Measurements of exhaust gas emission of light vehicles

Stephan Schmidt, TU Graz

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101056777

L-vehicles Emissions and Noise mitigation Solutions

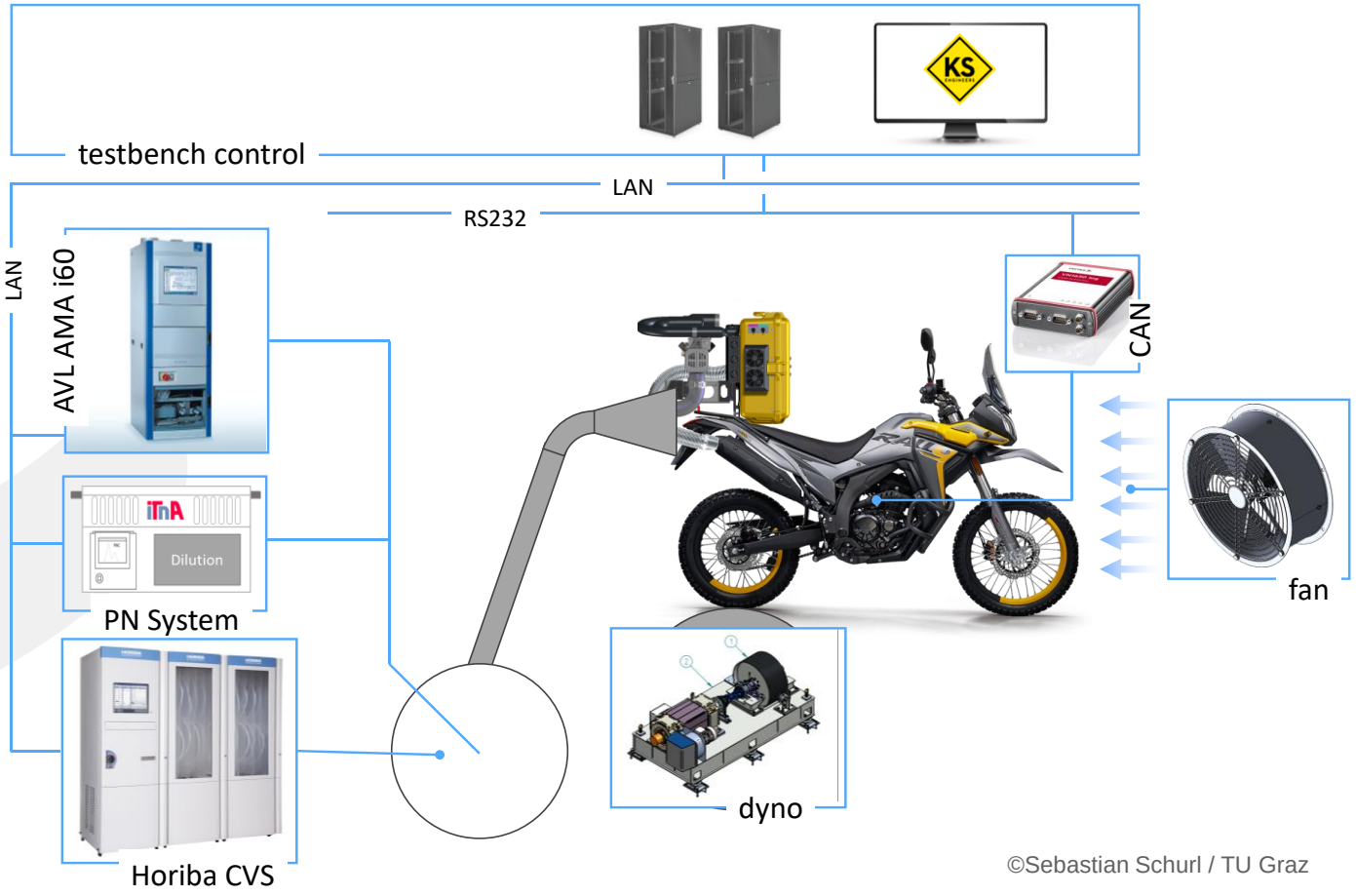
Preliminary Outcome

Method & Results

- Measurement Equipment & Methods: findings & developments
  - PEMS, Mini-PEMS, SEMS
  - RDE Trip composition
  - RDC cycle
- First results of fleet emission
  - Type Approval emission
  - On-Road emission

