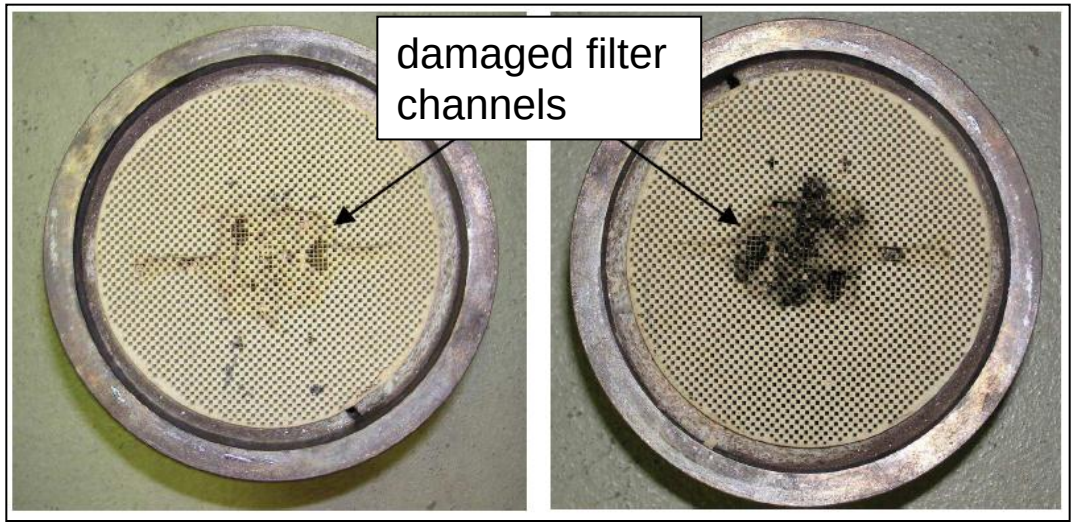
Deterioration / Defect status	Particular Mass PM			Partikel numbers	Particular-Masse (max.Peak) Streulicht (MPM4)	DTC - trouble codes	MIL
	mg/km	% v. Typ approval value	% of OBD-threshold value	n	mg/m³		
Ok - Condition	1,070	21,4	2,14	$7{,}031*10^{8}$	8,01	0	off
Step 1 (1 hole)	8,570	175	17,5	$2{,}521*10^{13}$	45,25	0	off
Step 2 (4holes)	15,059	301	30,1	$3{,}660*10^{13}$	90,25	0	off
Step 3 (29 holes)	51,300	1026	102,6	-	400,6	0	off

DTC = Diagnostic Trouble Code // MIL = Malfunction Indicator Light

Results of the Studies

German Project UBA (2010-2011)
(German Environmental Protection Agency):

- OBD specially on diesel engines is not covering all emission aspects
- Present limit (k value 1.5 m^{-1} / k value 3.0 m^{-1}) values used during PTI are too high
- Second generations of opacimeter and light scattering measurement devices are much more sensitive and precise
- Reference value for Diesel vehicles with after treatment systems should not be higher than k value 0.1 m^{-1} (Opacity) !
- Petrol vehicles with direct injection are producing significant amount of particles – particle filters are necessary too

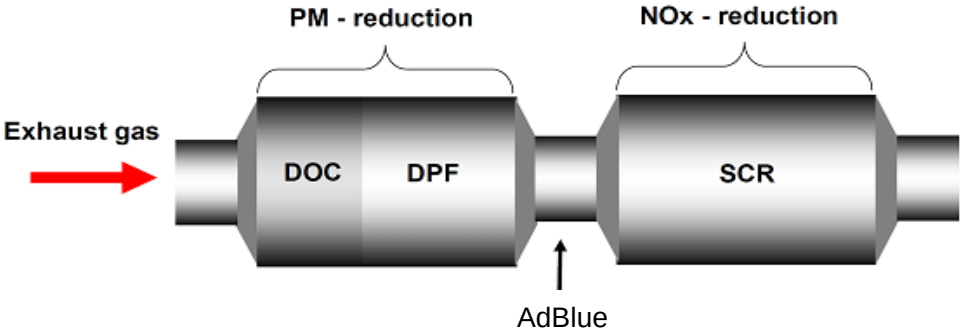


Results of the Studies

EU TEDDIE Study (2011-2012):

