

Session 2: 10:50 – 11:50



Adapting driver behaviour  
for lower emissions

# **OBD – Retrofits – Tampering – Inspection**

Moderator: Dimitri Margaritis

Mid-term results on the road to low emissions: 28 May 2021

## ***Speakers:***

**Data access from On-Board Diagnostics (OBD)**  
**Dimitri Margaritis (CERTH/HIT)**

**Simulation of retrofits**  
**Haibo Chen (University of Leeds)**

**Real-world tests of retrofits**  
**Arno Amberla (Proventia)**

**Tampering and inspection: technical aspects**  
**Dimitri Margaritis (CERTH/HIT)**

**Tampering and inspection: legal aspects**  
**Esther Tenge (Spark Legal Network)**





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# Data access from On-Board Diagnostics (OBD)

Dimitri Margaritis  
CERTH/HIT

Mid-term results on the road to low emissions: 28 May 2021

# Dongles for OBD data access

- Dongles are often provided in various variants or models
- Mainly differ in the access interface, e.g., Bluetooth Cellular, RS232
- There is a huge number of dongles in the market that
  - all base on the ELM327 chipset, or
  - provide compatibility to the ELM327 commands

# Indicative list of current OBD dongles with their variants

Brand / Product	Link
<b>OpenXCP</b>	<a href="http://openxcplatform.com/">http://openxcplatform.com/</a>
Ford Reference VI	<a href="http://openxcplatform.com/vehicle-interface/hardware.html#ford-reference-design">http://openxcplatform.com/vehicle-interface/hardware.html#ford-reference-design</a>
CrossChasm C5 BT	<a href="http://openxcplatform.com/vehicle-interface/hardware.html#crosschasm-c5-bt">http://openxcplatform.com/vehicle-interface/hardware.html#crosschasm-c5-bt</a>
CrossChasm C5 Cellular	<a href="http://openxcplatform.com/vehicle-interface/hardware.html#crosschasm-c5-cellular">http://openxcplatform.com/vehicle-interface/hardware.html#crosschasm-c5-cellular</a>
CrossChasm C5 BLE	<a href="http://openxcplatform.com/vehicle-interface/hardware.html#crosschasm-c5-ble">http://openxcplatform.com/vehicle-interface/hardware.html#crosschasm-c5-ble</a>
DIY chipKIT-based VI	<a href="http://openxcplatform.com/vehicle-interface/hardware.html#diy-chipkit">http://openxcplatform.com/vehicle-interface/hardware.html#diy-chipkit</a>
<b>Freematics</b>	<a href="https://freematics.com/products/">https://freematics.com/products/</a>
Freematics ONE	<a href="https://freematics.com/products/freematics-one/">https://freematics.com/products/freematics-one/</a>
Freematics ONE+ Model A	<a href="https://freematics.com/products/freematics-one-plus/">https://freematics.com/products/freematics-one-plus/</a>
Freematics ONE+ Model B	<a href="https://freematics.com/products/freematics-one-plus-model-b/">https://freematics.com/products/freematics-one-plus-model-b/</a>
Freematics ONE+ Model H	<a href="https://freematics.com/products/freematics-one-plus-model-h/">https://freematics.com/products/freematics-one-plus-model-h/</a>
Freematics OBD-II UART Adapter V2.1 (for Arduino)	<a href="https://freematics.com/products/freematics-obd-ii-uart-adapter-mk2">https://freematics.com/products/freematics-obd-ii-uart-adapter-mk2</a>
Freematics OBD-II I2C Adapter (for Arduino)	<a href="https://freematics.com/products/arduino-obd-adapter/">https://freematics.com/products/arduino-obd-adapter/</a>
<b>OBDLink</b>	<a href="https://www.obdlink.com">https://www.obdlink.com</a>
OBDLink MX+	<a href="https://www.obdlink.com/mxp/">https://www.obdlink.com/mxp/</a>
OBDLink MX BlueTooth	<a href="https://www.obdlink.com/mxblt/">https://www.obdlink.com/mxblt/</a>
OBDLink LX BlueTooth	<a href="https://www.obdlink.com/lxblt/">https://www.obdlink.com/lxblt/</a>
OBDLink EX	<a href="https://www.obdlink.com/ex/">https://www.obdlink.com/ex/</a>
OBDLink SX	<a href="https://www.obdlink.com/sxusb/">https://www.obdlink.com/sxusb/</a>
<b>CSS Electronic</b>	<a href="https://www.csselectronics.com">https://www.csselectronics.com</a>
CANedge1	<a href="https://www.csselectronics.com/screen/product/can-logger-sd-canedge1/language/en">https://www.csselectronics.com/screen/product/can-logger-sd-canedge1/language/en</a>
CANedge2	<a href="https://www.csselectronics.com/screen/product/can-lin-logger-wifi-canedge2/language/en">https://www.csselectronics.com/screen/product/can-lin-logger-wifi-canedge2/language/en</a>
CL1000	<a href="https://www.csselectronics.com/screen/product/can-bus-logger-canlogger1000">https://www.csselectronics.com/screen/product/can-bus-logger-canlogger1000</a>
CL2000	<a href="https://www.csselectronics.com/screen/product/can-bus-logger-canlogger2000">https://www.csselectronics.com/screen/product/can-bus-logger-canlogger2000</a>
CL3000	<a href="https://www.csselectronics.com/screen/product/can-bus-logger-canlogger3000">https://www.csselectronics.com/screen/product/can-bus-logger-canlogger3000</a>
<b>Simma Software</b>	<a href="http://www.simmasoftware.com/j1939-adapter-j1708.html">http://www.simmasoftware.com/j1939-adapter-j1708.html</a>
VNA2-ELD	<a href="http://www.simmasoftware.com/eld-brochure.pdf">http://www.simmasoftware.com/eld-brochure.pdf</a>
VNA-232	<a href="http://www.simmasoftware.com/j1939-to-rs232.pdf">http://www.simmasoftware.com/j1939-to-rs232.pdf</a>
VNA-USB	<a href="http://www.simmasoftware.com/j1939-to-usb.pdf">http://www.simmasoftware.com/j1939-to-usb.pdf</a>
VNA-WiFi	<a href="http://www.simmasoftware.com/wireless-j1939-to-wifi.pdf">http://www.simmasoftware.com/wireless-j1939-to-wifi.pdf</a>
VNA2-BT	<a href="http://www.simmasoftware.com/wireless-j1939-to-bluetooth.pdf">http://www.simmasoftware.com/wireless-j1939-to-bluetooth.pdf</a>
<b>Pace</b>	<a href="https://www.pace.car/de">https://www.pace.car/de</a>
Pace Link	
<b>LAWICEL</b>	
CANUSB	<a href="https://www.obd-2.de/shop/can-bus/20/can-car-sniffer-kit">https://www.obd-2.de/shop/can-bus/20/can-car-sniffer-kit</a>
<b>comma.ai</b>	<a href="https://comma.ai/">https://comma.ai/</a>
panda OBD II Interface (white)	<a href="https://comma.ai/shop/products/panda-obd-ii-dongle">https://comma.ai/shop/products/panda-obd-ii-dongle</a>
panda OBD II Interface (gray)	<a href="https://comma.ai/shop/products/panda-obd-ii-dongle">https://comma.ai/shop/products/panda-obd-ii-dongle</a>

# Selection criteria for a dongle

Characteristics	Car	Heavy duty vehicle	Required	Potential Dongles		
				ELM327 compatible	OBDLink (MX+, LX)	Freematics One+ (Model B, Model H)
Supported protocols	Raw CAN OBD	Raw CAN J1939	all	Raw CAN OBD J1939	Raw CAN OBD J1939	Raw CAN OBD J1939 (H)
Accepted maximal voltage	≥ 12V	≥ 24V for J1939		12V	12V	12V (B) ≥ 24V (H)
Main connector	OBD II Type A	OBD II Type B for J1939		OBD II Type A OBD II Type B for J1939	OBD II Type A	OBD II Type A (B) OBD II Type B (H)
Interfaces	Bluetooth Low Energy Bluetooth WiFi USB LTE/4G SD / ROM (on-unit logging)		one	Bluetooth	Bluetooth (MX+, LX)	BLE/BT WiFi USB LTE/4G SD / ROM (on-unit logging)
Features	Geolocation/GPS G-Force Accelerometer Orientation Real Time Clock			-	-	Geolocation/GPS G-Force Accelerometer Orientation Real Time Clock
Data Exchange Format	JSON CSV non-proprietary		one	non-proprietary	non-proprietary	custom programmable
Commands	ELM327 AT/ST documented		one	ELM327 AT	ELM327 AT/ST	
Developer Libraries	NodeJS Python Flutter Ionic support		one	broadest support all important languages	broadest support all important languages	

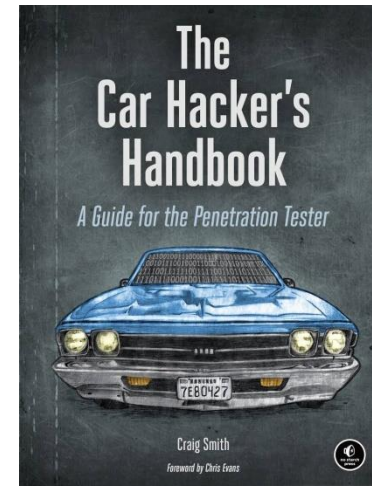
# Do all vehicles provide the same data set?

- Availability of Public PIDs vs different cars
  - Number of PIDs/total PIDs
  - Number of emission-specific PIDs
  - Data versus age of the car; type of engine
- Sampling frequency
  - Avg/min/max; distribution; ... of time

```
{
  "protocol": {
    "id": "",
    "name": ""
  },
  "brand": "Fiat",
  "model": "Qubo",
  "year_reg": 2011,
  "ELM_VERSION": "None",
  "VIN": "ZFA22500000224144",
  "PIDS_A": "None",
  "PIDS_B": "None",
  "PIDS_C": "None",
  "PIDS_D": "None",
  "PIDS_E": "None",
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  "MIDS_C": "None",
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    0.0,
    0.0
  ]
}
```

# Is OBD a gate for comprehensive data?

- Open standard for OBD-purpose only covers a subset of all potentially available data accessible via the OBD/CAN-interface
- ...but the remaining are non-standard, largely OEM specific
- OBD is also relevant only to passenger cars and vans, because HD vehicles have another kind of architecture and set of standards
- A serious effort should be made to “crack” the messages and obtain a larger sample of parameters that can be monitored for:
  - Exhaust emissions level
  - Maintenance
  - Tampering
  - Driving patterns of the motorist at the wheel
- But is “cracking” a legal act?





# OBD vulnerability to tampering

- ***OBD suppressors***: OBD fault code memory with diagnostic trouble codes can be erased
- An anti-tampering procedure is the development of a function that aims to specifically detect and prevent only the malicious DTC (diagnostic Trouble Code) deletion
- **Solution** (advises also by DIAS EU project)
  - Setting a permanent fault
  - Logging and reporting faults
  - Set the frequency of a DTC reset



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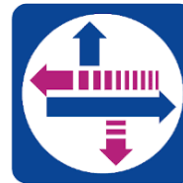
**Thank you**

**Contact:**

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**CERTH/HIT**

**Email: [dmarg@certh.gr](mailto:dmarg@certh.gr)**





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# **Simulation of retrofits**

MODALES mid-term event, virtual meeting, 28 May 2021

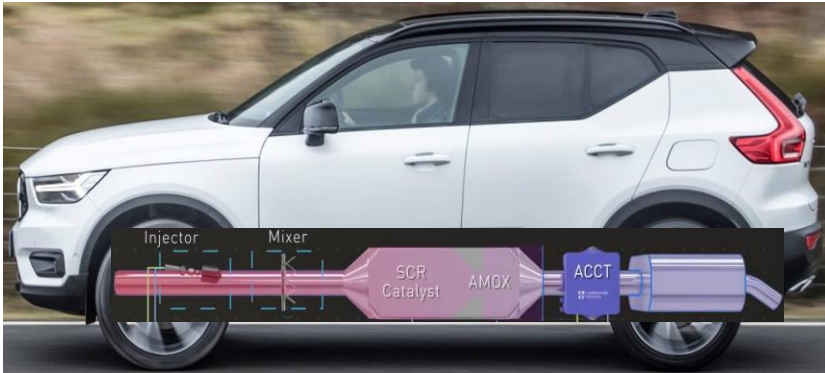
Dr. Haibo Chen & Dr. Jianbing Gao  
Institute for Transport Studies, University of Leeds

# The MODALES methodology:

## “Real-world test”

vs

## “Simulation & Modelling”



- Ground-truth data
- Performance under real-world conditions
- Real impact on AQ, exposure and health
- Expensive and time-consuming
- Limited tests in terms of vehicle types, traffic conditions, driving behaviours *etc.*
- Data quality due to unknown errors