Measurement equipment & Methods

Available measurement equipment lab tests



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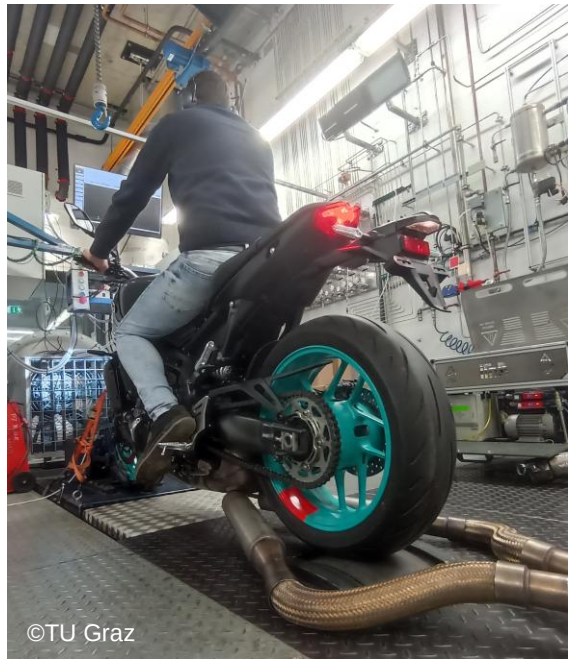
Measurement equipment & Methods

Available measurement equipment lab tests

- 2-Wheeler Chassis dyno with restricted suitability for High Power Motorcycles:
  - Rear Wheel Slip
  - Power restrictions of the standard chassis dynamometer
- 4-Wheeler Chassis dyno with restricted suitability for All Terrain Vehicles
  - Off road tires
  - Small wheel base

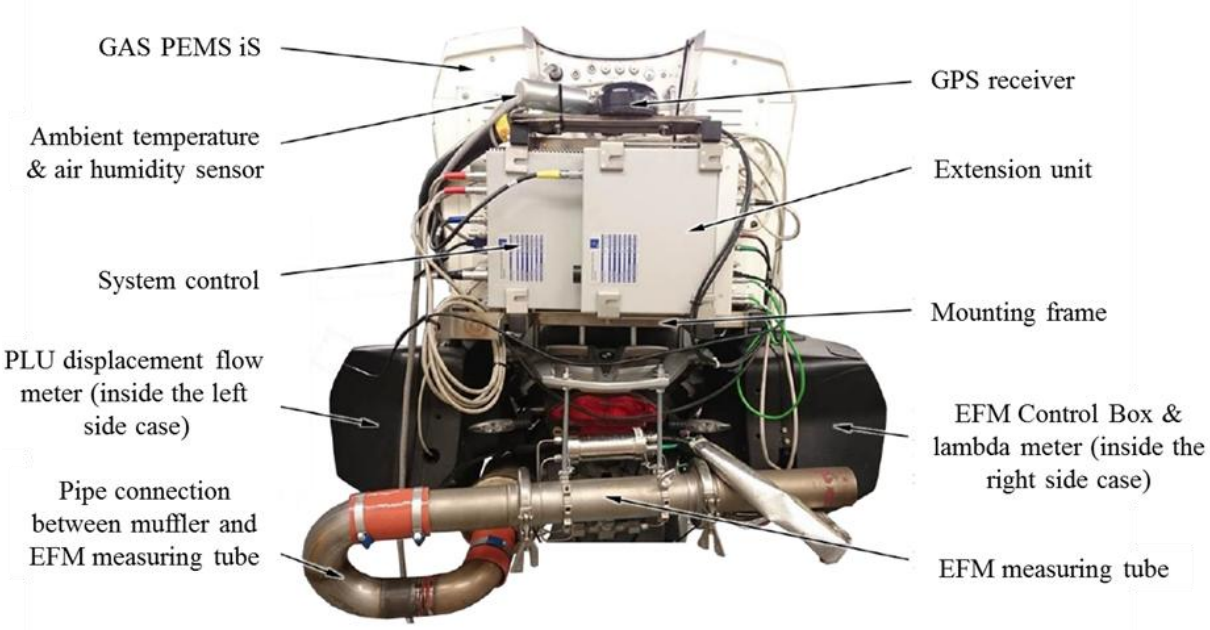


Measurement equipment & Methods

Available measurement equipment on-road

Portable emission measurement system PEMS

- Weight typically 60-90kg
- Mounted rear outside of vehicle
- Connection to exhaust pipe for exhaust gas mass flow measurement (EFM)



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Measurement equipment & Methods

Available measurement equipment on-road

PEMS mounted on Heavy Duty Vehicle

PEMS mounted on Passenger Car

Measurement equipment & Methods

Available measurement equipment on-road

Automotive standard PEMS mounted on Mid-Size Motorcycle

L-vehicles Emissions and Noise mitigation Solutions

Measurement equipment & Methods

Available measurement equipment lab & on-road -- Conclusion

Commercial available on-road measurement equipment PEMS & EFM not suitable for all L-Cat vehicles

