

# Introduction to the LENS project

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**LENS** L-vehicles Emissions and Noise mitigation Solutions

# L-vehicles Emissions and Noise mitigation Solutions

- Horizon Europe project
- 09/2022 → 08/2025
- 15 partners
  - R&D providers
  - Academia
  - OEM



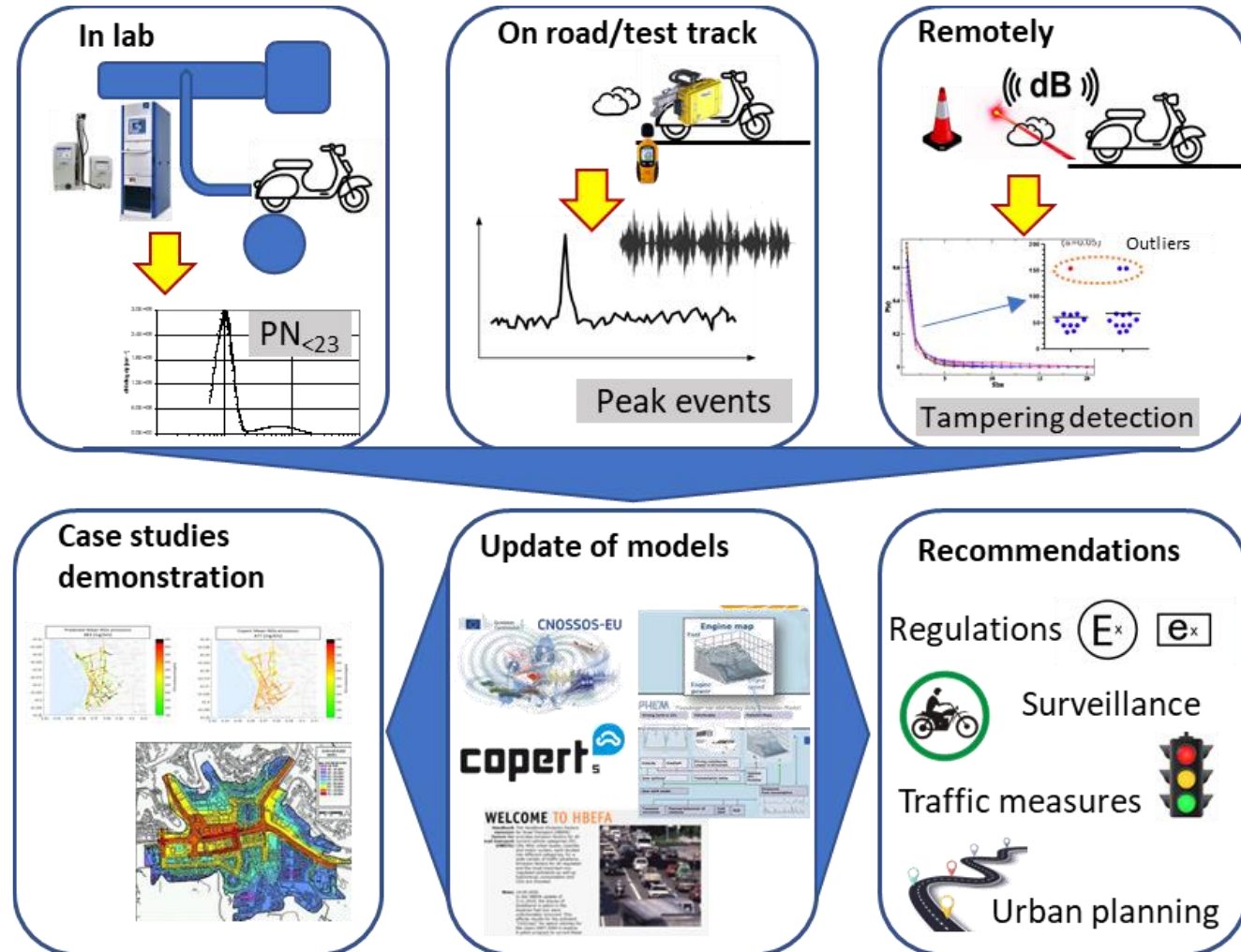
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# LENS objectives

	What	Why
1	Develop LVs emission & noise measurement techniques	<ul style="list-style-type: none"><li>→ To measure emissions &amp; noise</li><li>→ Real-world conditions</li><li>→ Cost-effectively</li></ul>
2	Characterize noise & pollutant emissions performance of LVs	<ul style="list-style-type: none"><li>→ Understand current fleet emissions</li><li>→ Non-regulated pollutants</li><li>→ High emitters?</li><li>→ Feed emission inventories (COPERT, HBEFA, etc.)</li><li>→ Feed noise inventories (TRANECAM, etc.)</li></ul>
3	In-field identification of tampered LVs	<ul style="list-style-type: none"><li>→ Understand the extend of the problem</li><li>→ Provide tools and methods able to capture tampered vehicles in the field.</li></ul>
4	Provide recommendations for decreasing noise and pollutants from LVs, and expected impact	<ul style="list-style-type: none"><li>→ Inform regulators, national, local authorities on how emissions and noise from LVs can be decreased</li></ul>











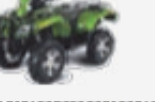

# LENS Methodology

- In lab emissions measurements
- On road emissions measurements
- On track noise measurements
- On road noise measurements
- Remote sensing & tampering detection
- Update models
- Recommendations for pollutants & noise reduction
- Demonstrate reductions in 3 case studies



# Vehicle testing campaign

- Fleet selection: Representative of current EU fleet
  - Euro 1 – Euro 5
  - All categories (L1e – L7e)
  - Priority to most common ones (sales)
- Pollutant emissions: 150 LVs
  - On-road (112 LVs)
  - Lab on a dyno, TA & RDC (60 LVs)
- Noise emissions: 164 LVs)
  - On-road (14 LVs)
  - On track, TA & Real-world pattern (150 LVs)

L1e	L1eB - Two-wheel moped	
L2e	3-wheel moped	
L3e & L4e	L3e-A1 Low-performance	
	L3e-A2 Medium-performance	
	L3e-A3 High-performance	
	L3e-AxE Enduro	
L5e Tricycle		 
L6e	L6e-A Light on-road quad	
	L6e-B Light quadri-mobile	
L7e	L7e-B1 All terrain quad	
	L7e-B2 Side By Side Buggy	




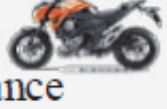








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# Vehicle testing campaign

- Fleet selection: Representative of current EU fleet
  - Euro 1 – Euro 5
  - All categories (L1e – L7e)
  - Priority to most common ones

## Status:

- Pollutant emissions: 150 LVs → 73% finished
  - On-road (112 LVs) → 63% finished
  - Lab on a dyno, TA & RDC (60 LVs) → 83% finished
- Noise emissions: 164 LVs) → 32% finished
  - On-road (14 LVs) → 64% finished
  - On track, TA & Real-world pattern (150 LVs) → 25% finished

L1e	L1eB - Two-wheel moped	
L2e	3-wheel moped	
L3e & L4e	L3e-A1 Low-performance	
	L3e-A2 Medium-performance	
	L3e-A3 High-performance	
	L3e-AxE Enduro	
L5e Tricycle		 
L6e	L6e-A Light on-road quad	
	L6e-B Light quadri-mobile	
L7e	L7e-B1 All terrain quad	
	L7e-B2 Side By Side Buggy	