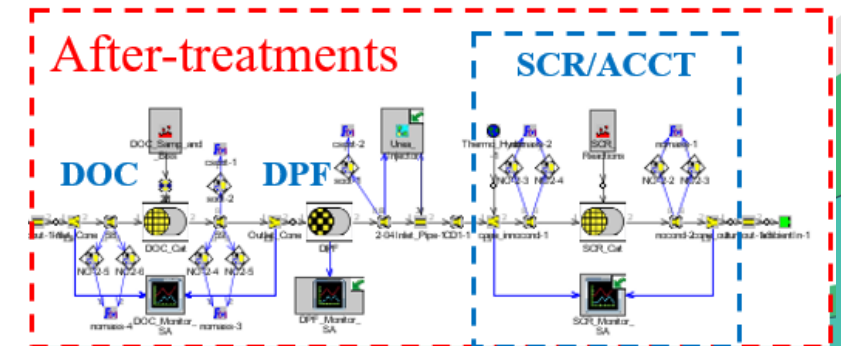
### Traffic model



### Driving simulator



### Vehicle model including

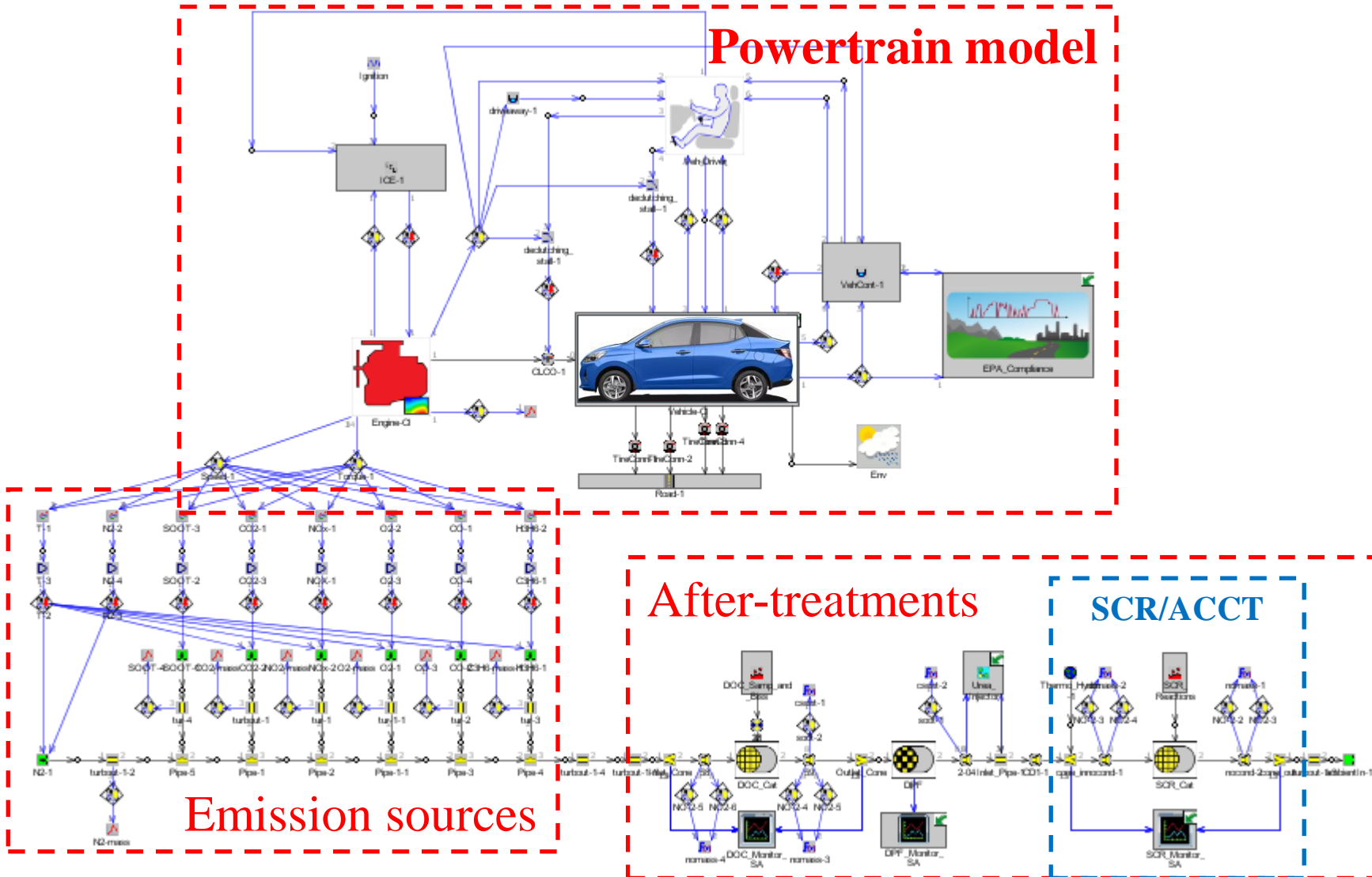


# Potential NOx control technologies

Based on ammonia generation (1-3), heat loss prevention (4), exhaust temperature increase (5-6), NOx adsorber (7)

No	Technology	Response	Energy Penalty	Complexity/Affordability/Adaptability	Effectiveness
1	<b>SCR*</b> (Selective Catalytic Reduction)	Medium	Low	Medium/Medium/Medium	Medium
2	<b>ACCT</b> (Ammonia Creation and Conversion Technology)	Fast	Medium/High	Complex/Low/Low	High
3	<b>ASDS</b> (Ammonia Storage and Delivery System)	Fast	Medium	Complex/Low/Low	High
4	<b>Thermal Insulation Technology</b> (Insulation materials covering SCR system)	Slow	Low	Simple/High/High	Low
5	<b>EHC</b> (Electrically Heated Catalyst)	Fast	High	Simple/High/High	High
6	<b>External burner</b>	Fast	High	Simple/High/High	High
7	<b>LNT</b> (Lean NOx Trap)	Fast	Medium	Medium/Medium/Medium	Low

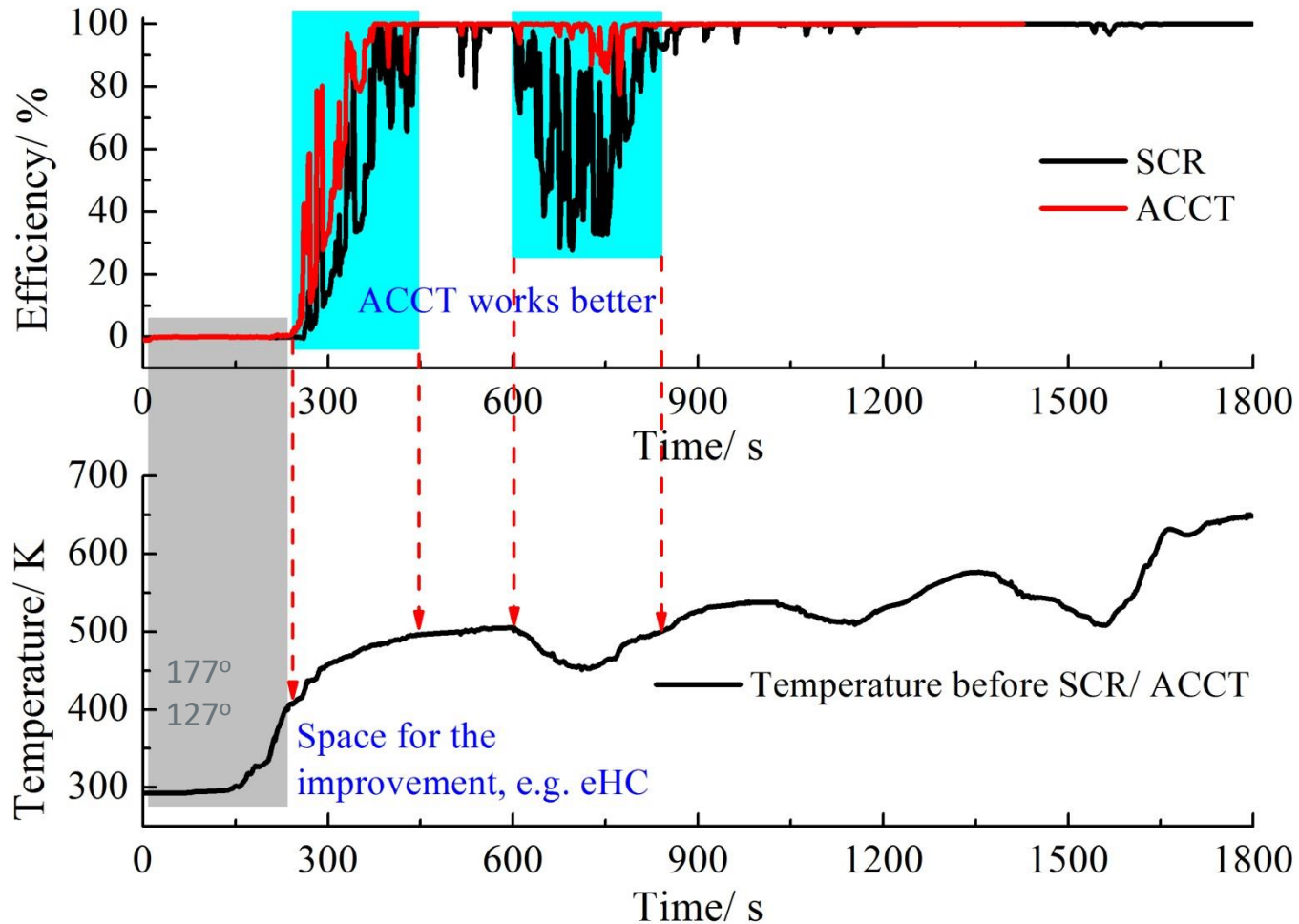
## Vehicle model including after-treatments



1. Emission sources of the vehicle model are based on the emission maps, with the signals of engine speed and torque from powertrain model as inputs.
2. Regarding the baseline vehicle, the original after-treatments include DOC, DPF, and SCR system.
3. When considering retrofit technology ACCT, SCR system will be replaced by ACCT system; other sub-models are kept the same



# Performance comparisons between SCR and ACCT

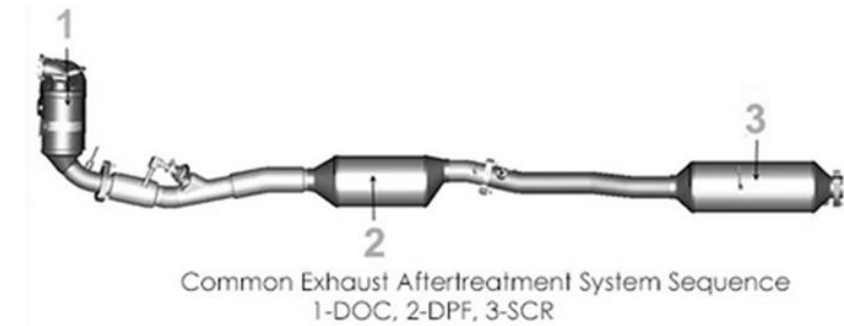


1. NO<sub>x</sub> emissions after SCR and ACCT systems are the same at the first 250s of the WLTC (Worldwide harmonized Light-duty vehicles Test Cycles) which is the warm-up process of the catalyst, where temperature is lower than light-off value at the start of the driving cycle.
2. Compared with SCR, NO<sub>x</sub> emissions drop significantly in the range of 600s ~ 800s for ACCT.
3. Hydrolysis and thermolysis reactions of ACCT fluid are much lower than AdBlue, which causes lower NO<sub>x</sub> emissions for ACCT system during some periods.

# Comparison of after-treatment layouts

NOx emission factors when **SCR** system is adopted

	CO/ g/km	HC+NOx/ g/km	NOx/ g/km
<b>Normal layout</b>	0.012	0.076	0.069
<b>Layout-1</b>	0.012	0.054	0.047
<b>Layout-2</b>	0.024	0.057	0.034



**Euro 6 emission regulations**

Emissions	Limits
CO	0.5 g/km
HC+NOx	0.17 g/km
NOx	0.08 g/km
PM	0.005 g/km
PN	6×10 <sup>11</sup> #/km

NOx emission factors when **ACCT** system is adopted

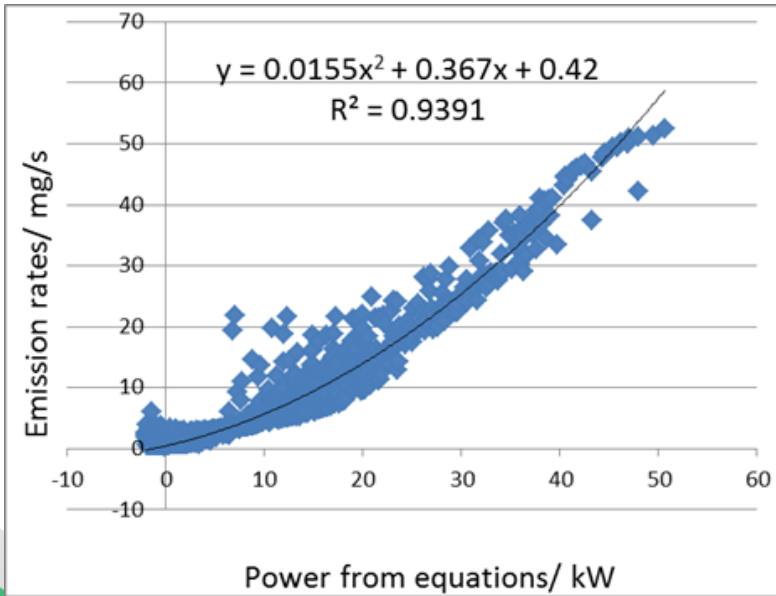
	CO/ g/km	HC+NOx/ g/km	NOx/ g/km
<b>Normal layout</b>	0.012	0.053	0.046
<b>Layout-1</b>	0.012	0.030	0.023
<b>Layout-2</b>	0.024	0.032	<b>0.008</b>

1. CO emission factor is much lower than the emission regulation limits for all the three layouts.
2. The NOx emission factor over normal layout is close to the limits for SCR scenarios.
3. Regarding the total emissions of HC+NOx, layout-1 presents the best performance.
4. Layout-2 has the best performance if future emission regulations care more about NOx emissions.
5. ACCT system performs much better in terms of emission reduction than SCR system.

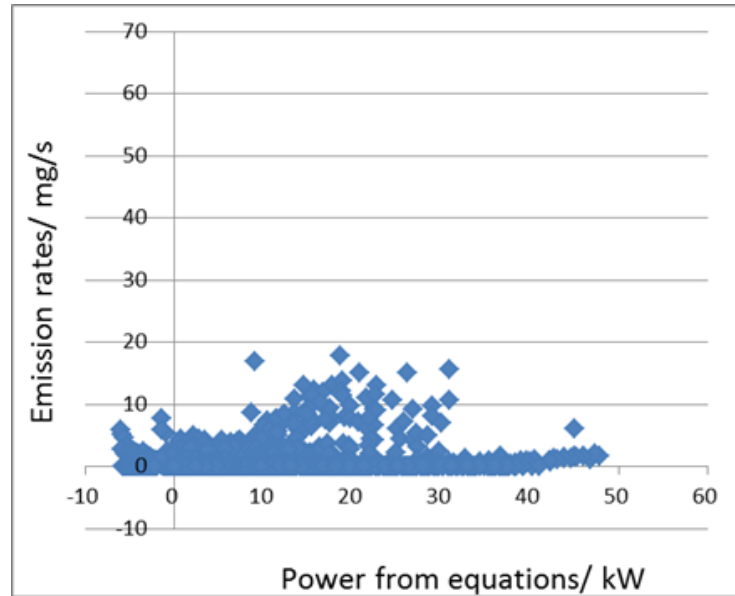


# Performance of retrofits for NOx reduction

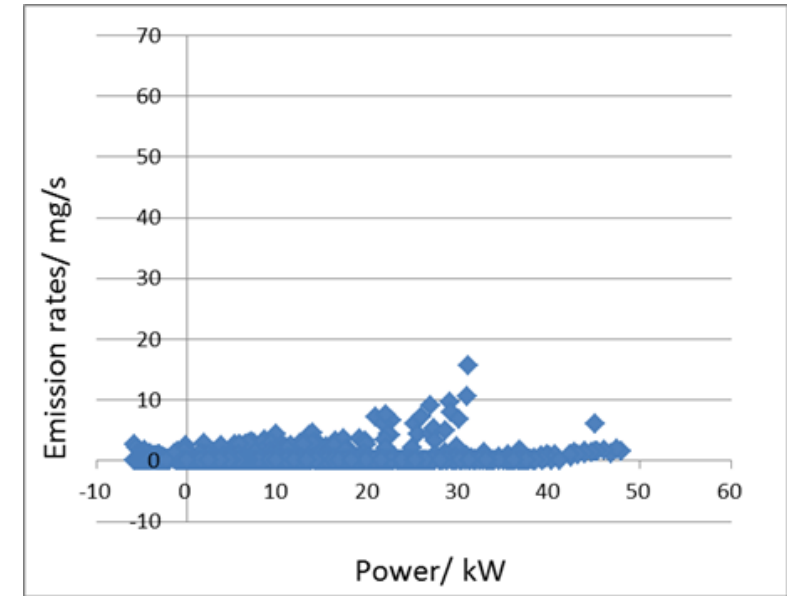
Engine-out NOx



Pipe-out NOx (include cold start)



Pipe-out NOx (exclude cold start)



# Summary and next step

- When the retrofit is up and running, the pipe-out NOx emission is **not significantly affected** by driving behaviour, but the engine-out emission is.
- Both SCR and ACCT are **not efficient for low exhaust temperatures**.
- Detailed analysis and results can be found in **scientific publications**:
  - 1) “The effect of after-treatment techniques on the correlations between driving behaviours and NOx emissions of passenger cars”, *Journal of Cleaner Production* (5-year IF: 8.41), <https://doi.org/10.1016/j.jclepro.2020.125647>.
  - 2) “Impacts of De-NOx system layouts of a diesel passenger car on exhaust emission factors and monetary penalty”, *Journal of Cleaner Production*, under review.
- More work needed to understand how NOx retrofits perform in **real-time** under **different traffic and weather conditions** (e.g. engine-off at traffic lights, stop-and-go, cold start etc.) and on certain vehicles (e.g. hybrids).