- Standard equipment big & heavy → influences driving behaviour, stability, handling & emission
- Not suitable for small vehicles
- To short calming lenght of EFM
- Standard EFM with Pitot principle → high inaccuracy for small capacity engines with low cylinder numbers

Measurement equipment & Methods

Adaped & newly developed on-road measurement equipment

- PEMS / Mini-PEMS / SEMS
- EFM-Systems
- + CAN-Bus
- + FTIR..
- Road Side Measurement

Measurement Equipment

RDE-Configuration

SEMS & Mini-PEMS

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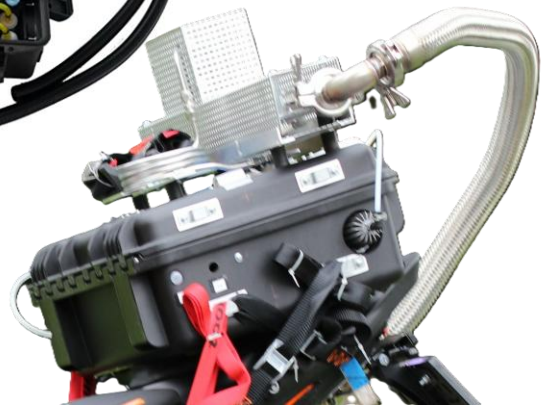
- Weight 8-13kg
- CO, NOx, (SEMS)
- CO2, CO, NO (Mini-PEMS)



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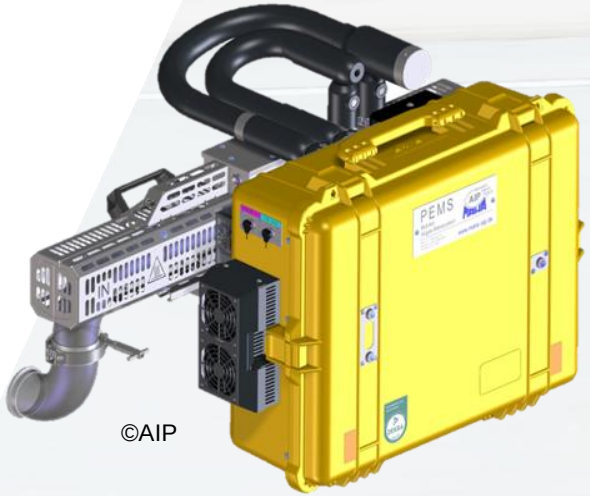
Standard PEMS



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- Weight ~40kg
- CO, CO2, NOx, PN

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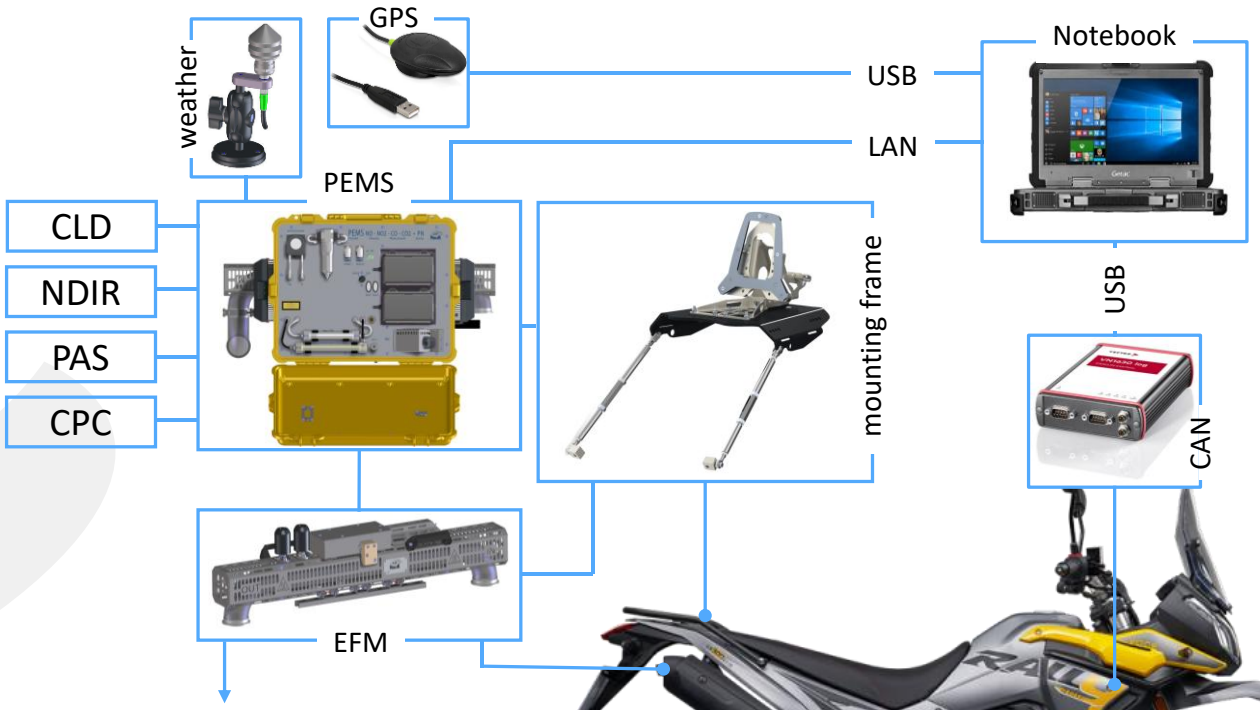
Measurement Equipment