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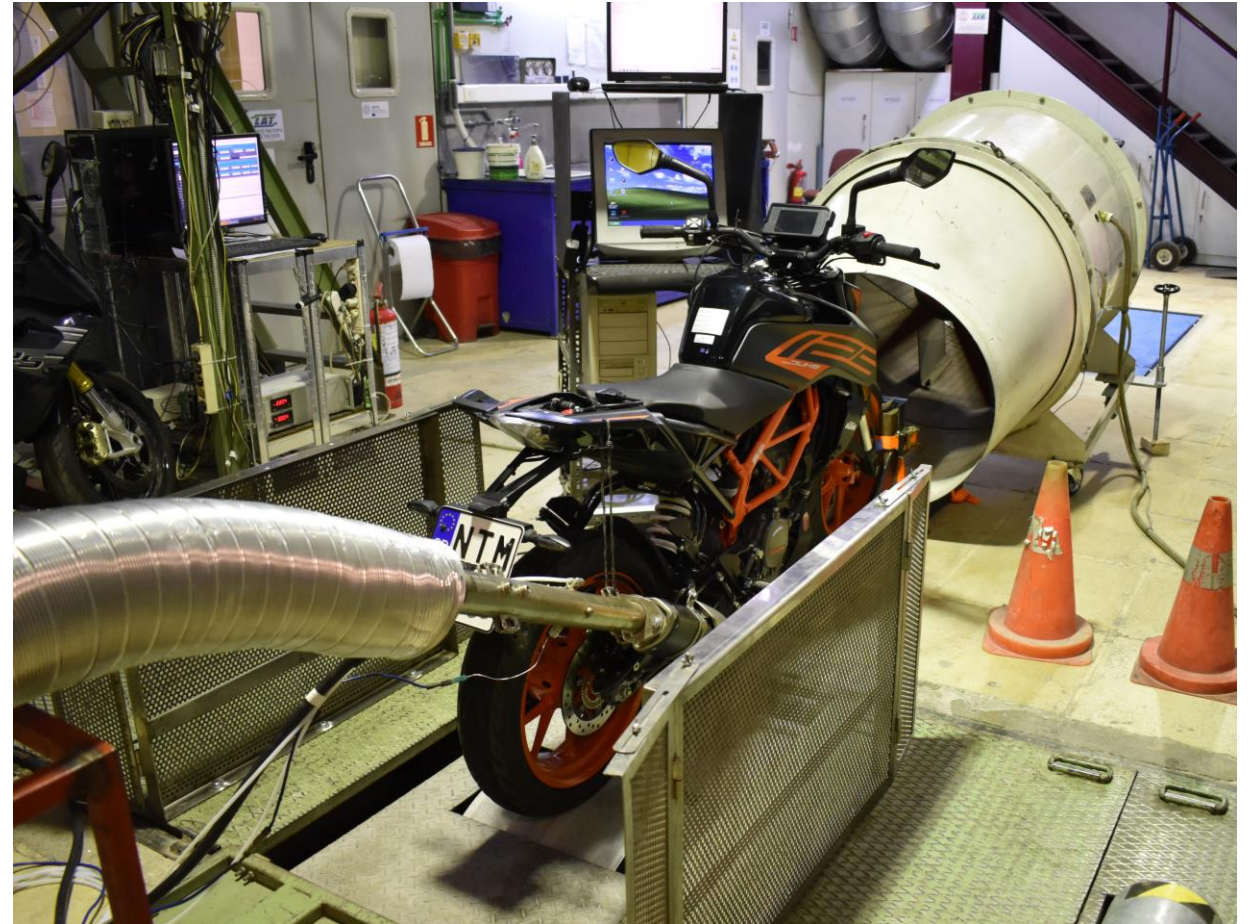
# On track noise testing

- Noise TA testing on ISO certified track
- Noise testing of Real-world patterns on track
- Real-world patterns derived from on road noise measurements.
- Testing partners:
  - IKA RWTH
  - IDIADA
  - TUG

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# Pollutant emissions testing – In lab

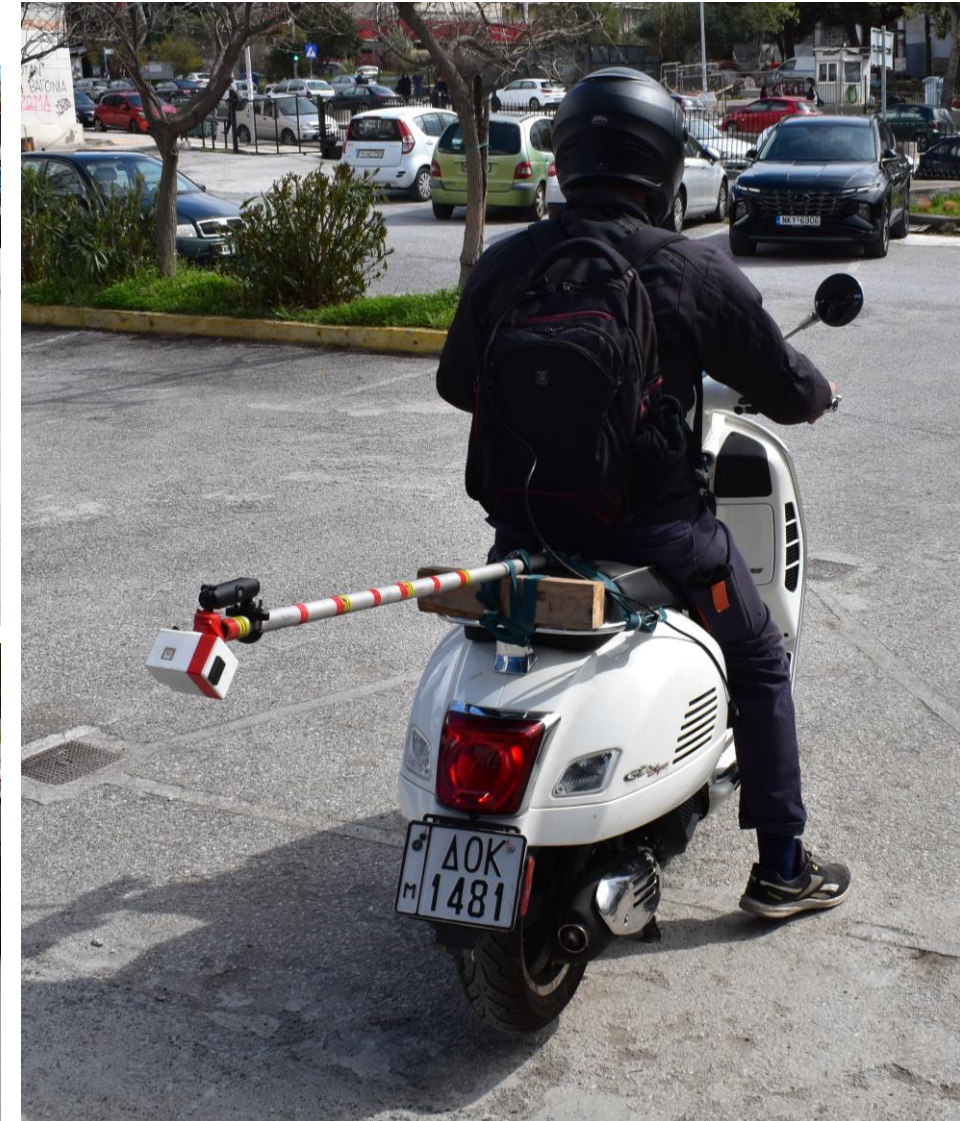
- Motorcycle dyno with CVS system
- Driving cycles: official WMTC & real-world alike RDC (Real Driving Cycle)
- Regulated pollutants: PM, CO, CO<sub>2</sub>, NO<sub>x</sub>, HC
- Non-regulated gaseous pollutants: NH<sub>3</sub>, N<sub>2</sub>O, etc.
- PN: 23nm, 10nm, 2.5nm, Solid & total
- Testing labs:
  - EMISIA/LAT
  - TUG
  - IFPEN
  - IDIADA
- Round-robin with 2 motorcycles in all labs → **DONE**





# On road noise testing

- On-board noise measurement device
- ECU data recorder (OBD)
- Locations:
  - IKA RWTH – Aachen
  - EMISIA – Thessaloniki
  - TUG – Gratz
  - IDIADA – Barcelona
  - IFPEN – Paris