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# **NO<sub>x</sub> EMISSION ANALYSIS OF RETROFITTED DIESEL-POWERED BUSES**

Arno Amberla  
Proventia

Mid-term results on the road to low emissions: 28 May 2021

# Overview

Analysis of retrofitted buses with online  
emission monitoring telemetry

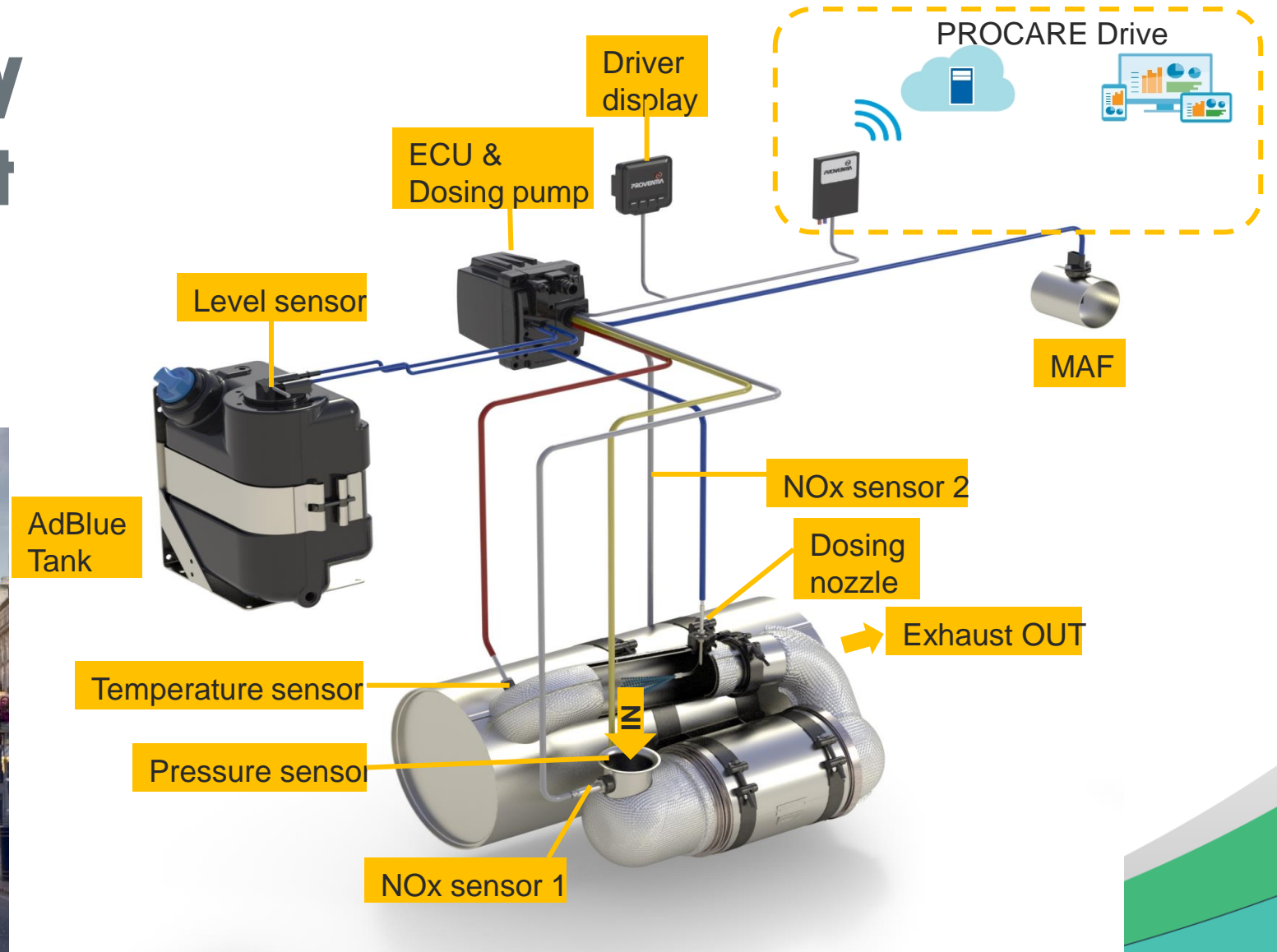
Scope of analysis

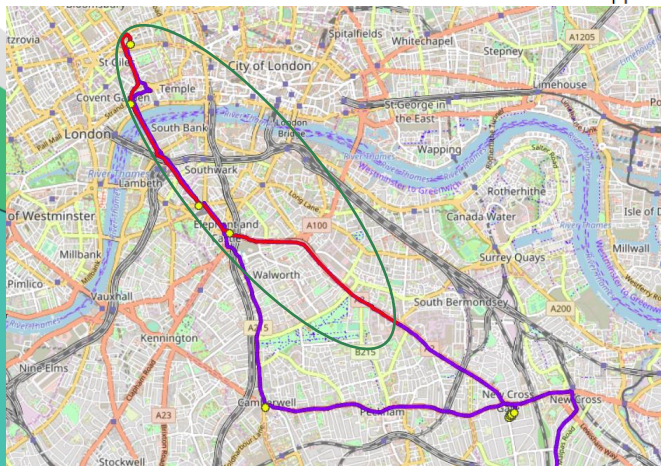
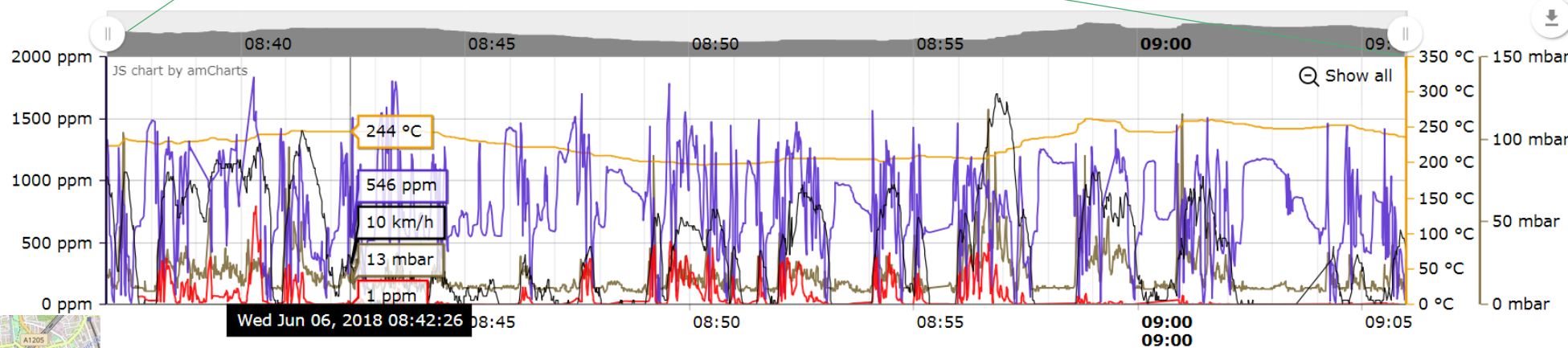
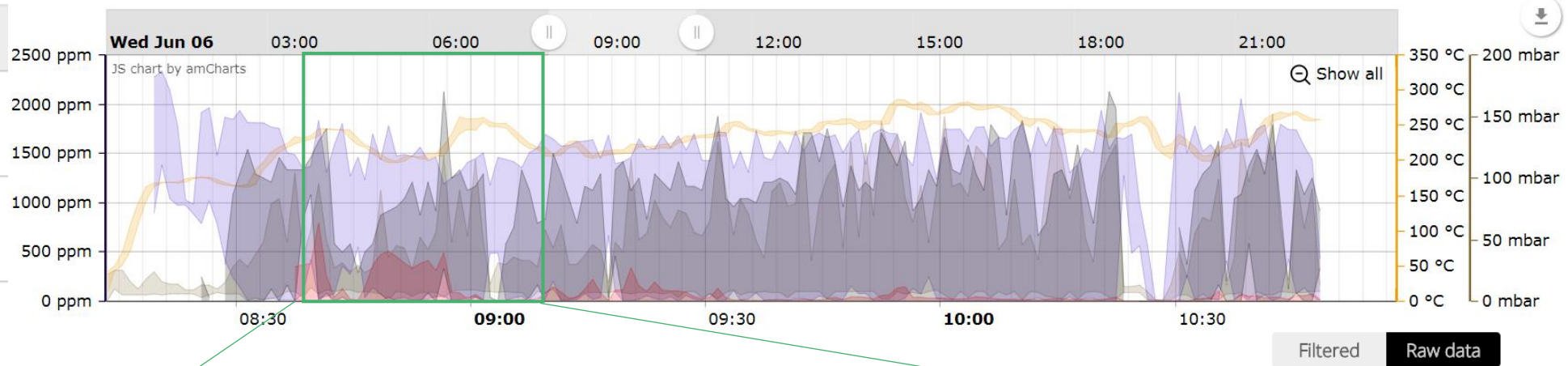
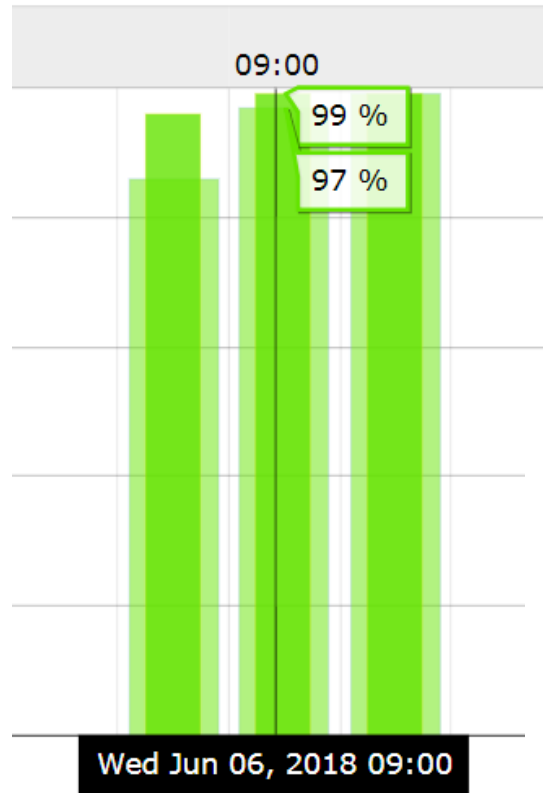
Key findings





# NOxBUSTER® City DPF+SCR Retrofit System





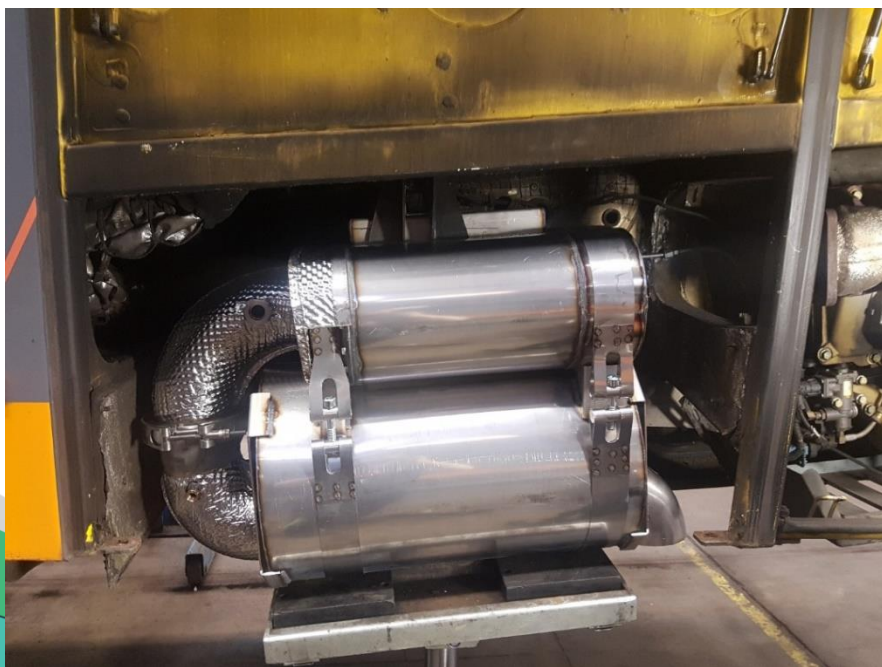
— Backpressure 13 — Exhaust inlet temperature 244 — NOx In ppm 546  
 — NOx Out ppm 1 — NOx In mg/s 35 — NOx Out mg/s 0  
 — Speed 10

Emission monitoring system enables large fleet's to be monitored closely for real drive emission