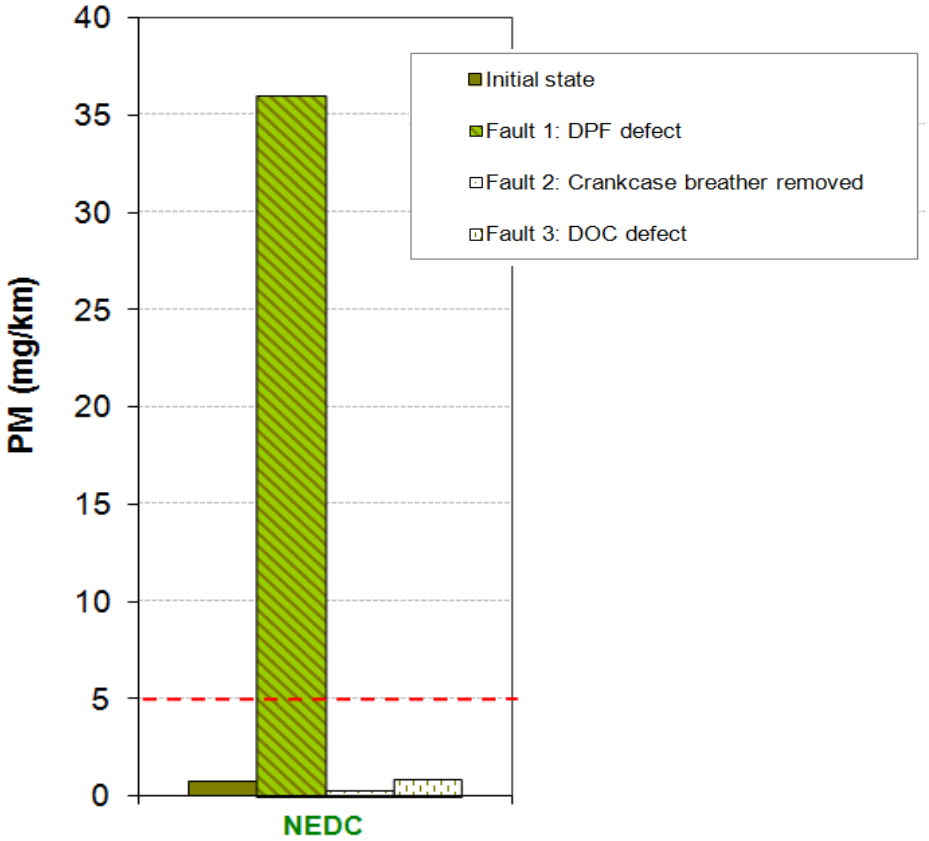
Founded by the European Commission in 2011
- to investigate new measurement devices for particle mass and NO/NO_2-ratio
- to evaluate if OBD is capable via MIL or storing DTCs to identify PM emissions above the given limits
  Limits: type approval = 5 mg/km in NEDC, OBD threshold = 50 mg/km
- to identify reliable and effective methods of emission testing

Vehicles prepared with defects of the exhaust emission system:
- defects of particle trap (DPF)
- defective/damaged/aged SCR
- manipulated crankcase breather
- defective air mass flow sensor



Source: DEKRA

EU TEDDIE: Deterioration of the Particle Trap (DPF)



New European Driving Cycle

Source: DEKRA

Results of the Studies

EU TEDDIE: Emission Test Results:

	Max. Particle Emission	OBD-MIL	OBD-DTC
results:	in use compliance (>5.0 mg/km)		
vehicle 1	5.1 mg/km	OFF	none
vehicle 2	36.0 mg/km	OFF	none
vehicle 3	8.9 mg/km	OFF	none
vehicle 4	51.3 mg/km	OFF	none

➔ Defects (e.g. defective particle traps) might cause higher emissions up to the OBD MIL threshold, without MIL and DTC activation.

Limits for emission testing (opacity is ranging from 3.0 m^{-1} down to values below 0.5 m^{-1}) comes closer to the technical limitations of opacity measurement.