# On road pollutant emissions testing

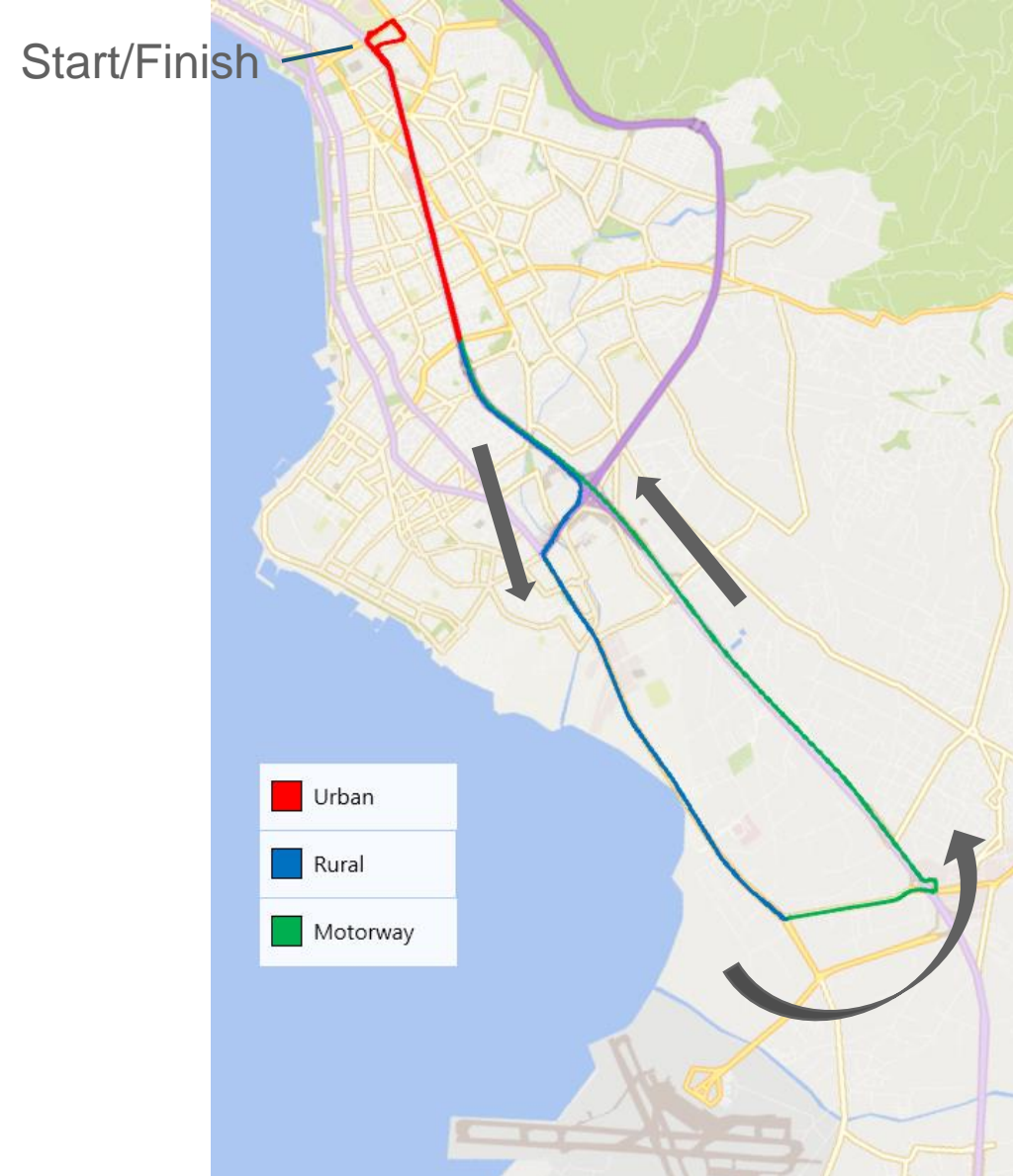
- Portable emission measurement equipment
- GPS
- ECU data recorder (OBD)
- Locations:
  - EMISIA – Thessaloniki
  - TUG – Gratz
  - IDIADA – Barcelona
  - IFPEN – Paris
  - CZU – Prague



# On road trips

- Standard RDE trip (20-60 min)
  - Cold starting
  - Casual driving
  - Urban, Rural & Motorway (not for L1,L2,L3-A1)
- Extreme RDE trip (20-60 min)
  - Cold starting
  - Strong accelerations, including from standstill
  - Engine revving
  - Engine RPM fluctuations,
  - Constant max speed (mopeds)
  - Backfire
  - Acceleration – Deceleration transition.

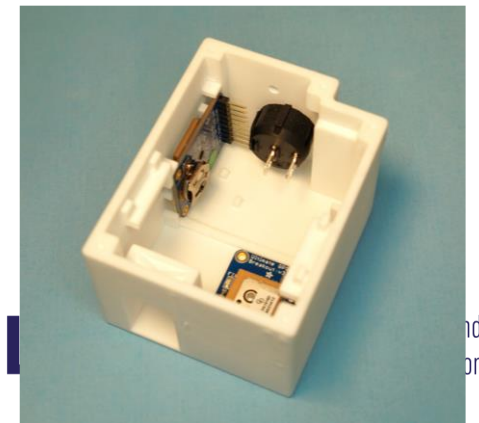
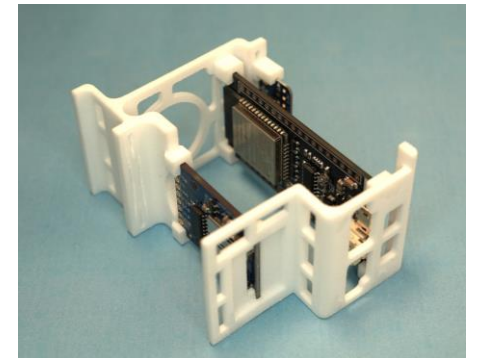
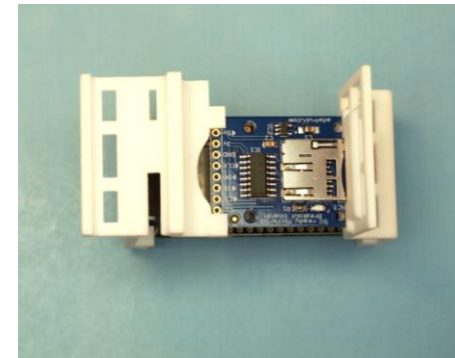
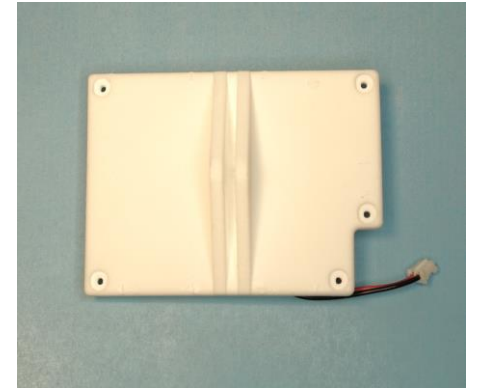
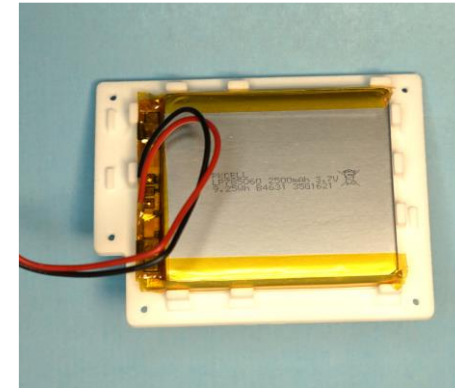
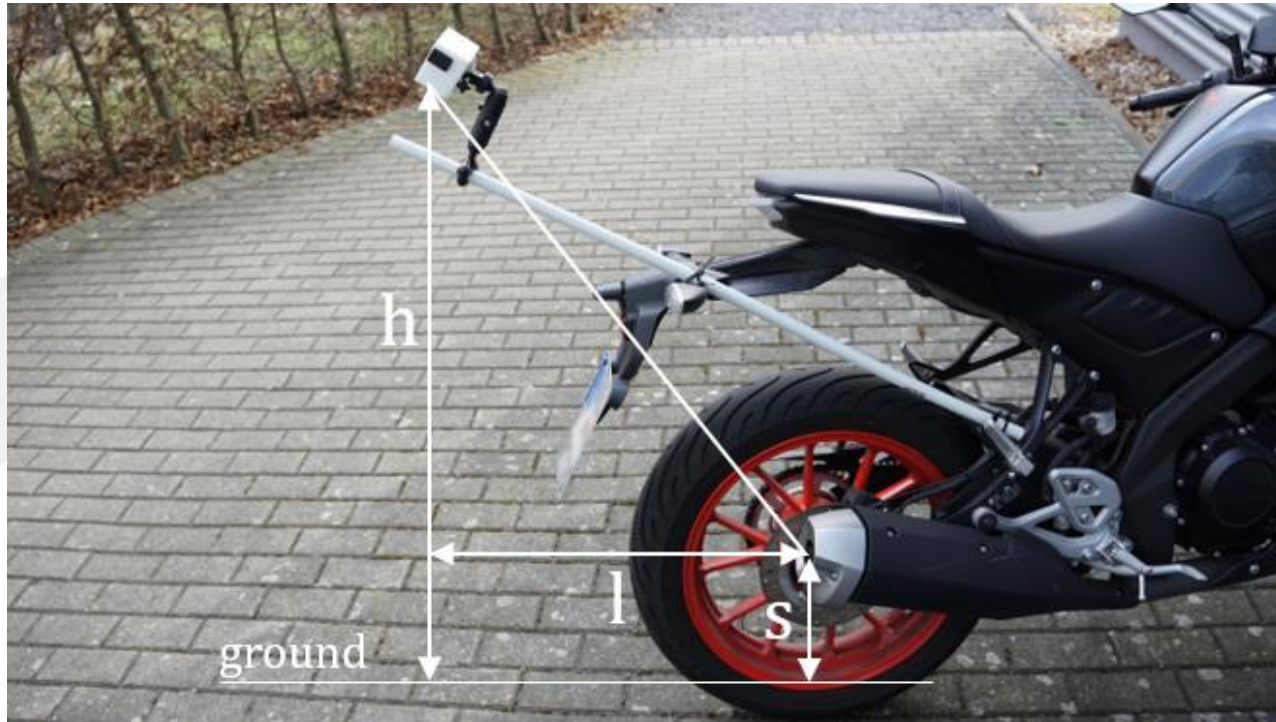
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*Standard RDE trip in Thessaloniki*

# On road noise measurements device

- Developed by IKA RWTH
- Sound recording
- GPS data
- Defined noise testing procedure, mounting position, etc.