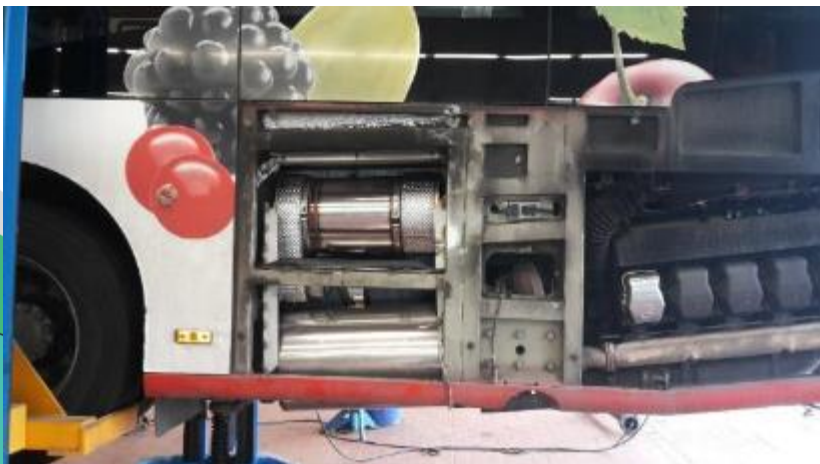
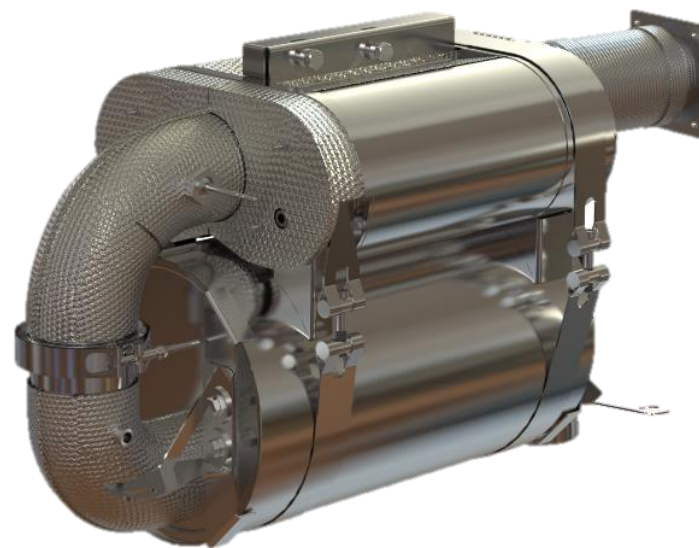
Body type	Manufacturer	Count, n	Total, n
Articulated	MAN	143	266
	Mercedes-Benz	123	
Double-decker	ADL	325	950
	Volvo	241	
	Wrightbus	301	
	VDL	83	
	ADL	284	
Solo	MAN	60	457
	Mercedes-Benz	81	
	Wrightbus	18	
	VDL	14	
	ADL	284	

TOTAL 1673



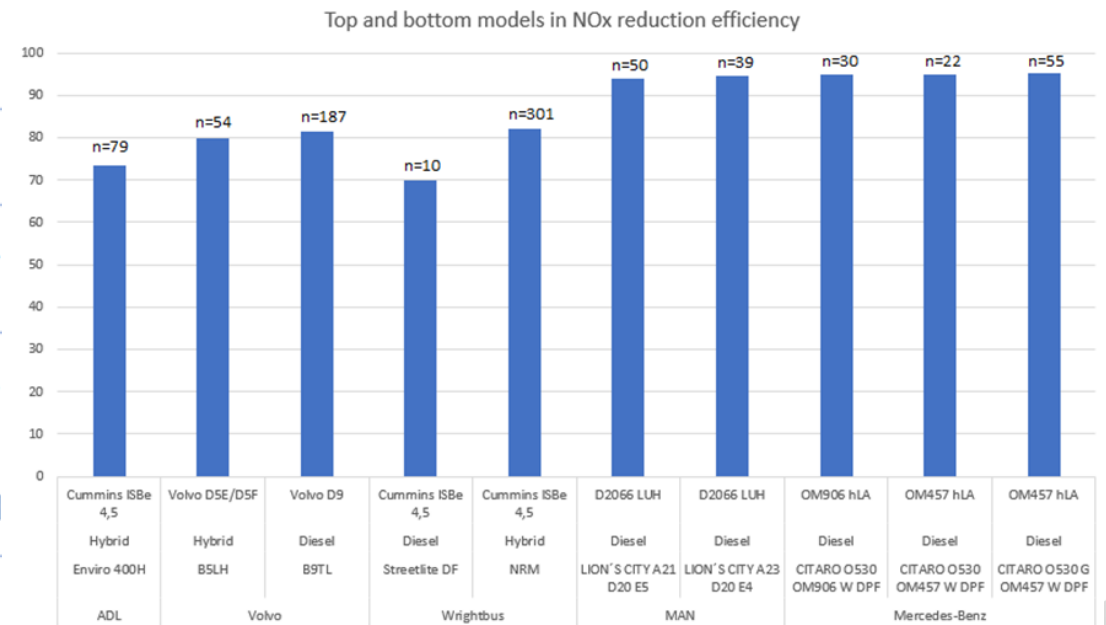


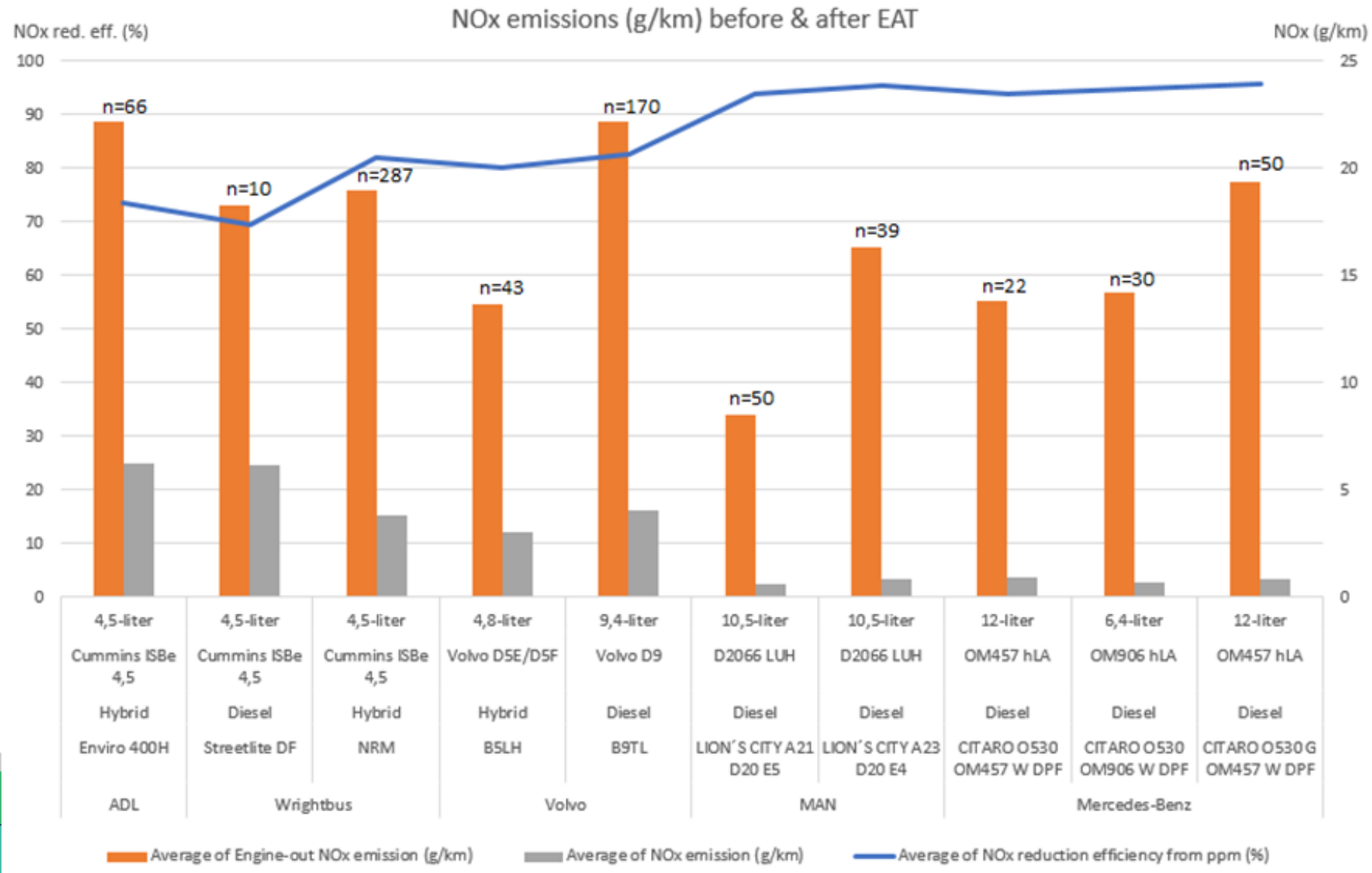


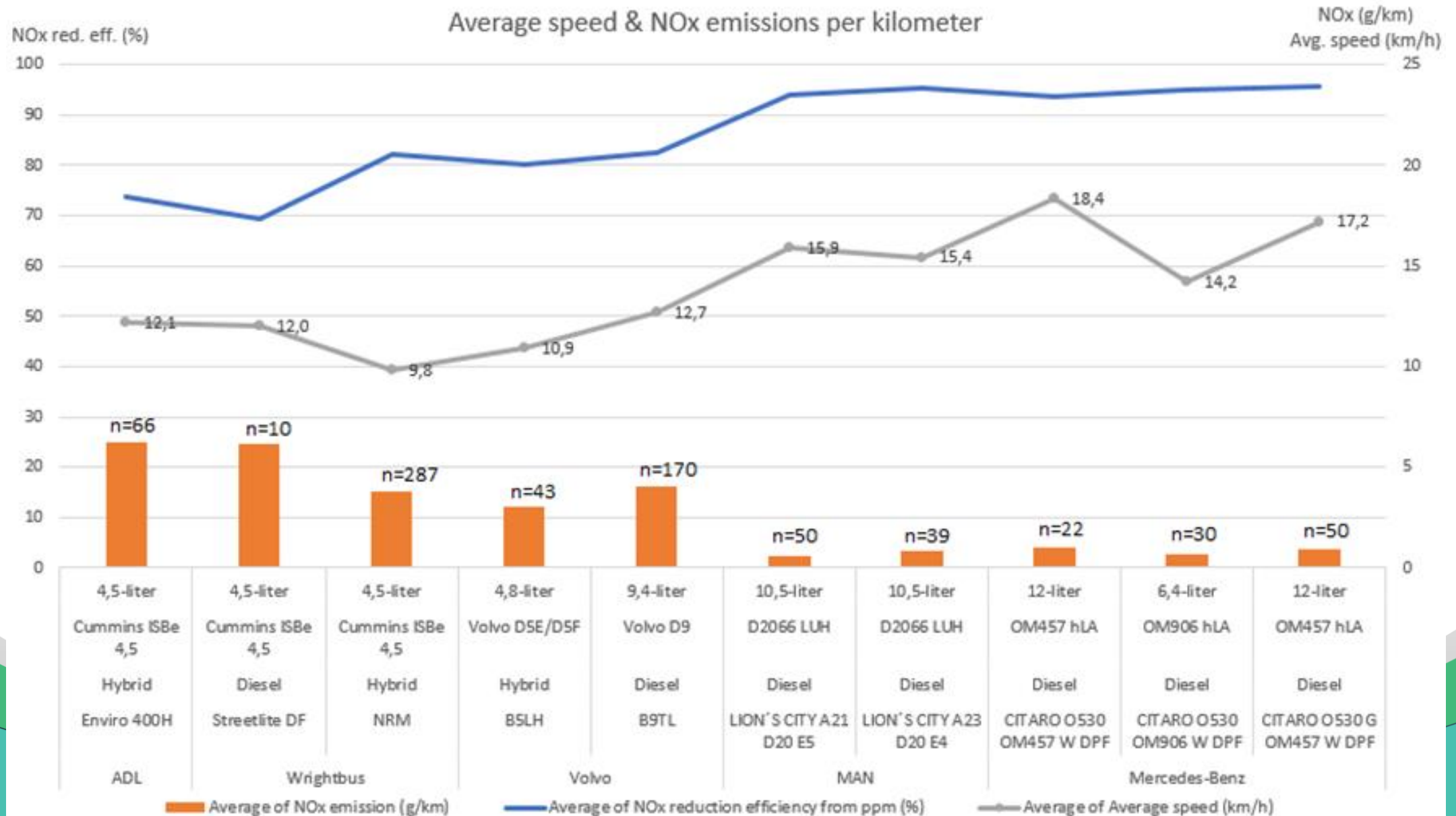


# NOx reduction efficiencies

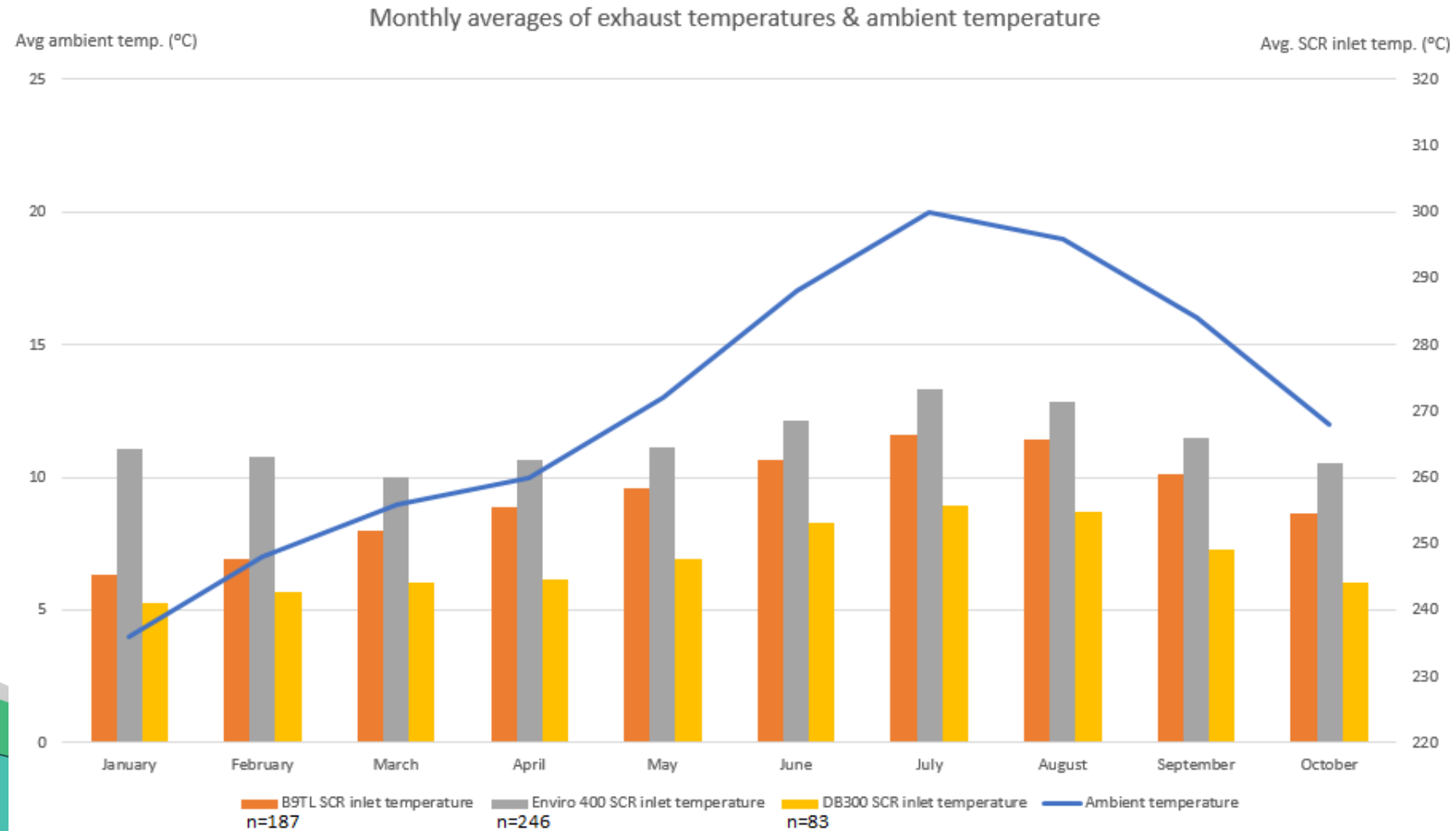
Row Labels	Distinct Count of Fleet Number	Average of NOx reduction efficiency from ppm (%)
<b>Volvo</b>		
⊕ B5LH	54	79,7
⊕ B9TL	188	81,5
<b>Wrightbus</b>		
⊕ Streetlite DF	10	70,0
⊕ NRM	301	82,1
⊕ Streetlite WF	8	89,5
<b>VDL</b>		
⊕ Citea LLE-120	14	85,3
⊕ DB300	83	86,7
<b>ADL</b>		
⊕ Enviro 400H	79	73,5
⊕ Enviro 200	284	83,4
⊕ Enviro 400	246	91,5
<b>Mercedes-Benz</b>		
⊕ CITARO O530 OM457	16	86,6
⊕ CITARO O530 OM457 WO DPF	13	87,2
⊕ CITARO O530 G OM457 WO DPF	68	87,9
⊕ CITARO O530 OM906 W DPF	30	95,0
⊕ CITARO O530 OM457 W DPF	22	95,0
⊕ CITARO O530 G OM457 W DPF	55	95,2
<b>MAN</b>		
⊕ LION'S CITY NG323	24	83,1
⊕ LION'S CITY A21 D20 E4	10	89,8
⊕ LION'S CITY A40 D20 E5	11	92,3
⊕ LION'S CITY A23 D20 E5	61	92,8
⊕ LION'S CITY A23 D28 E3	8	93,6
⊕ LION'S CITY A21 D20 E5	50	93,9
⊕ LION'S CITY A23 D20 E4	39	94,8
<b>Grand Total</b>	<b>1674</b>	<b>86,3</b>