➔ New measurement technology:
Laser Light Scattering Photometry (LLSP) / Opacimeter New Generation

Source: DEKRA

Use of OBD and Tailpipe Measurements

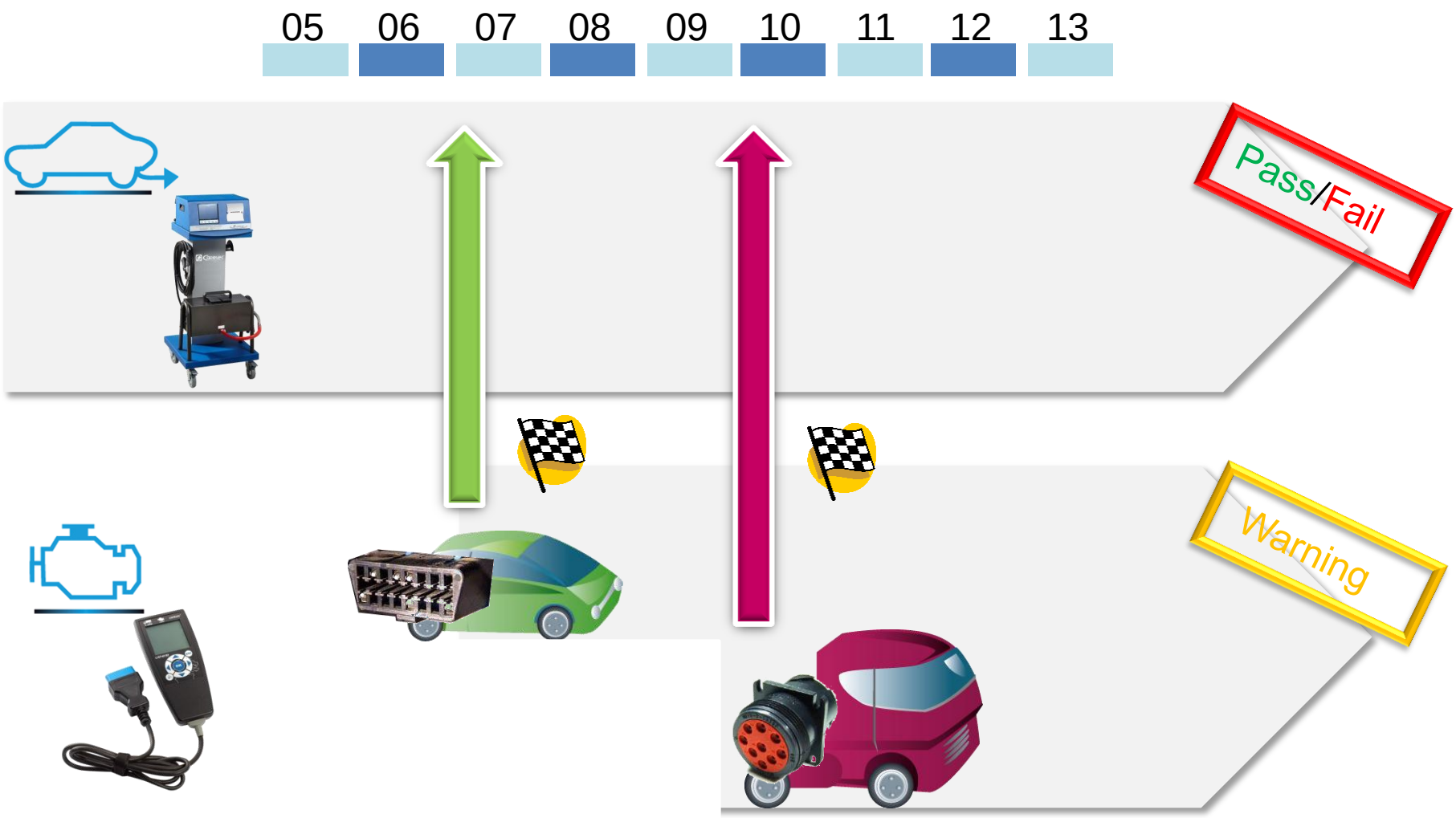
European studies show that a variety of serious defects of emission systems in diesel engines will not be identified by OBD.

Tailpipe emissions may increase by more than 10 times without being detected by OBD !

➔ The new technologies for measuring tail pipe PM concentration are sufficiently sensitive to deliver valid results even with Euro 6/VI engines. It is not necessary to rely on OBD to identify faults in the emission system.