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# Emission measurement equipment

- Commercial PEMS for heavy motorcycles & quads
- SEMS devices
  - Novel prototypes
  - Gaseous pollutants (CO<sub>2</sub>, CO, NO<sub>x</sub>, HC, NH<sub>3</sub>, BCPM)
  - Particles (PN, BCPM)
- On-board FTIR
- OBD
- GPS

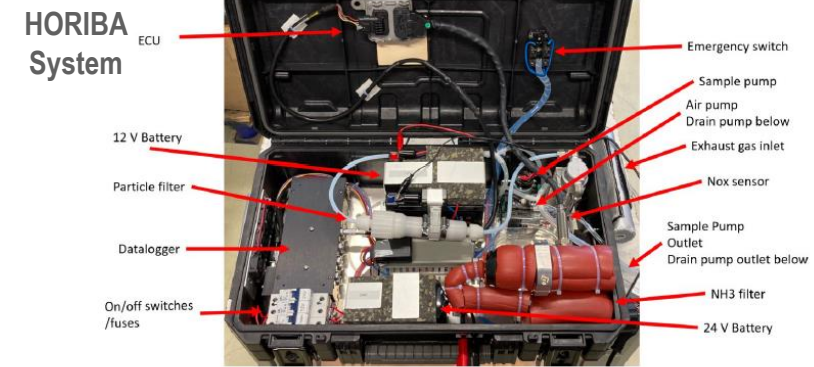


Figure 6-3: Horiba SEMS Unit

Commercial PEMS



CZU FTIR



Commercial PEMS



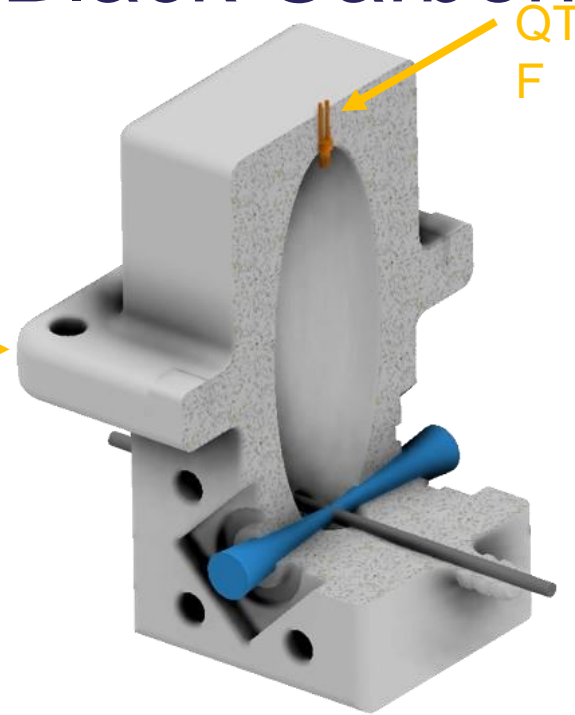
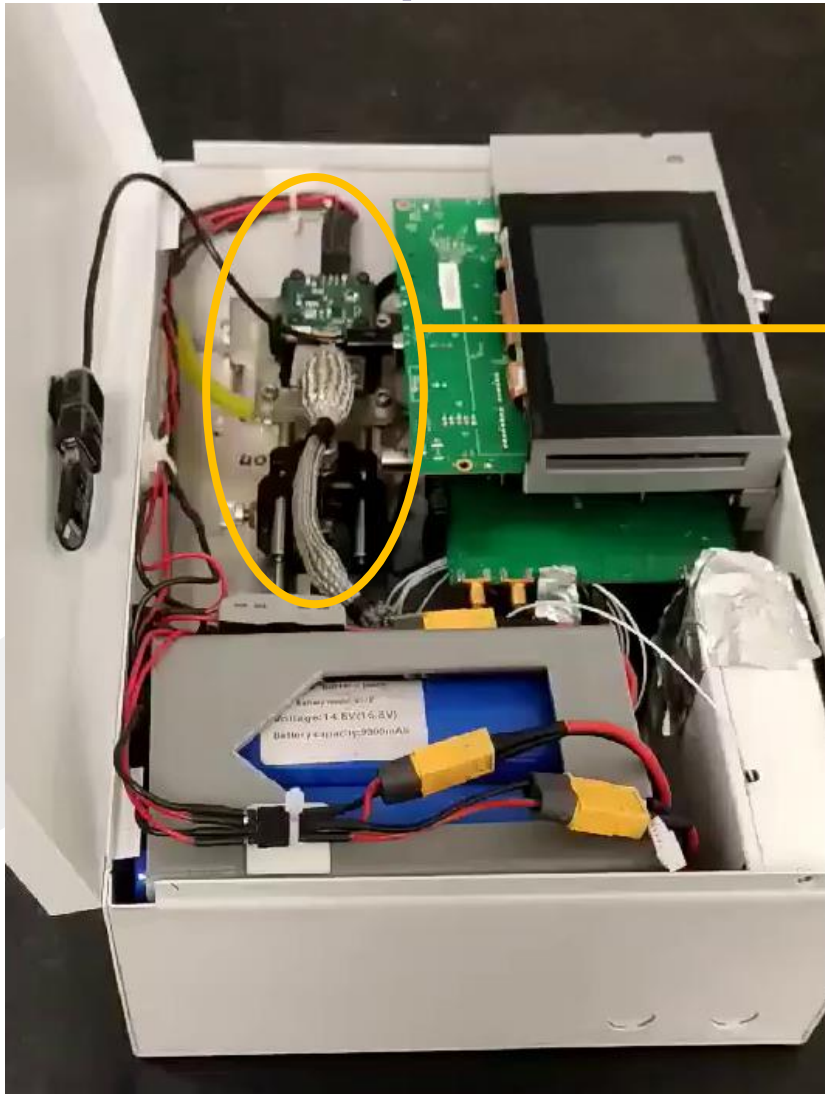
IFPEN System