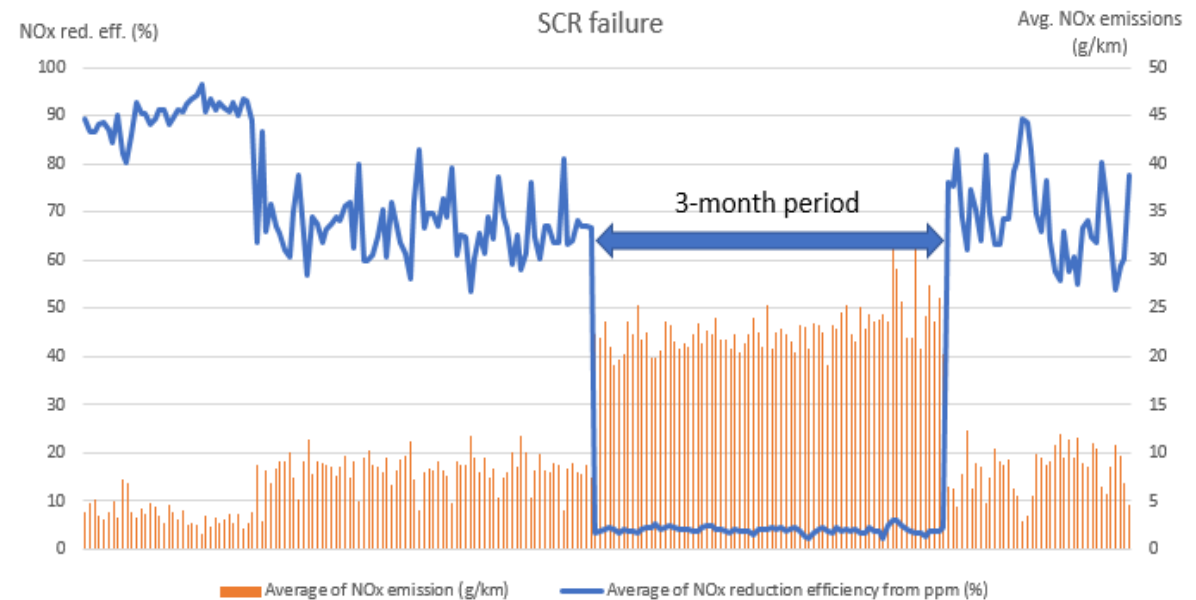
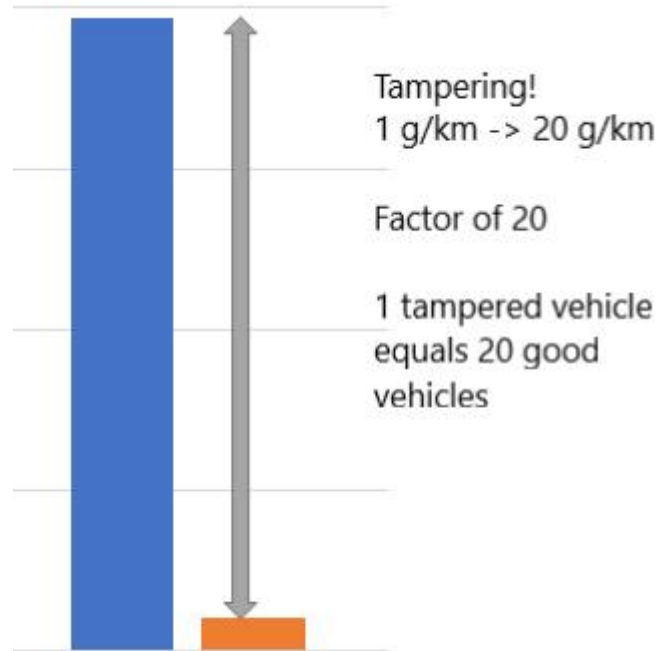


# Influence of ambient temperature





# Maintenance importance



In certain cases tampering has less negative effect, but still in magnitude of x 3...10

# Conclusions

- Retrofitting is effective way to reduce emission of heavy vehicles in cities
- Ambient temperature and exhaust gas temperature have rather direct correlation (10 deg C difference vs 10 deg C difference)
- In this study Euro 5 hybrids were operated at lowest speed routes. Electrification of buses moves these buses to faster lines and efficiency of retrofitted SCR systems improves



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**Thank you**

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# **Tampering and inspection: technical aspects**

Dimitri Margaritis  
CERTH/HIT

Mid-term results on the road to low emissions: 28 May 2021

# Common inspection failures on PTI (periodic technical inspection) (example)

- Over 80 percent of the vehicles on the road have one or more service or repair that is needed, but has not been taken care of
- That translates into over 160 million vehicles in the US alone

Table 1 Common Causes of Inspection Failure—Commercial Vehicles

Vehicle Documents and Miscellaneous Items	Vehicle Body	Vehicle Safety
<ul style="list-style-type: none"> <li>• Missing or incorrect tags</li> <li>• Non-operational HVAC</li> <li>• Damaged or torn upholstery</li> <li>• Unacceptable sanitation</li> <li>• Damaged wheel chair</li> <li>• Damaged lift wheel</li> <li>• Incorrect tag mounting</li> </ul>	<ul style="list-style-type: none"> <li>• Damaged or rusted doors</li> <li>• Damaged and/or rusted quarter panel</li> <li>• Damaged and/or rusted hood</li> <li>• Damaged and/or rusted fenders</li> <li>• Damaged and/or missing bumpers</li> <li>• Damaged and/or missing bumper guards</li> <li>• Incorrect tag mounting</li> <li>• Missing or improper gas cap</li> <li>• Damaged body work</li> </ul>	<ul style="list-style-type: none"> <li>• Missing or damaged mirrors</li> <li>• Missing or damaged horn</li> <li>• Missing or damaged seatbelts</li> <li>• Missing or damaged speedometer</li> <li>• Missing or damaged gear indicator</li> <li>• Missing or damaged safety chains</li> <li>• Missing or damaged chain guard</li> </ul>
Vehicle Lights	Vehicle Glass	Vehicle Suspension
<ul style="list-style-type: none"> <li>• Non-operational signal lights</li> <li>• Non-operational backup lights</li> <li>• Non-operational tail lights</li> <li>• Non-operational stop lights</li> <li>• Non-operational tag lights</li> <li>• Non-operational clearance lights</li> <li>• Non-operational marker lights</li> <li>• Non-operational fog lights</li> <li>• Incorrect lens color</li> <li>• Damaged or missing side reflectors</li> <li>• Damaged or missing rear reflectors</li> <li>• Non-operational headlights</li> <li>• Non-operational indicator lights</li> </ul>	<ul style="list-style-type: none"> <li>• Cracked or damaged windshield</li> <li>• Cracked or damaged side window</li> <li>• Cracked or damaged rear window</li> <li>• Non-operational window controls</li> <li>• Unacceptable window tint</li> <li>• Missing or non-operational wipers</li> <li>• Missing or damaged wiper blades</li> </ul>	<ul style="list-style-type: none"> <li>• Damaged or unacceptable: <ul style="list-style-type: none"> <li>• Kingpin</li> <li>• Shocks</li> <li>• Ball joints</li> <li>• Control arm</li> <li>• Rack and pinion</li> <li>• Tie rod ends</li> <li>• Idler arm</li> <li>• Pitman arm</li> <li>• Sleeve</li> <li>• Springs</li> <li>• Steering box</li> <li>• Steering wheel</li> <li>• Bearings</li> <li>• Steering linkage</li> <li>• Column</li> <li>• Alignment</li> <li>• Power steering</li> <li>• Bellows</li> <li>• CV joints</li> </ul> </li> </ul>
Vehicle Exhaust	Vehicle Tires	Vehicle Brakes
<ul style="list-style-type: none"> <li>• Leaking exhaust</li> <li>• Tampered exhaust</li> </ul>	<ul style="list-style-type: none"> <li>• Unacceptable or worn tire tread</li> </ul>	<ul style="list-style-type: none"> <li>• Worn or warped rotors</li> </ul>

<ul style="list-style-type: none"> <li>• Missing or damaged exhaust converter</li> <li>• Loose exhaust</li> <li>• Flexible piping exhaust</li> <li>• Excessive exhaust noise</li> <li>• Excessive exhaust smoke</li> <li>• Excessive exhaust hydro carbon</li> <li>• Excessive exhaust carbon monoxide</li> </ul>	<ul style="list-style-type: none"> <li>• Unacceptable or cut tire</li> <li>• Mixed tire types</li> <li>• Unacceptable knots and bulges in tires</li> <li>• Over- or under-inflated tires</li> <li>• Visible tire cord</li> <li>• Tire recap/tread front</li> <li>• Missing lug nuts</li> </ul>	<ul style="list-style-type: none"> <li>• Damaged or worn front brakes</li> <li>• Damaged or worn rear brakes</li> <li>• Excessive brake noise</li> <li>• Leaking or damaged master cylinder</li> <li>• Leaking or damaged wheel cylinder</li> <li>• Damaged or non-operational vacuum booster</li> <li>• Non-operational parking brake</li> <li>• Non-operational brake warning light</li> <li>• Incorrectly adjusted pedal reserve</li> <li>• Missing and/or damaged pedal pads</li> </ul>
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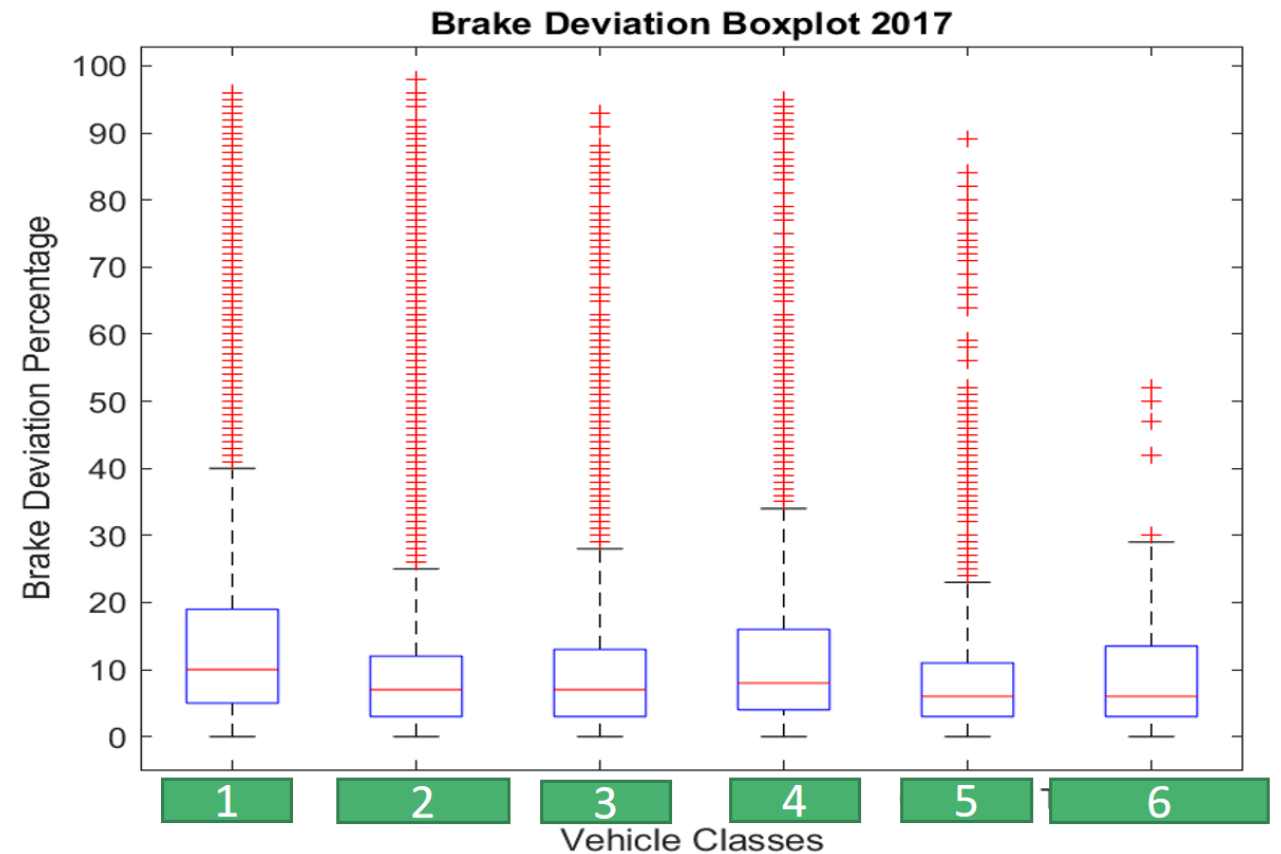
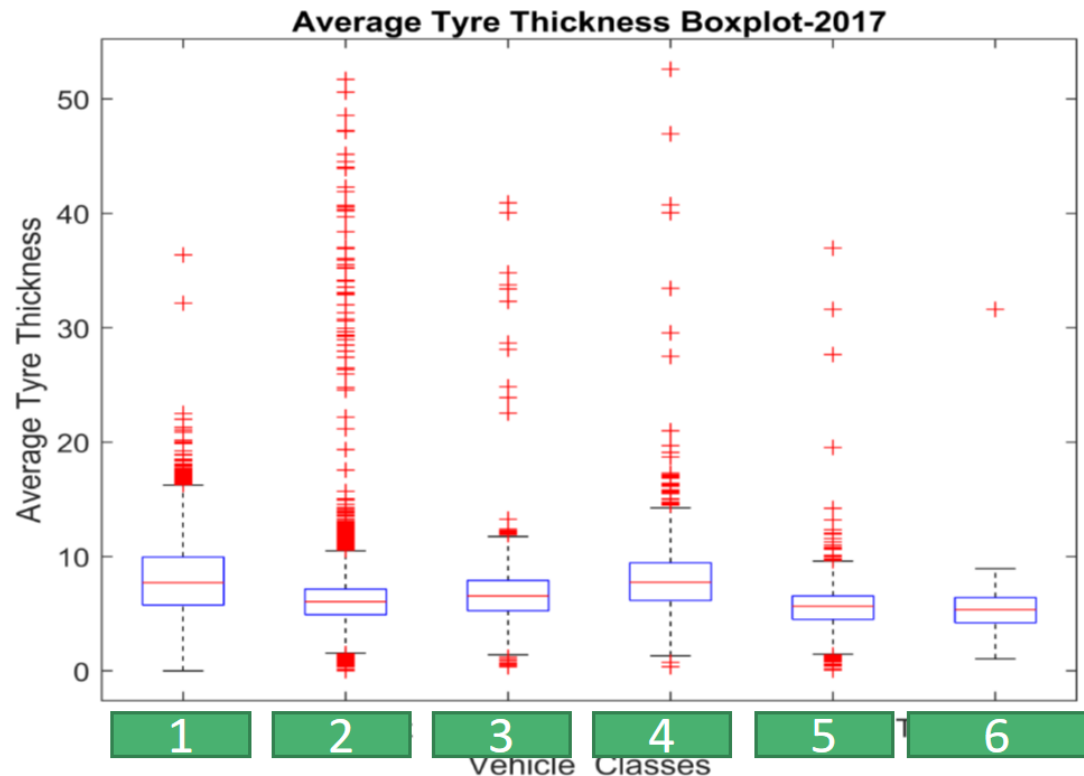
## Tail Pipe Test – Typical causes for failing a tailpipe test include:

- Air to fuel mixture may be incorrect.
- Positive Crankcase Ventilation (PCV) valve may be malfunctioning or missing \*
- Vacuum leak present
- Exhaust Gas Re-Circulation (EGR) may be malfunctioning \*
- Ignition timing may be incorrect
- One or more worn, damaged, or fouled sparkplugs are present
- Catalytic converter is clogged, missing, or ineffective \*
- Malfunctioning oxygen sensor
- Internal engine parts may be malfunctioning or damaged
- Dirty or contaminated engine oil
- Clogged air filter

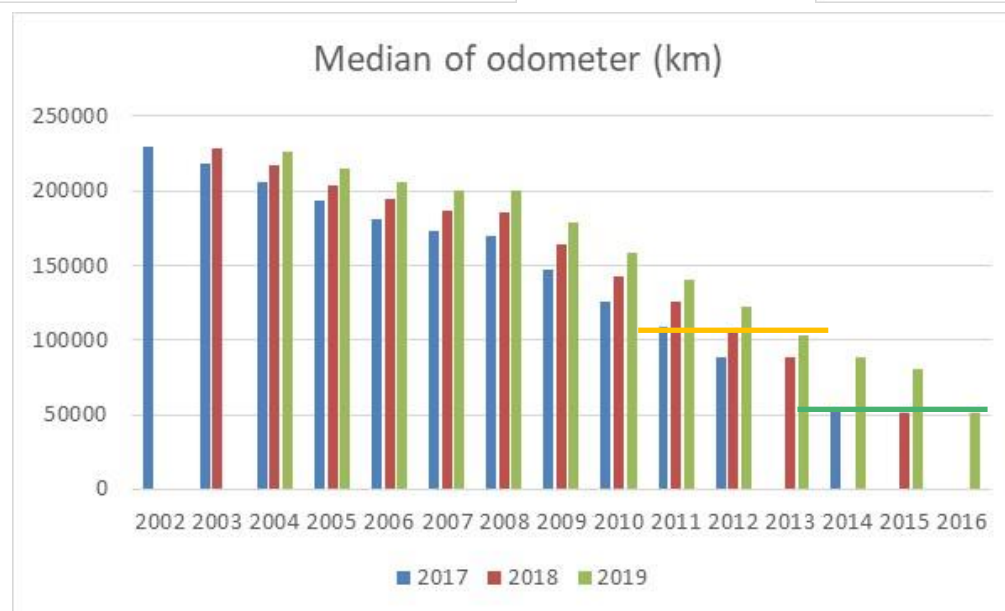
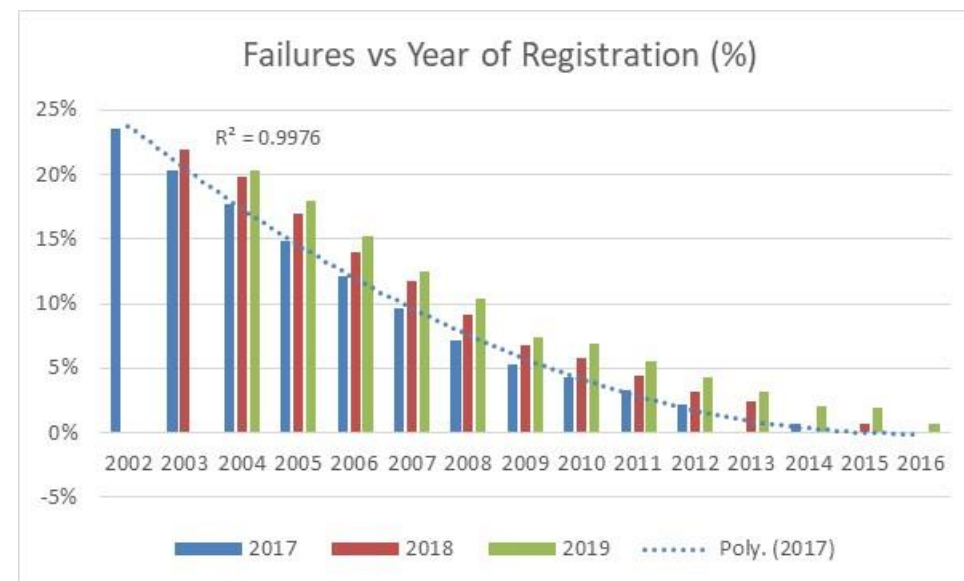
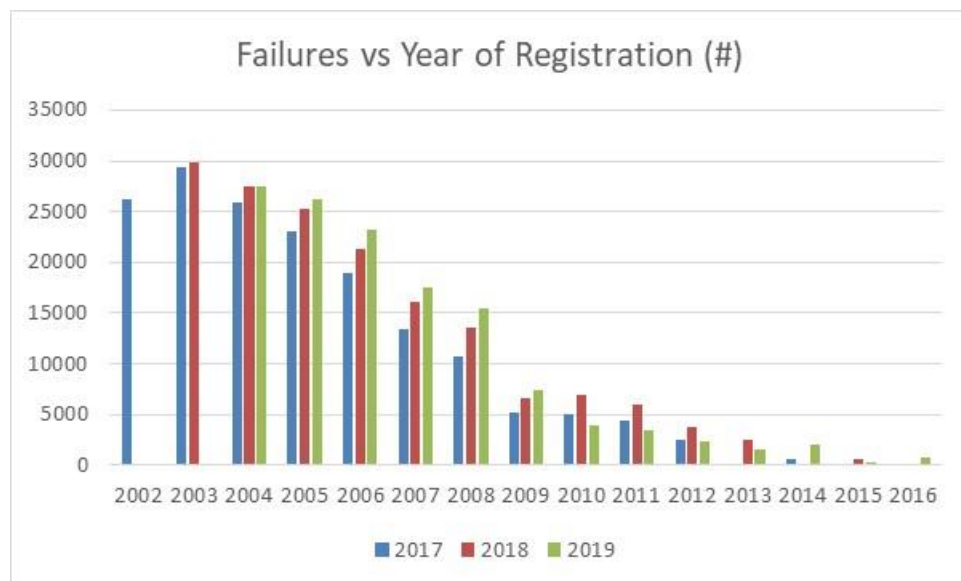
\* Indicates items that may or may not be standard equipment

# Mandatory Periodic Inspection data (example from Turkey)

- Brake and Tyre Inspection database of 2017-2019
- Meta Analysis performed



# Mandatory Periodic Inspection data (example from Finland)



# Tampering techniques for manipulating the EPS

- In general, there are four tampering techniques that used today for manipulating the environmental protection system (EPS)

Tampering technique	Work description
ECU re-flashing	A workshop alters the ECU flash and checks using test drives or dyno tests if any errors or problems arise. In the end, the workshop alters the ECU code in such a way that the requested EPS is deactivated, and no MILs are activated or OBD fault codes are stored. (Mostly LD vehicles)
Emulators	The majority of the emulators offered for HD vehicles are devices that attack the SCR system. Most of these SCR or NOx sensor emulators are CAN only, meaning they only communicate with the vehicle through the CAN-bus.
Modifiers	Specific hardware solutions that are simpler to emulators in design and mainly aim to alter the control state of an EPS
OBD Suppressors	These devices sent specific CAN-bus messages to suppress the onboard diagnostics of the vehicle (by periodically erasing the fault code storage).

# Mandatory Periodic Inspection data: OBD scans

- PTI legislation has introduced an alternative test method where OBD testing is allowed, without any independent assessment
- It is a part of the Roadworthiness Directive 2014/45/EU, where independent emission testing using direct tailpipe measurement (measured at the end of the exhaust), can be replaced with an on-board diagnostic (OBD) test for Euro 6 vehicles
- The OBD system is not an emissions test, but is a diagnostic monitoring of the components that are part of the vehicle emission control system
- An independent study by CITA (International Motor Vehicle Inspection Committee) and with extensive PTI testing evidence from France who have introduced OBD tests, has shown that measurements via the OBD system are not sufficient to ensure that the exhaust emission levels continue to comply with the requirements
- OBD and tailpipe measurement methods are needed to be able to measure the correct functioning of the exhaust control system and for independent testing of the actual vehicle emissions
  - An example, many diesel vehicles have had their particulate filter or the EGR (exhaust gas re-circulation system) modified or removed and the engine management software changed to circumvent the OBD monitoring to avoid performance problems, especially in urban environments

# Maintenance and tampering testing: method

- **Test vehicles sourced amongst VTT employees**
- **First batch: six petrol fueled cars, MY 2006 to MY 2013**
- **Mileages appr. 100 000 to 200 000 km**
- **Driven appr. 20 000 km since last maintenance**
- **Test sequence: cold-start NEDC, warm-start ARTEMIS-Urban**
- **Tests before and after service**
- **Service consists of: change of oil & filter, new air filter, new spark plugs**
- **OBD scan and printout before/after service**

# Basic Test Sequence – Petrol-fuelled Cars



Pre-test: "as is" -condition



Service

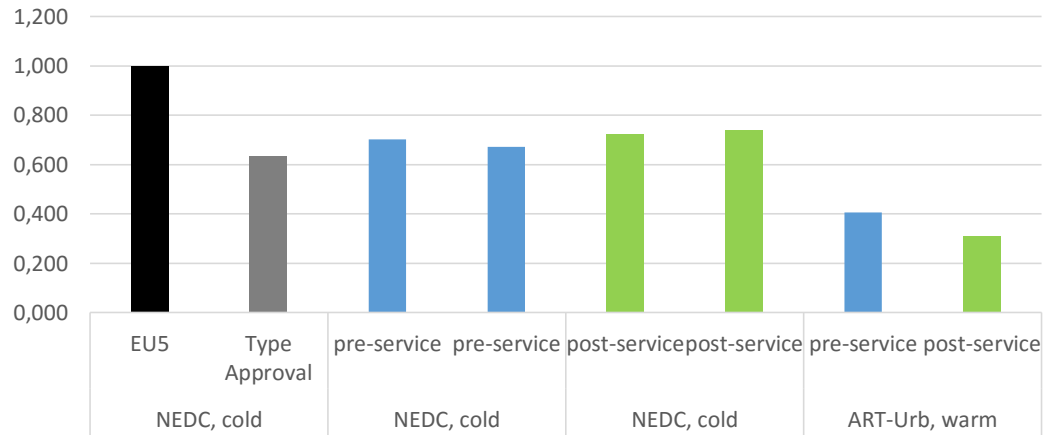


Re-Test

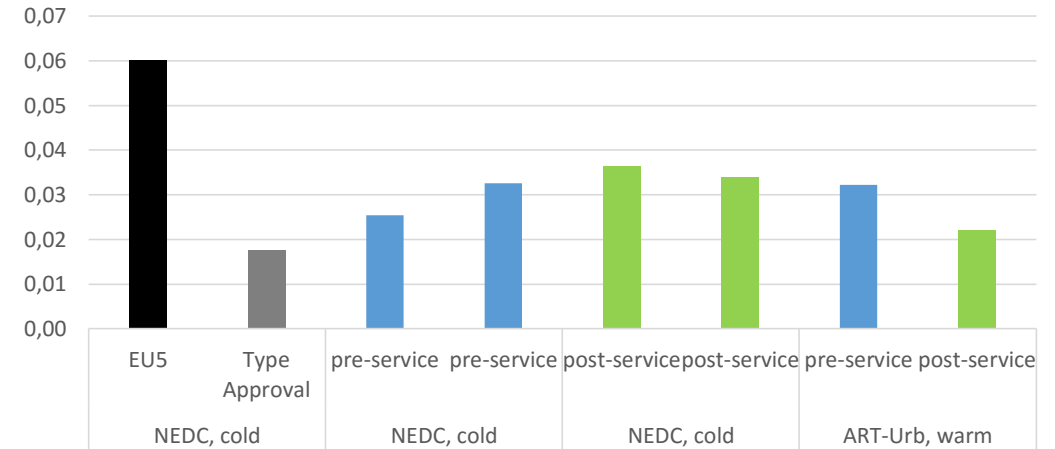


# Preliminary results – CAR B (1/2)

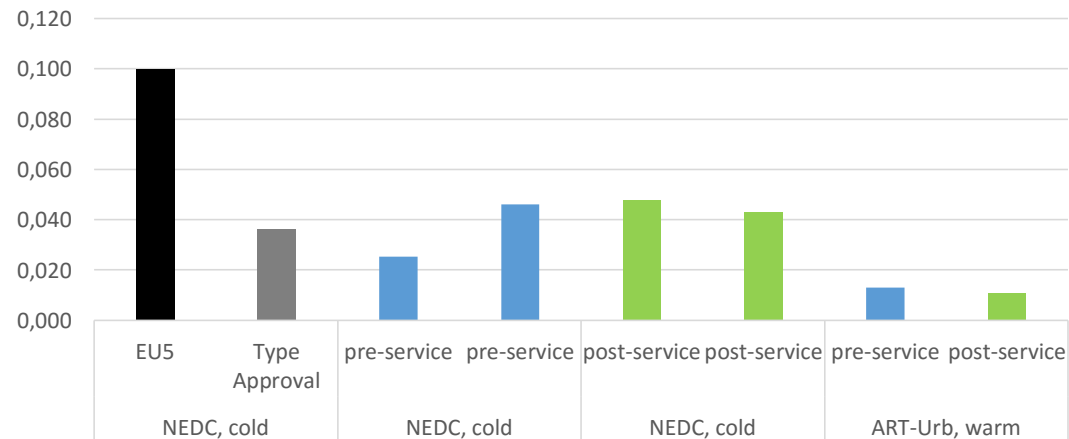
CO (g/km)