Source: DEKRA & http://ec.europa.eu/transport/road_safety/pdf/projects/teddie.pdf

Comparison OBD/Tailpipe Measurement Made by UTAC/OTC



The French Landscape:
Sample's Extraction from OTC Data Base

PTI
National Agency

OTC Data Base

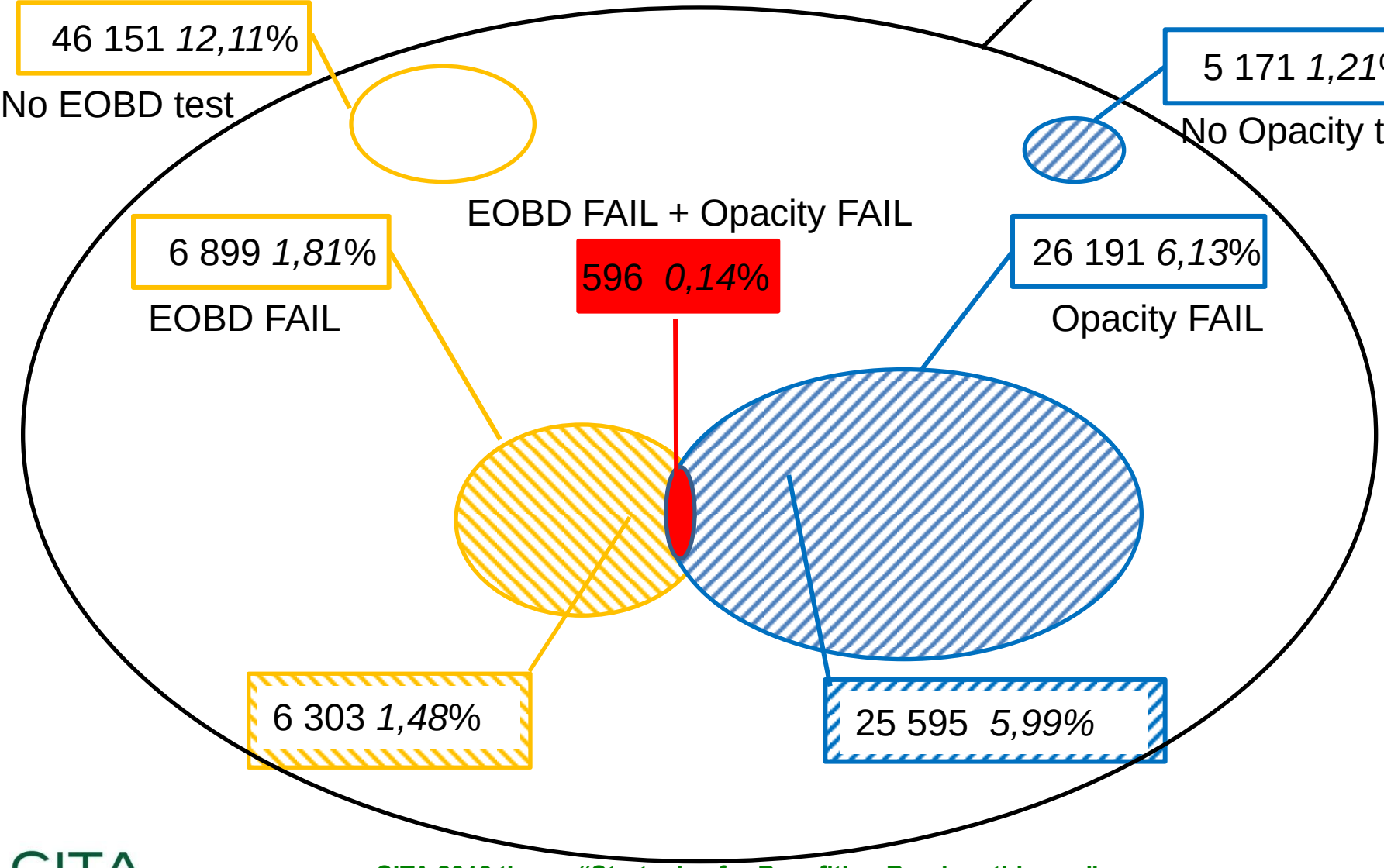
January 2013

≥ Euro 4

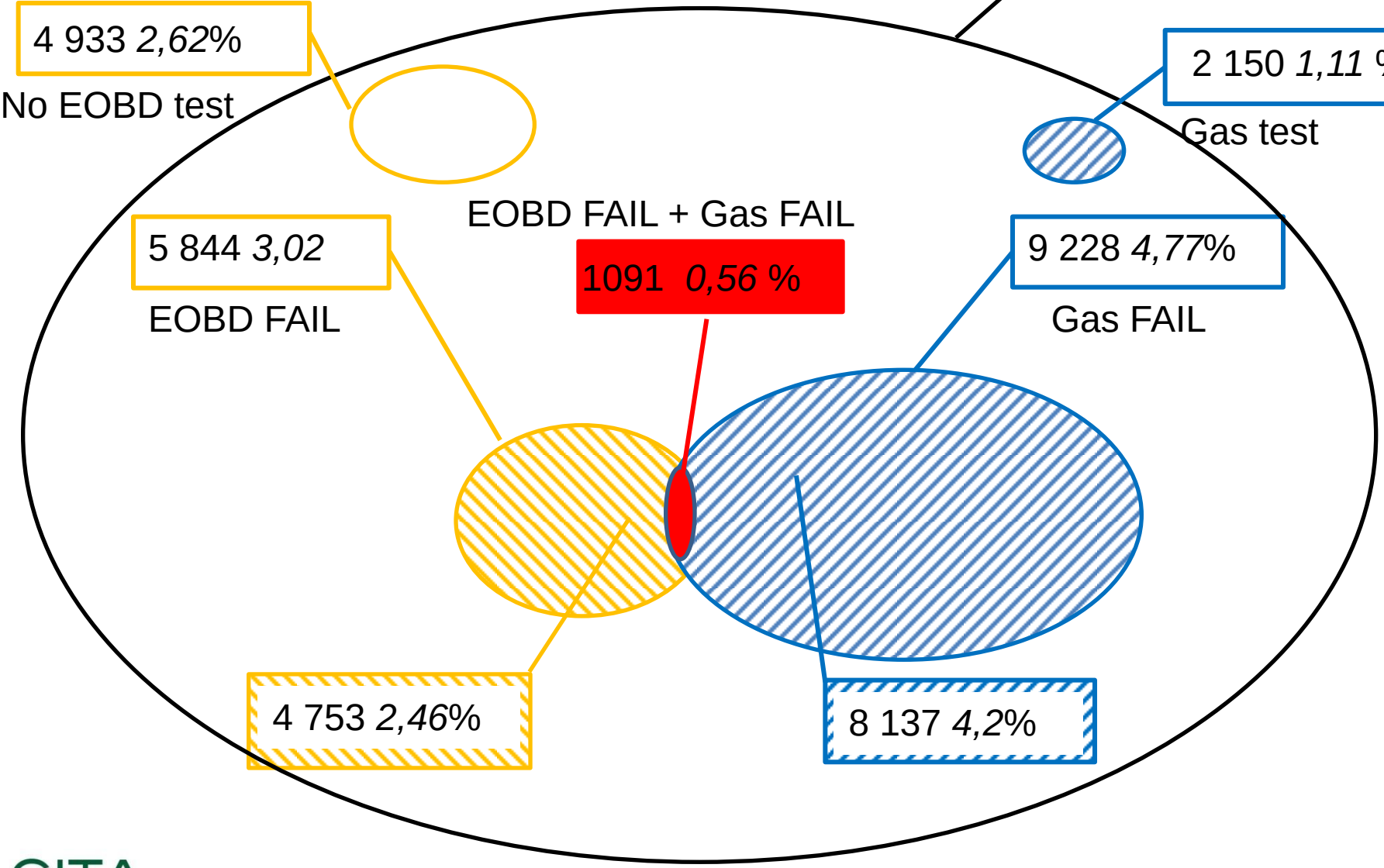
427 286 vehicle records

193 521 vehicle records

Tail Pipe vs. EOBD



Tail Pipe vs. EOBD



Comparison OBD/Tailpipe Measurement Made by UTAC/OTC

This is a first level of analysis… more data are available (since 2007!).
Trucks data are also available.
Noticeable:

- No direct correlation between Tail pipe and EOBD for Diesel and Petrol.
- Tail pipe test is more severe.
- Diesel Tail pipe test are relevant on Euro 4 vehicle car park
- Ratio of MIL off when engine is off, and key on, are related to attempted fraud
- Visual MIL inspection are less efficient than electronic reading (delta between MIL KO Engine ON Visual and MIL KO Engine ON internal)
- Additional analysis might be required in order to understand the level of EOBD DTC presents without MIL trouble

Conclusions

Limits for emission testing and measurement devices

The pass-fail criteria for PTI test should be set to reflect the certification standard of the vehicle being tested. It should allow for some reasonable deterioration during the service life of the vehicle.