EMISIA System



# Novel Optoacoustic Black Carbon sensor - RSENSE



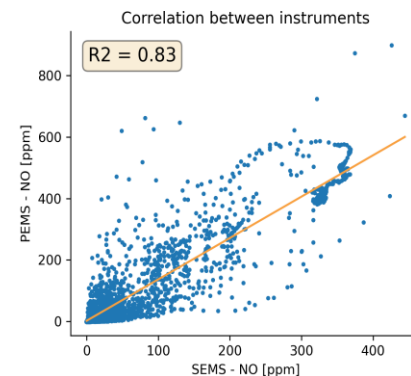
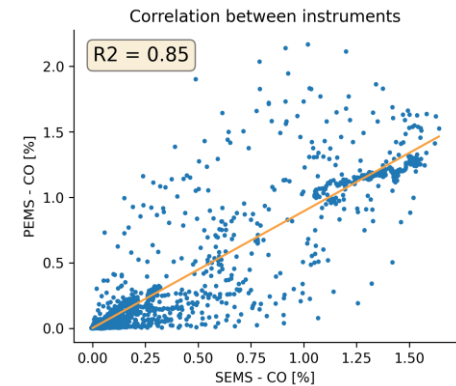
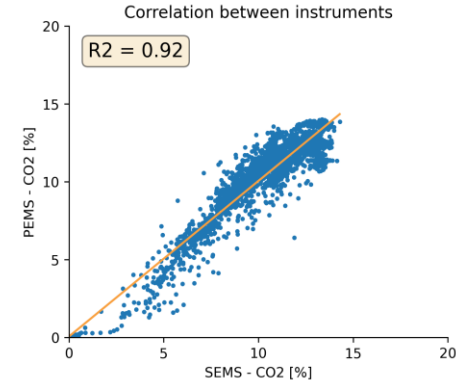
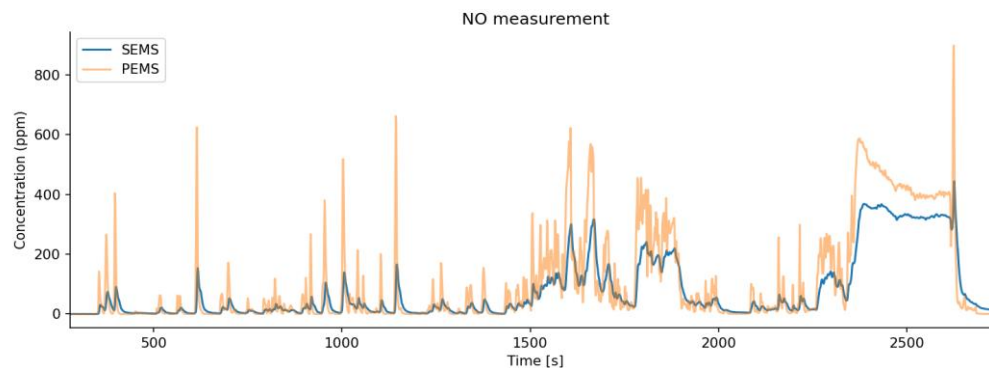
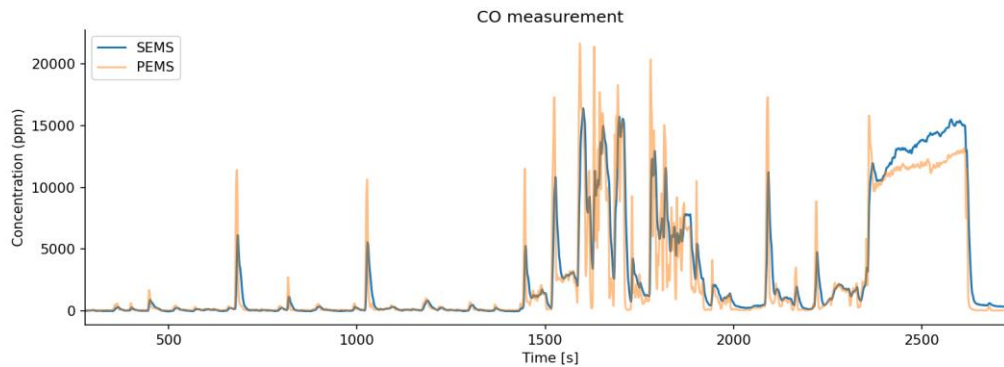
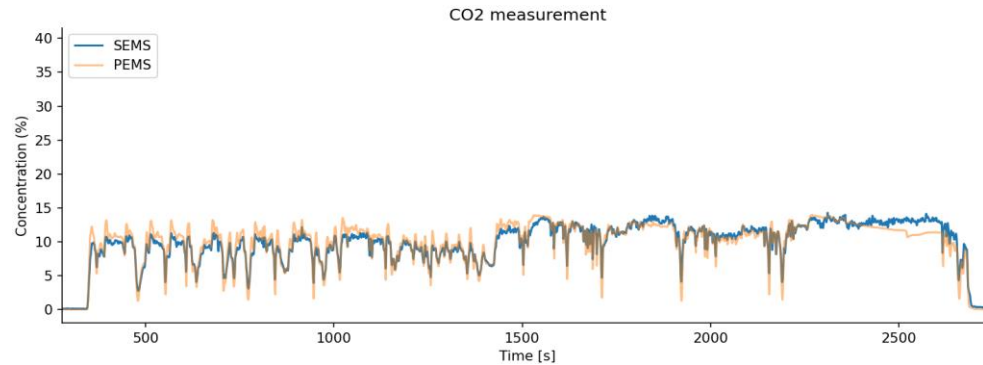
- Optoacoustic principle
- 808 nm Laser Diode for BC detection
- Ellipsoid chamber for sound refocusing

	Current version	Potential
Weight	4 kg	2 kg
Dimensions	33 x 22 x 12 cm	20 x 20 x 10 cm
Cost	4k €	1.5k €

- The sensor was provided pro bono by LAT/RSENSE to EMISIA for the LENS project

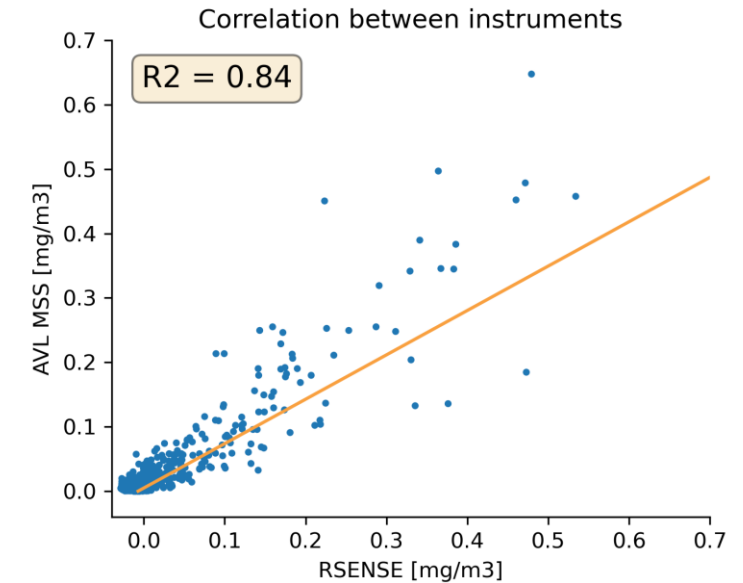
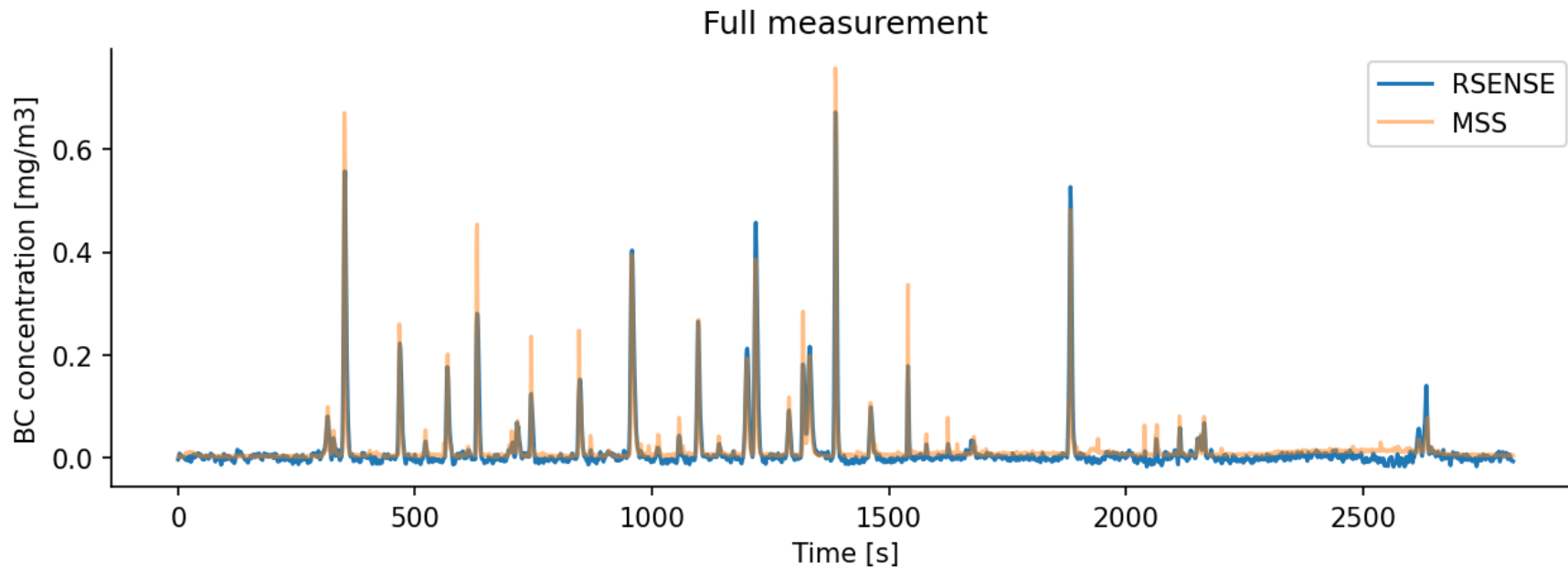
# Novel SEMS device evaluation