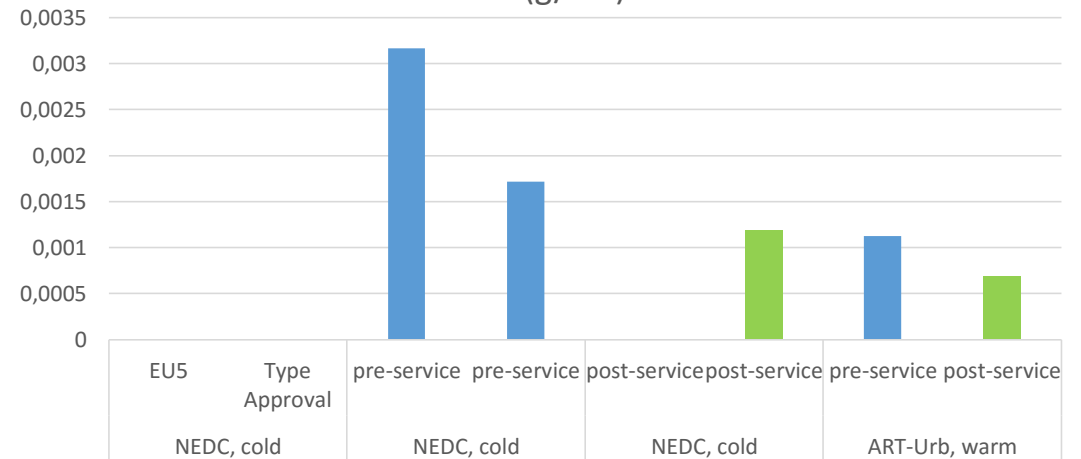
NOx (g/km)



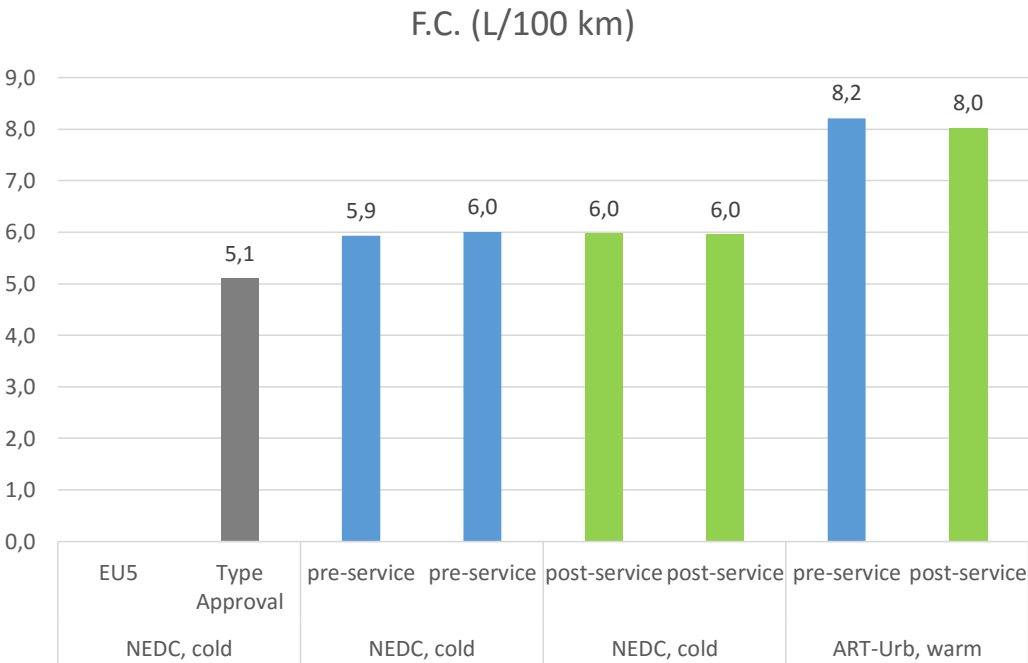
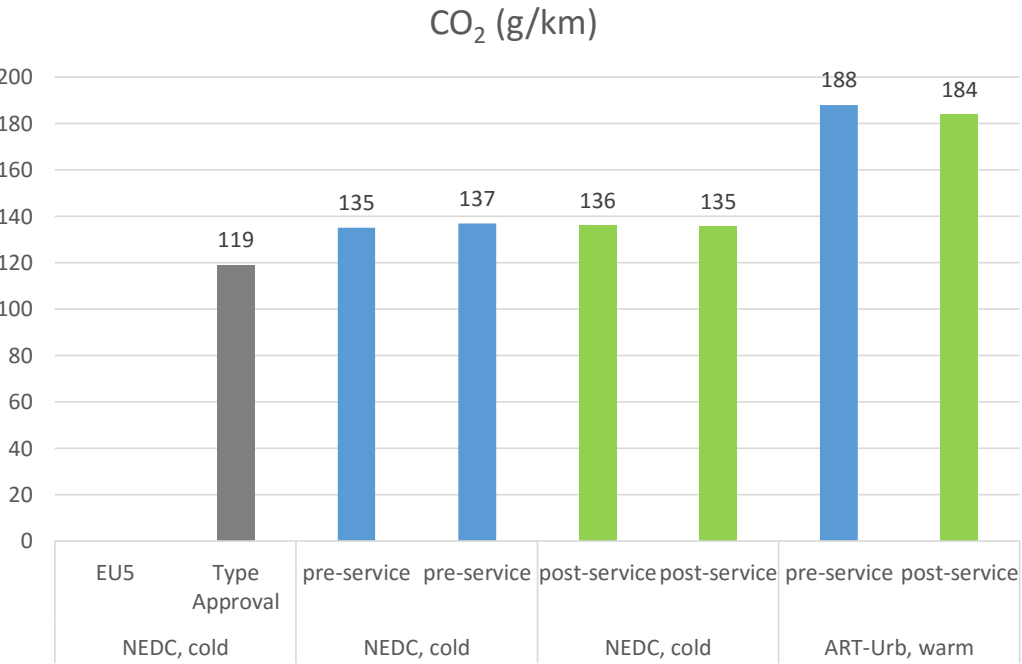
HC (g/km)



PM (g/km)



# Preliminary results – CAR B (2/2)



# Basic Test Sequence – Diesel-fuelled Cars



Pre-test "as is" -condition



Service



1st Re-Test



DPF Cleaning  
or Renewal

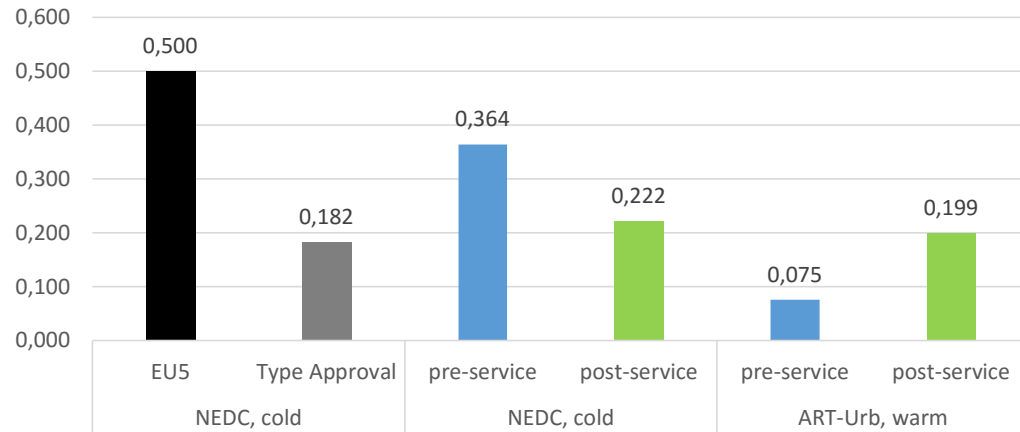


2nd Re-Test

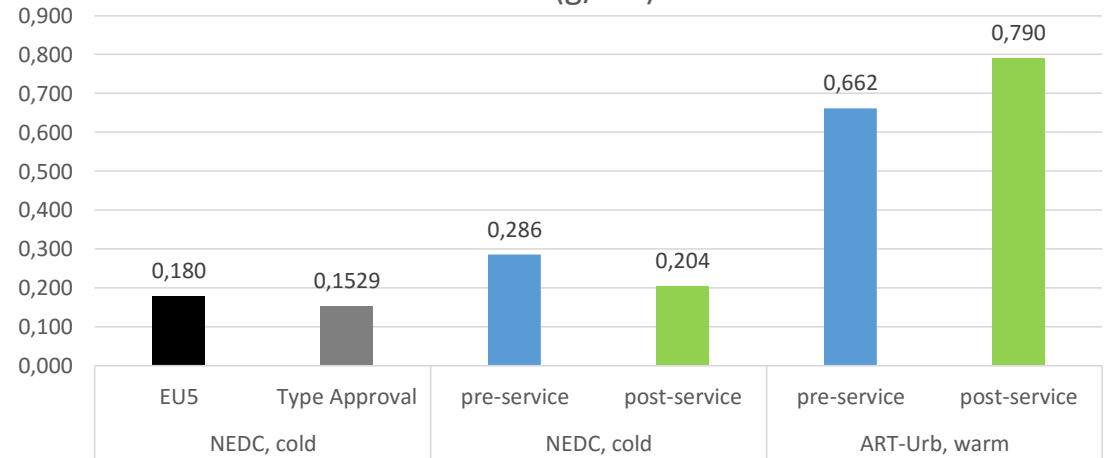
< If PM/PN results show abnormal >

# Preliminary results – CAR G (1/2)

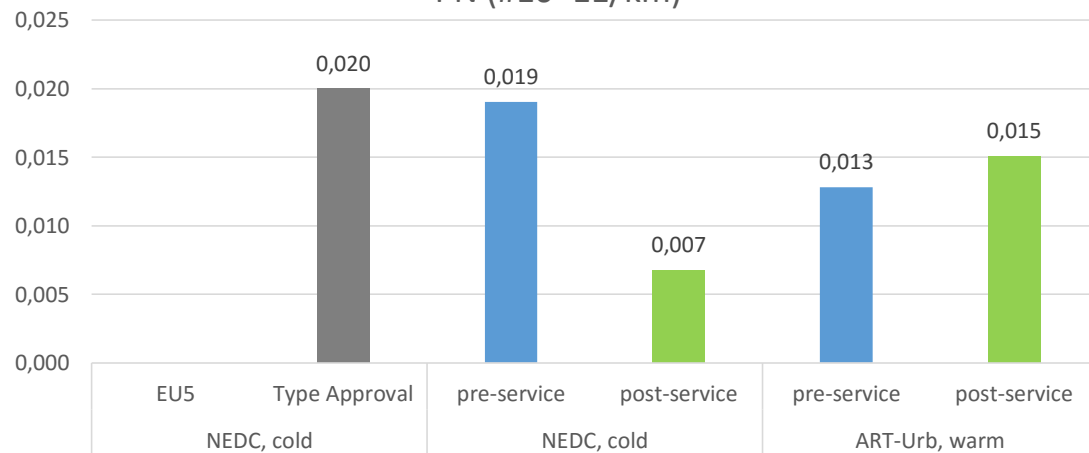
CO (g/km)



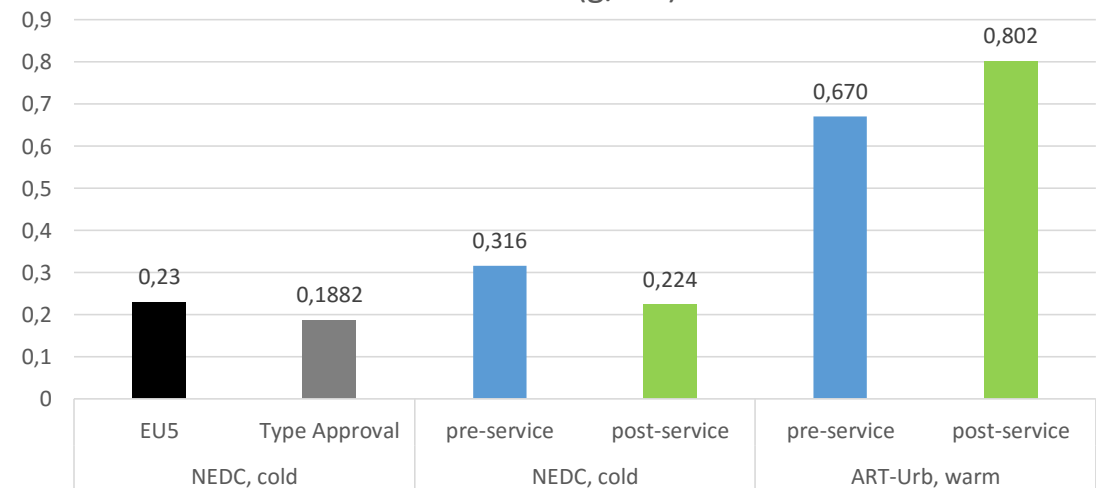
NOx (g/km)



PN (#10<sup>11</sup>/km)