- Limit k value of 0.1 m^{-1}
- But the limit should not allow excessive deterioration to occur before repair- maintenance is required

Further Studies

BASt Study (August 2012 – approx. July 2013)

The German Transport Ministry has commissioned BASt (Federal Highway Research Institute) as „the Federal Government's field-oriented, technical-scientific institute in the field of highway research" to have this actual situation examined in a study:

Determination of the extent of different emission test results between tail pipe measurement and outcome of the on-board diagnostic system

Bundesministerium für Verkehr, Bau und Stadtentwicklung

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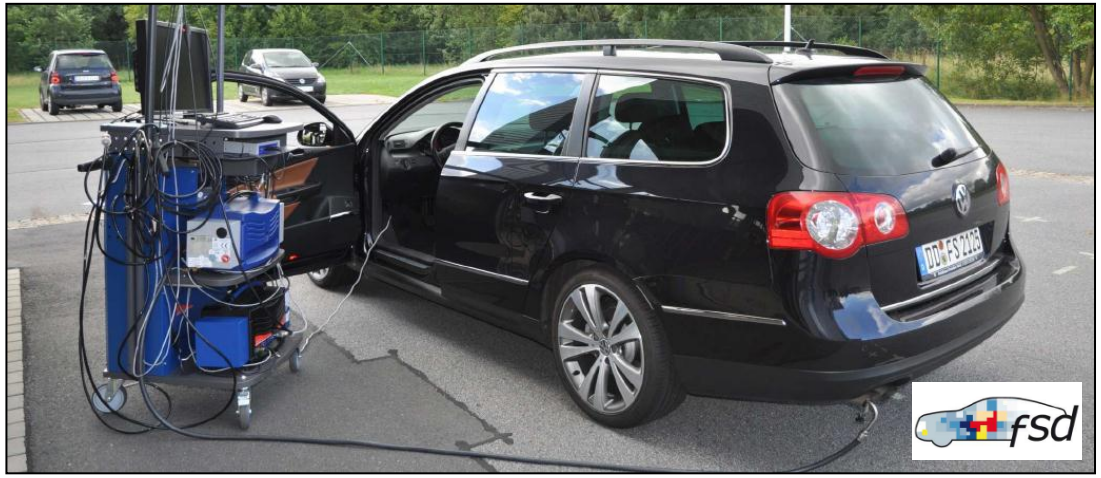


Further Studies

BASt Study (August 2012 – approx. July 2013)

According to the German Emission directive (national implementation of 2010/48/EU), gaseous emissions can be inspected either by “measurement using an exhaust gas analyser” (tail pipe measurement) or by “appropriate reading of the OBD device and checks on the proper functioning of the OBD system”.

It is known from several studies that, between these two alternative inspection methods, differences in the detection of emission relevant failures can occur.

As a basis for possible political decisions in Germany, a **data collection** is necessary to assess the relevance of the difference of both methods.

BASt Study (August 2012 – approx. July 2013)

Conditions

- inspection on entry, visual inspection
- tail pipe measurement according to 2010/48/EU plus
- OBD outcome according to 2010/48/EU
- ~2000 vehicles M1, ~50% Diesel-, ~50% Otto-engines
- first registration from 2006 on
- random sample on PTI stations
- Nationwide
- high/low mileage
- different vehicle users
- inspectors of several German PTI bodies
- especially instructed for this project

Further Studies

BASt Study (August 2012 – approx. July 2013)