- EMISIA gas SEMS against commercial PEMS



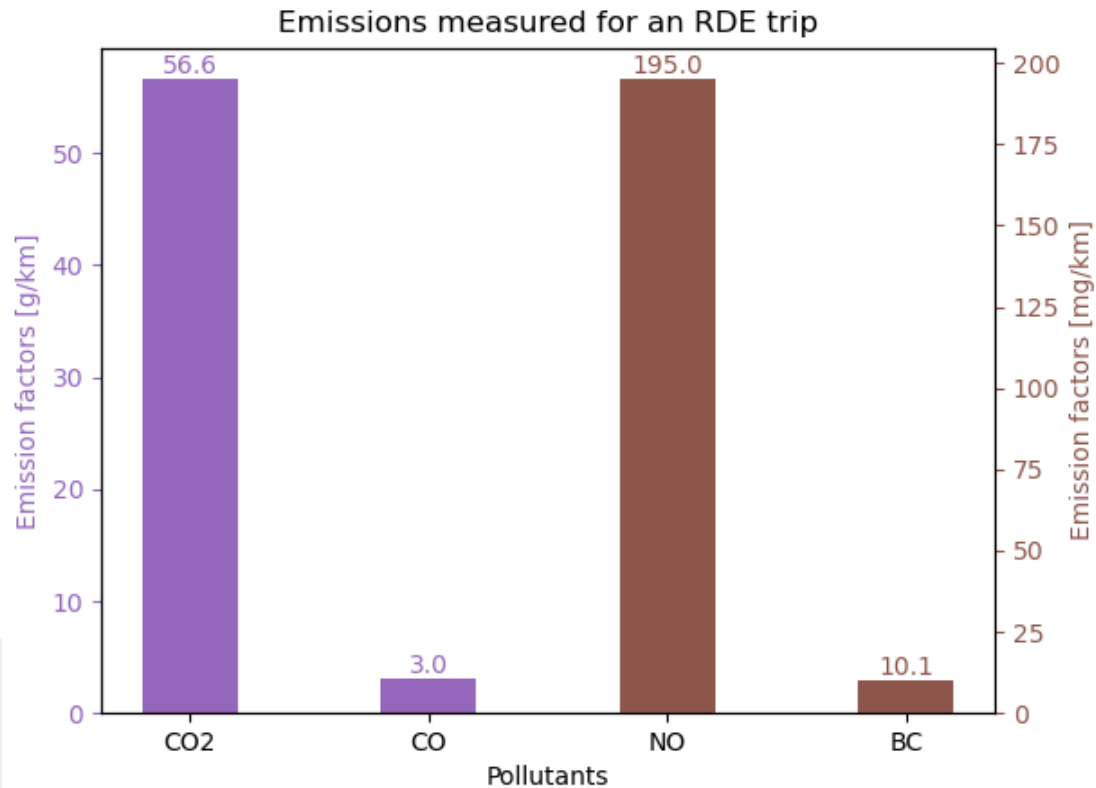
# Novel SEMS device evaluation

- RSENSE Optoacoustic BC SEMS against MSS (commercial BC analyzer)