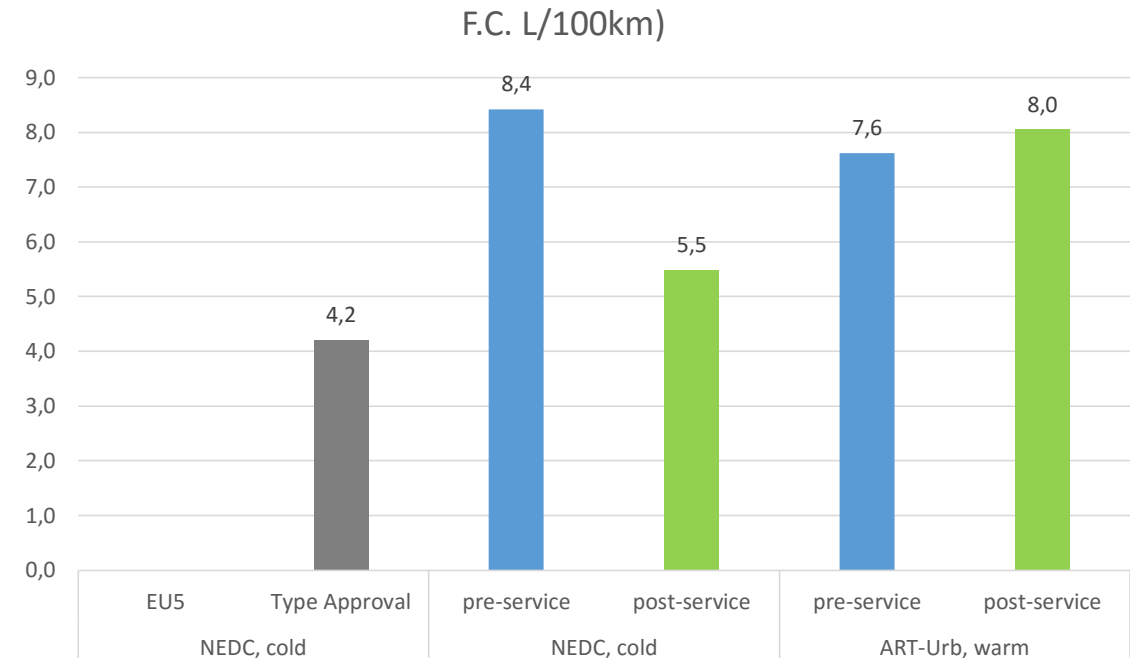
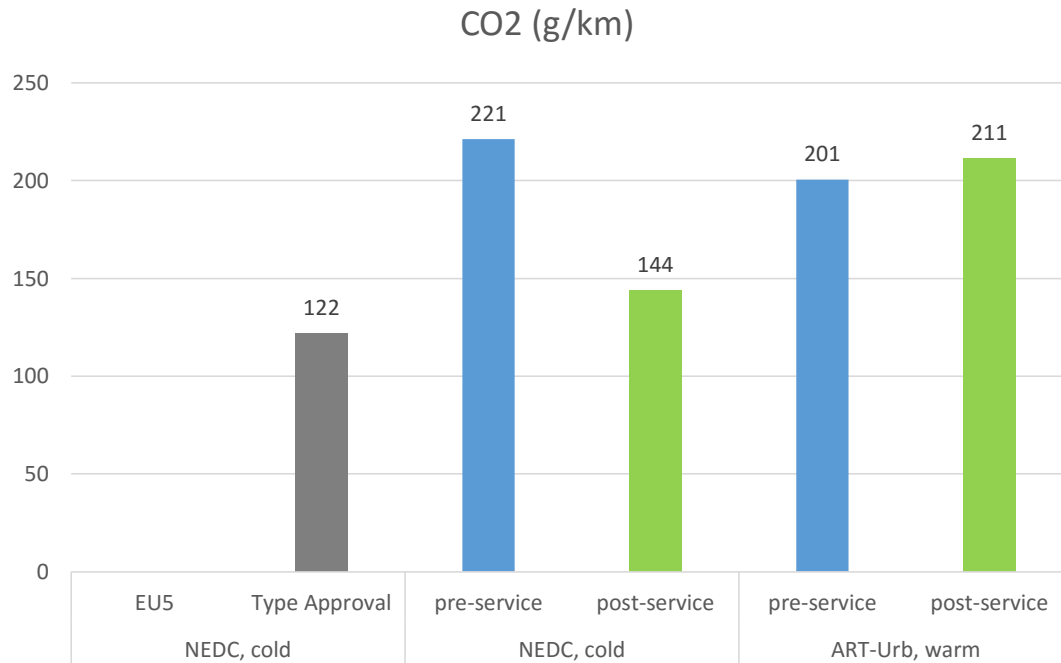


HC+NOx (g/km)

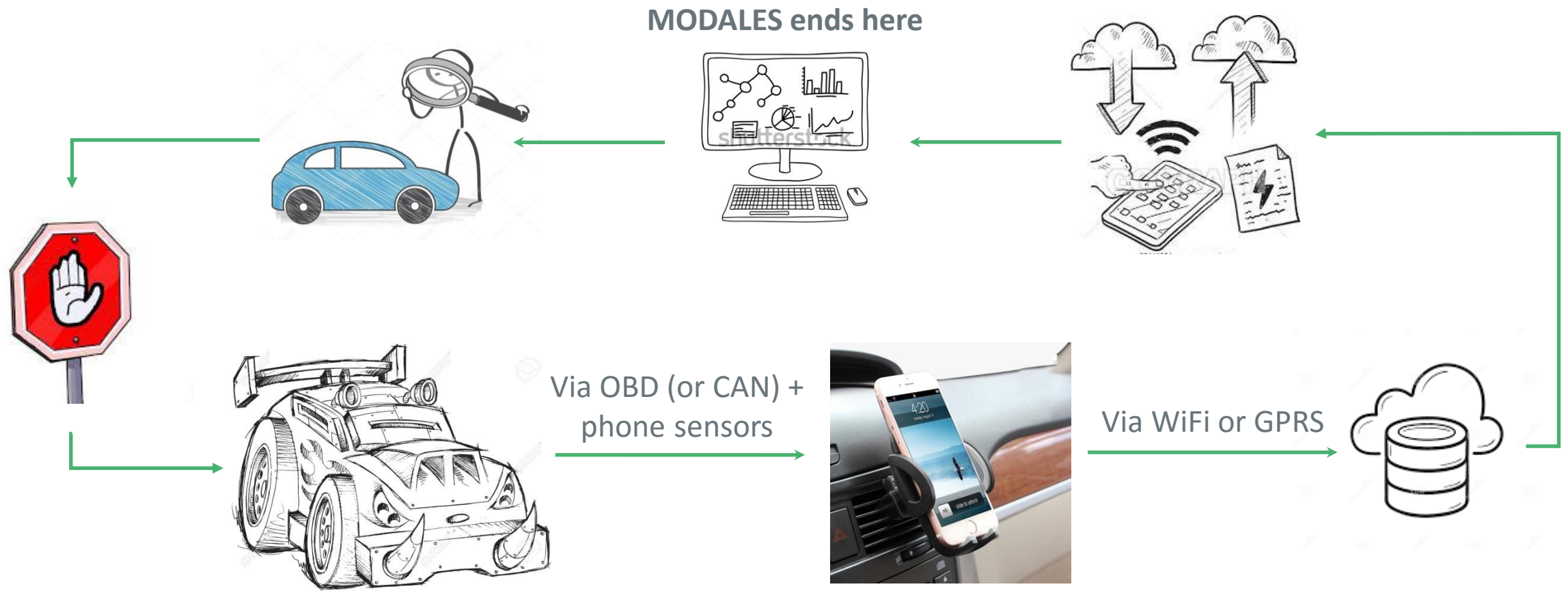


# Preliminary results – CAR G (2/2)

MY2013, 1.6 TDI, DSG7, 291 000 km



# MODALES tampering and poor maintenance registration & reporting solution







**Adapting driver behaviour  
for lower emissions**

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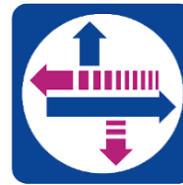
**Thank you**

**Contact:**

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Adapting driver behaviour  
for lower emissions

# Legal issues on tampering

Esther Tenge  
Spark Legal Network

Mid-term results on the road to low emissions: 28 May 2021

# Overview

Methodology

Legal requirements on vehicle tampering

Penalties and sanctions

National strategies and initiatives regarding vehicle tampering

Effectiveness of rules on tampering and enforcement

# Methodology

Research on the legal situation on vehicle tampering across EU Member States

## Data collection

1. Legal desk research in 14 countries (13 EU Member States + UK) carried out by national legal experts
2. Stakeholder survey (EU Survey) sent out to governmental and industry stakeholders, and associations

**Comparative analysis** aimed at identifying the commonalities and contrasts in legislation on vehicle tampering across EU Member States

# Legal requirements on vehicle tampering

EU law on type approval: Defeat devices are generally and explicitly prohibited (tampering is only defined in the context of heavy duty vehicles)

EU law on periodic roadworthiness tests: Member States should consider appropriate measures to prevent adverse manipulation of, or tampering with, vehicle parts and components that could have a negative bearing on required safety and environmental characteristics of the vehicle

National law on vehicle tampering: Few specific national requirements targeting (the prevention of) tampering going beyond EU law

# Legal requirements on vehicle tampering (examples)

## Type approval

- NL: The use of defeat strategies that reduce the effectiveness of emission control equipment (both relating to heavy duty vehicles and light passenger and commercial vehicles) is prohibited
- DE: The German Road Traffic Act prohibits and penalises the *preparation* of offences related to vehicle tampering

## Post-type approval

- FI: A vehicle used in traffic may not be repaired, modified, allowed to change or be equipped with an accessory after commissioning in such a way that the vehicle no longer meets the requirements that were in force in Finland at the time of the vehicle's first commissioning or later
- PL: The Director of the Transport Technical Supervision revokes the type-approval certificate in case of a negative compliance inspection result
- IE: If the emission control system fitted by the manufacturer is absent, modified or obviously defective, this may be recorded as a major deficiency in the context of roadworthiness testing



# Penalties and sanctions (examples)

## **Type approval** (mostly applicable to manufacturers)

- SK: Fine of 300 EUR to 50,000 EUR
- IE: Fine up to 5,000 EUR, a prison sentence of up to 6 months (or both) / fine up to 100,000 EUR, a prison sentence up to 12 months (or both)

## **Post-type approval**

- LU: Imprisonment for eight days to one year and/or fine of 251 to 5000 EUR (Professional sellers may also face a criminal offence)
- FI: Fine of 70 EUR for intentional or negligent vehicle violation / a vehicle violation

# National strategies and initiatives regarding vehicle tampering (examples)

## Access to the mileage history

- SK: Anyone can request a mileage certificate based on information from a national database when giving the VIN number of a vehicle and paying 8 EUR

## Measuring of emissions

- BE: The Walloon Region of Belgium is testing a remote emission measurement equipment along a highway, with an Automatic Number Plate Recognition camera

# Effectiveness of rules on tampering and enforcement

## Awareness of rules

- No official data or research identified at national level
- Media coverage of the topic and/or of the “*Dieseldate*” events could have cause awareness regarding rules on tampering in the Member States to have risen

## Effectiveness of the national rules on tampering

- Studies generally identify national systems as proportionate and globally efficient
- Some gaps in national legislation were identified
- DE: Law prohibits odometer manipulation, but not the sale of manipulation devices

## Effectiveness of the enforcement of rules on tampering

- Issues mostly relate to the lack of severity of the sanctions
- FI: Anti-emission tampering rules are not considered dissuasive enough according to a study



## Thank you

**Contacts:**

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Spark Legal Network

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# modales

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# **Questions / Discussion**

*Moderated by*

**Jean-Charles Pandazis**

ERTICO – ITS Europe

**If you have a question please write it in the chat box**



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for lower emissions**

# **Wrap-up**

**Andrew Winder**

*Project Coordinator*

**ERTICO – ITS Europe**

Mid-term results on the road to low emissions: 28 May 2021



# Next events

13-15 July 2021: **XXI Congreso español sobre Sistemas Inteligentes de Transporte (21<sup>st</sup> Spanish Congress on ITS)**, Madrid and online

- Presentation “**Como reducir las emisiones de vehículos fomentando un estilo de conducción favorable a las bajas emisiones y el buen mantenimiento del vehículo: Experiencia del proyecto MODALES**” by Joan Domingo (RACC) in congress theme 3: Movilidad Conectada (Connected Mobility)
- [www.itsspain.es/xxi-congreso-its](http://www.itsspain.es/xxi-congreso-its)

11-15 October 2021: **ITS World Congress**, Hamburg

- Session accepted/confirmed on “**Intelligent systems to help drivers and road authorities reduce pollutant emissions: Beyond eco-driving**” including the projects MODALES, uCARE, CARES and also from the company HERE
- A technical paper on MODALES from the University of Leeds is also expected
- <https://itsworldcongress.com>

**Targeted webinars on specific topics** will also be organised as appropriate.

To be informed, stay connected to our media (on the next slide)

# Wrap-up

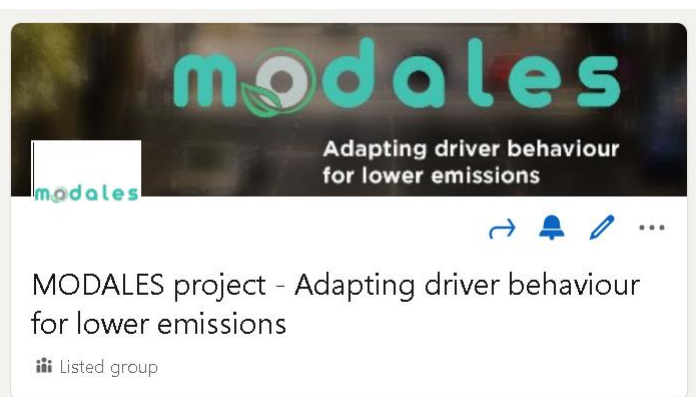
- Presentations will be made available on the project website in the next few days
- The webinar recording will also be made available on YouTube

## Stay connected

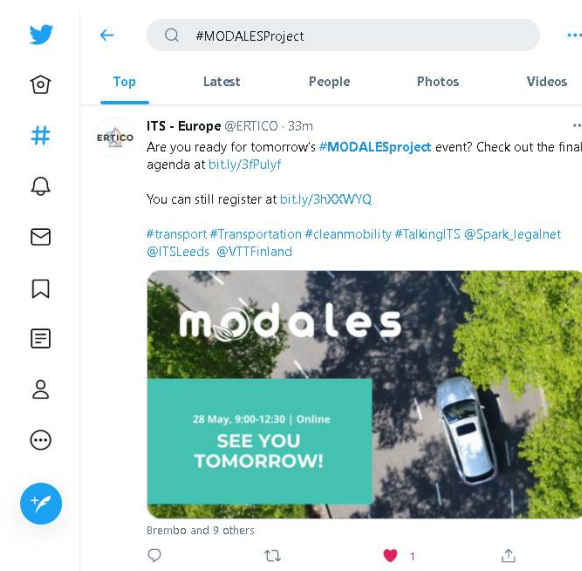
Project website: [www.modales-project.eu](http://www.modales-project.eu)

Contains news, events and a library section including public deliverables and other publications

**LinkedIn**  Join the “MODALES project” group



Search the #MODALESProject hashtag or follow @ERTICO



# Thank you very much for participating!



MODALES General Assembly on board the barge  
“Naiade” in Toulouse, France, January 2020

[www.modales-project.eu](http://www.modales-project.eu)



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