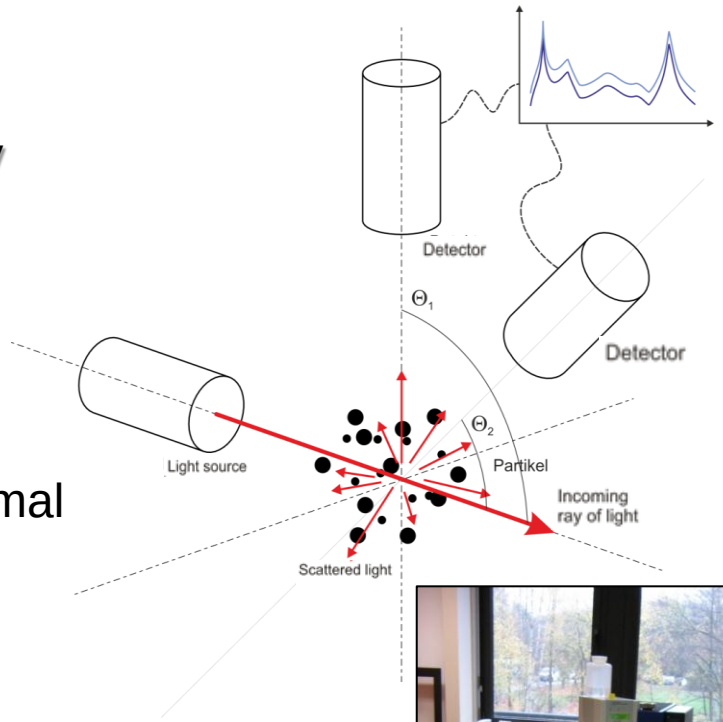
Analysis

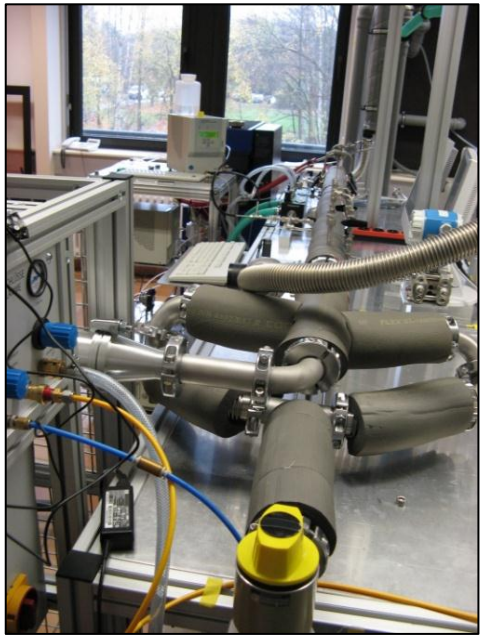
- percentage of vehicles which have passed (not passed) the OBD
- percentage of vehicles which have passed (not passed) the tail pipe measurement
- percentage of vehicles which have passed OBD and not passed the tail pipe measurement
- percentage of vehicles which have passed the tail pipe measurement and not passed OBD
- differentiated between Diesel- and Otto-engines
- analysis of the influence of vehicle age, mileage, emission standard, vehicle model, …

Technological Outlook

LLSP – Laser Light Scattering Photometry

- size range 40 to 1000 nm
- 0.01 – 700.00 mg/m^3 PM concentration
- m^{-1} (Opacity) by correlation
- #/m^3 number concentration
- nm (mode) particle at logarithmical normal size distribution
- non road PM emitters
- …





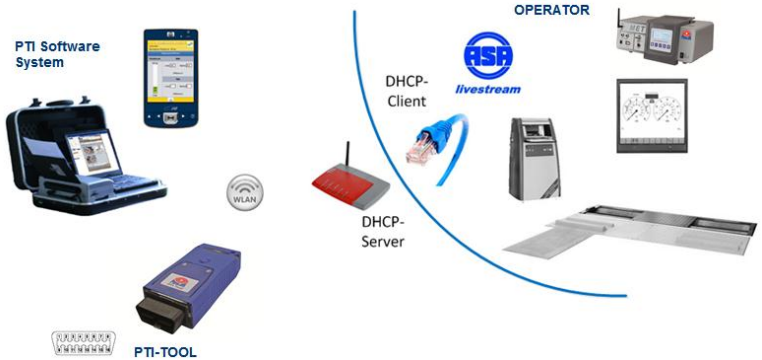
Summary

For an Environmental effective Diesel and Petrol Emission Test it is necessary to have a modern Mechatronic System.

OBD + Tail Pipe = is the **U**ltimate **D**iesel and **P**etrol **E**mission **T**est **S**ystem **for an 100% PTI or garage test for Diesel and Petrol Emissions.**

Especially for modern diesel-powered vehicles equipped with a emission after treatment system such as a diesel particulate filter, SRC, SRCT,…, only this combination of tests ensure the effectiveness of the emission test during PTI.

The above mentioned measuring instruments are available today.



Thank you for your attention!