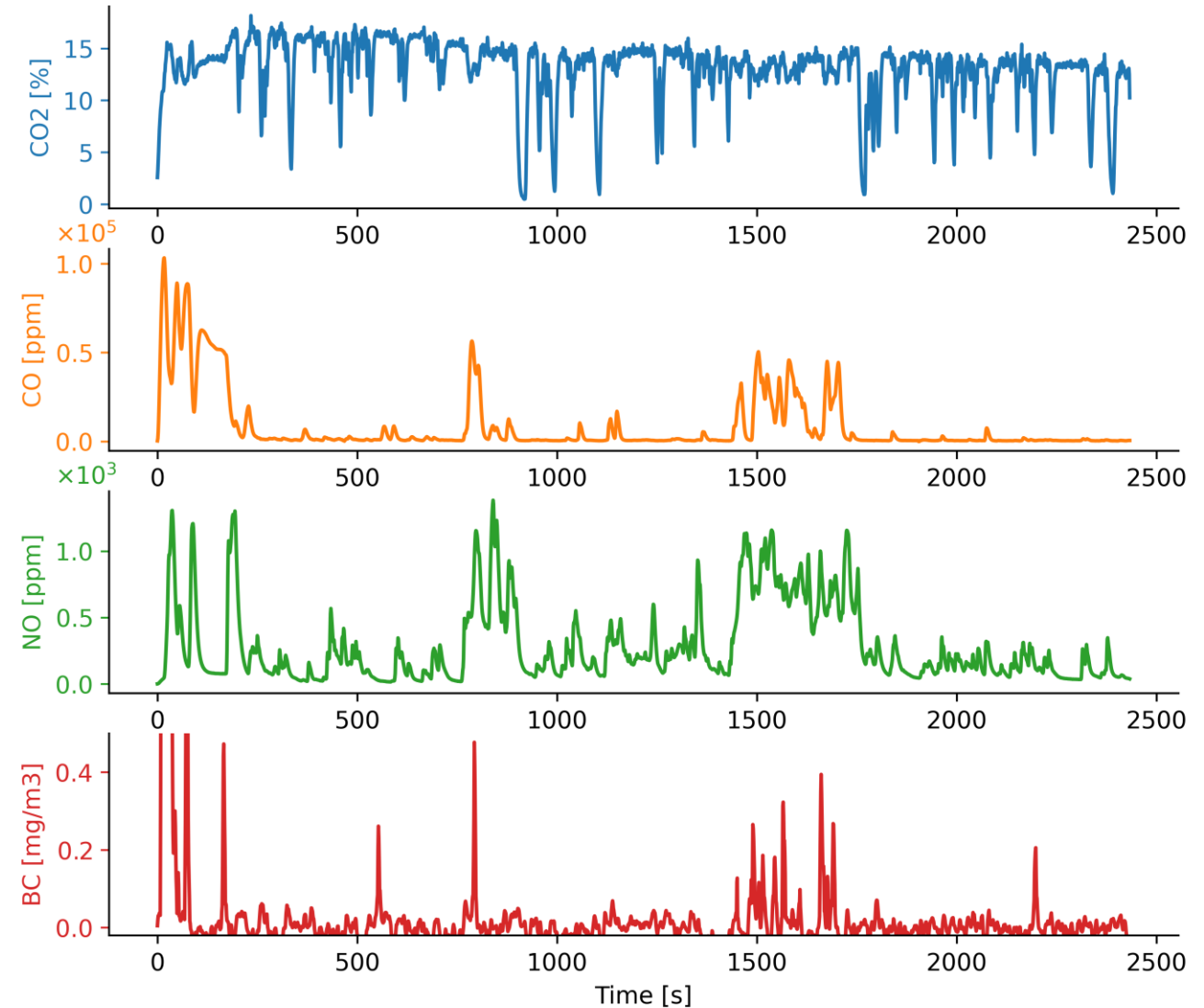




# Euro 5 L3-A1 RDE test result using SEMS

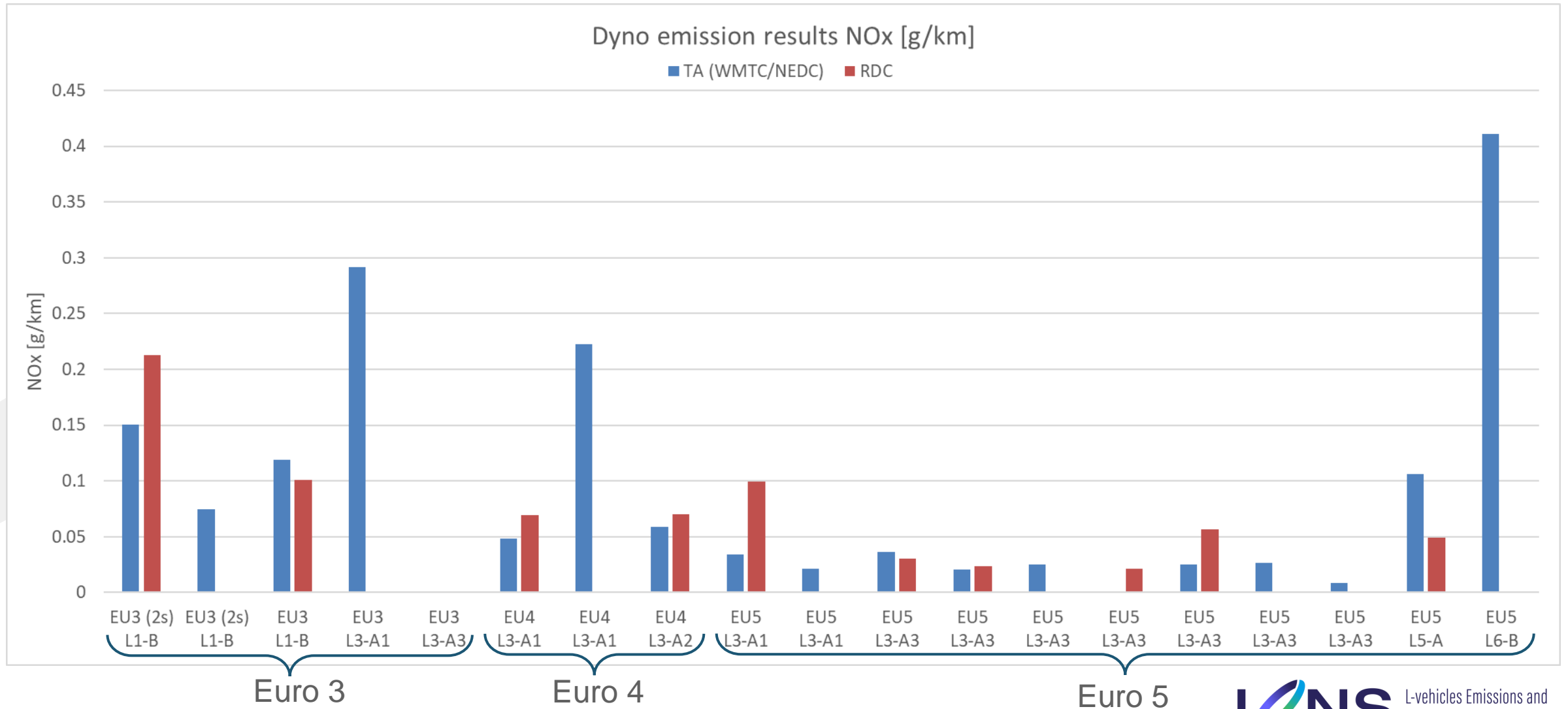


RDE\_test\_timeseries



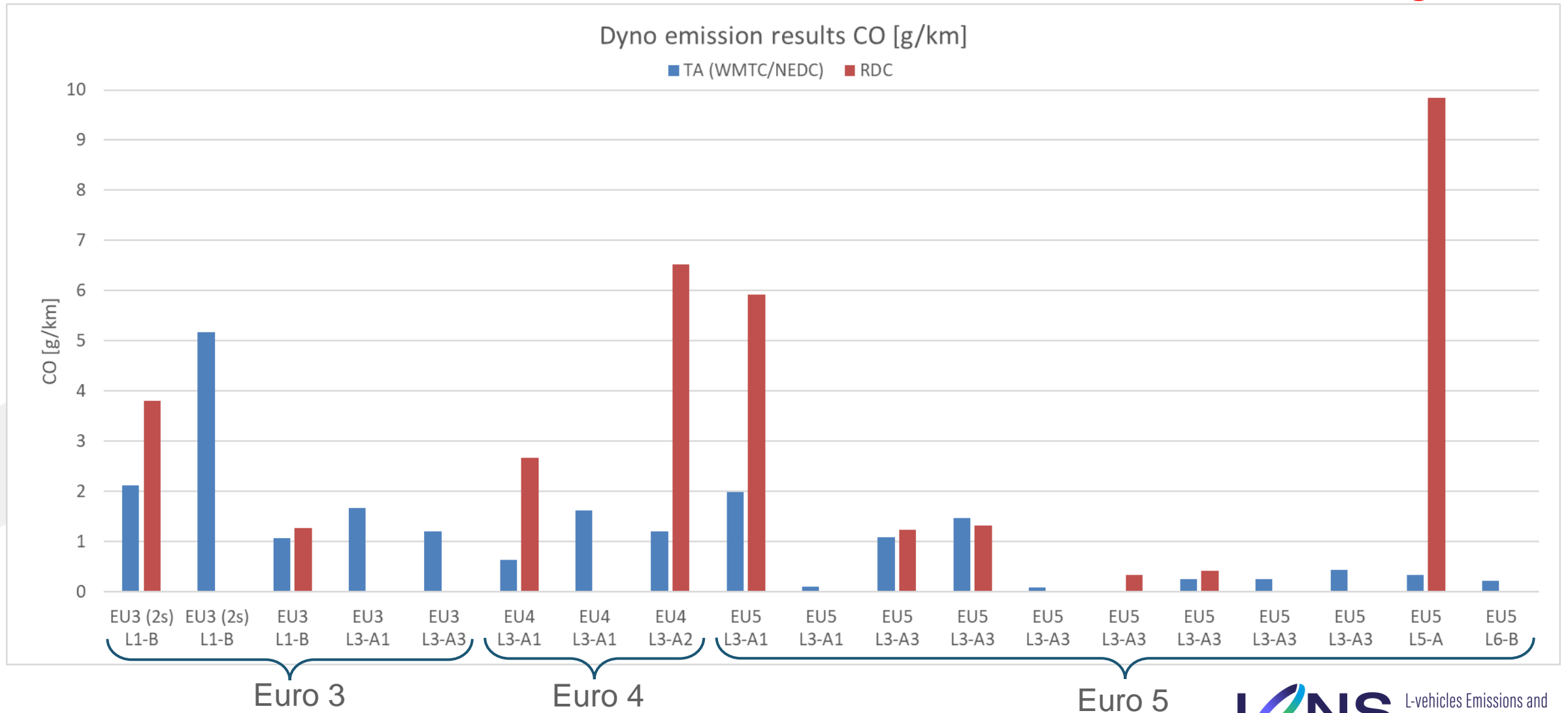
# Pollutant emissions testing

**Euro 5 NOx limit = 0.06 g/km**



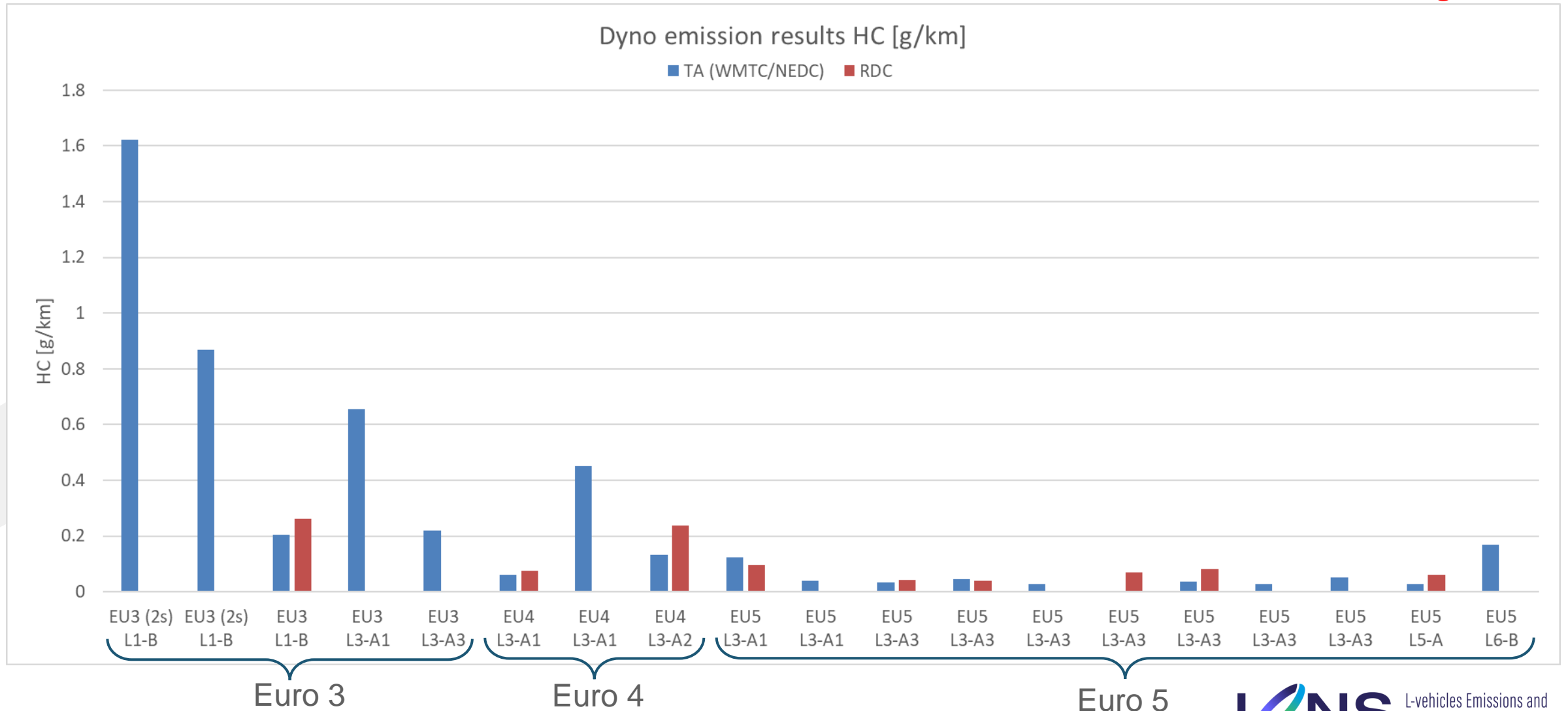
# Pollutant emissions testing

Euro 5 CO limit = 1 g/km

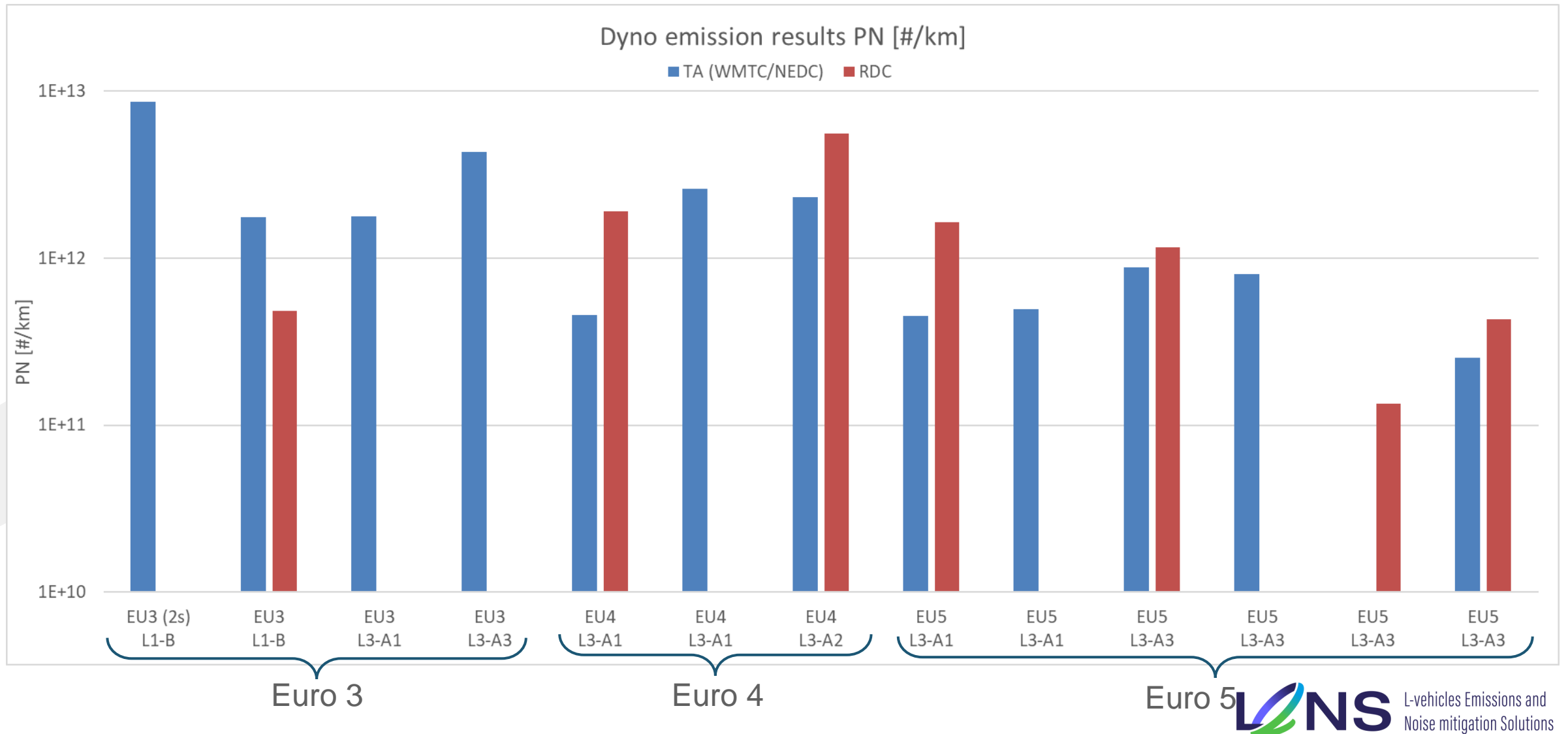


# Pollutant emissions testing

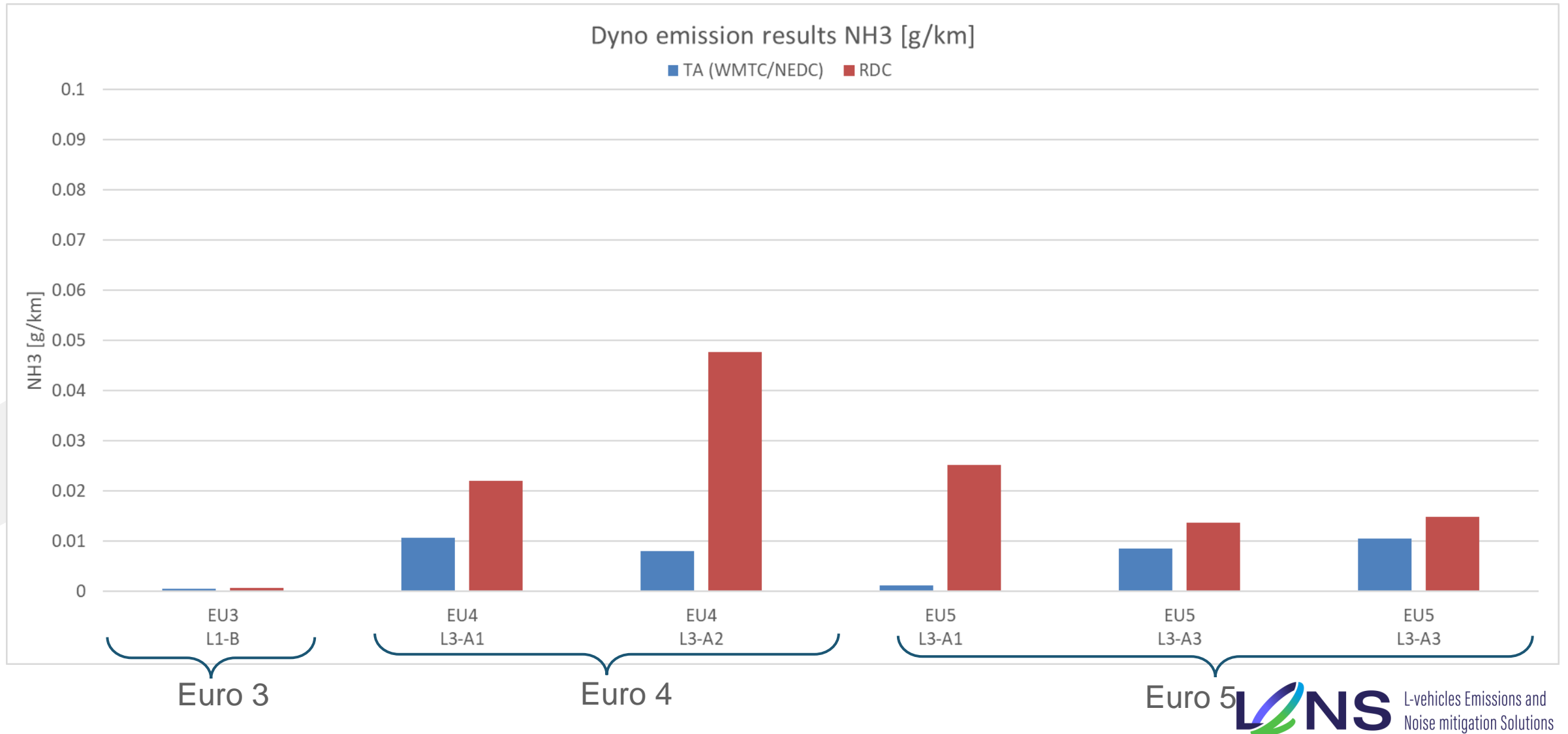
**Euro 5 HC limit = 0.1 g/km**



# Pollutant emissions testing



# Pollutant emissions testing



# Tempering detection & Remote sensing

- Roadside measurement of noise & pollutant emission.
- Field survey locations:
  1. Flanders - Leuven [done in May]
  2. France - Paris region [ongoing]
  3. Spain - Barcelona [scheduled]



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# Noise & pollutant reduction measures to be simulated

- Mitigation measures currently being investigated:
  - Stricter TA standards
    - Assuming technical advances
  - Anti-tampering measures
    - strengthening roadside inspections (increase number & fines)
    - Make modifications difficult to carry out (prohibit sale and use of modification parts)
  - Local measures
    - access restrictions
    - Speed limits
    - Surveillance/noise cameras
  - Behavioral changes (usage-oriented, standards and fleet remaining the same)
    - Enforcement of vehicle condition standards by law enforcement
    - Warning sign
    - Deterrent (escalating penalties, fines etc.)

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# Remaining LENS tasks

- Finish noise & pollutant emission testing
- Test data analysis
- Update existing emissions factors and noise factors using the measured data (COPERT, TRANECAM)
- Run simulations to quantify the emission & noise reduction effects of selected mitigation measures
- CBA of each mitigation measure
- Communicate results (reports, events, publications)

# Thank you!

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