RDE-Configuration



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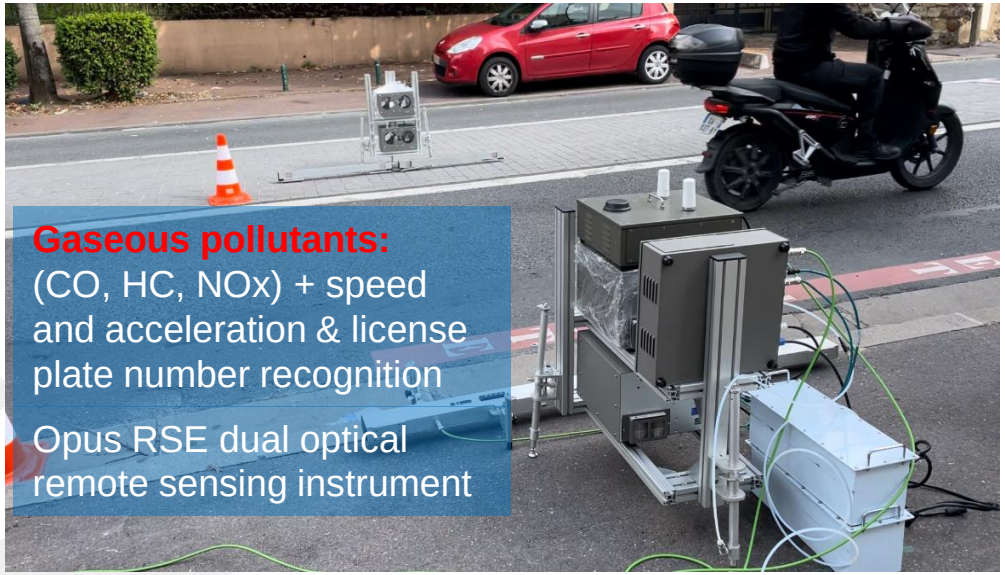
Measurement Equipment

RDE-Configuration

L-vehicles Emissions and Noise mitigation Solutions

Measurement Equipment

Roadside emission measurements

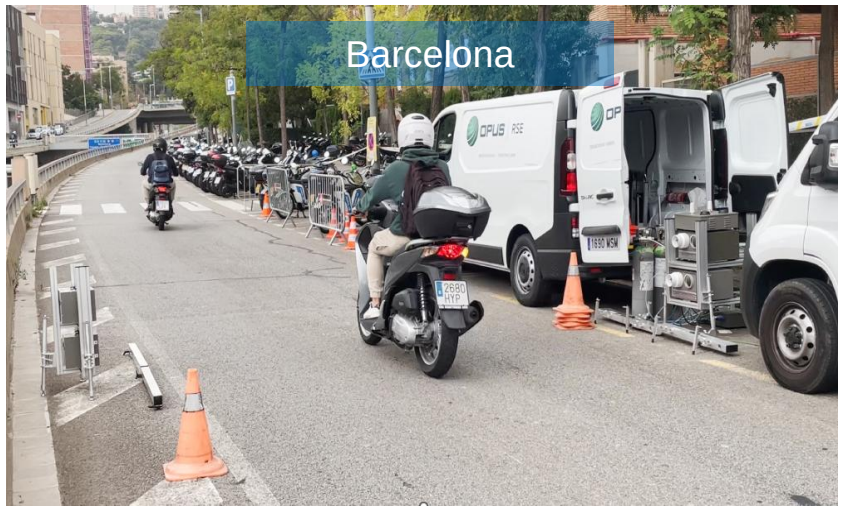


Gaseous pollutants:
(CO, HC, NOx) + speed and acceleration & license plate number recognition

Opus RSE dual optical remote sensing instrument

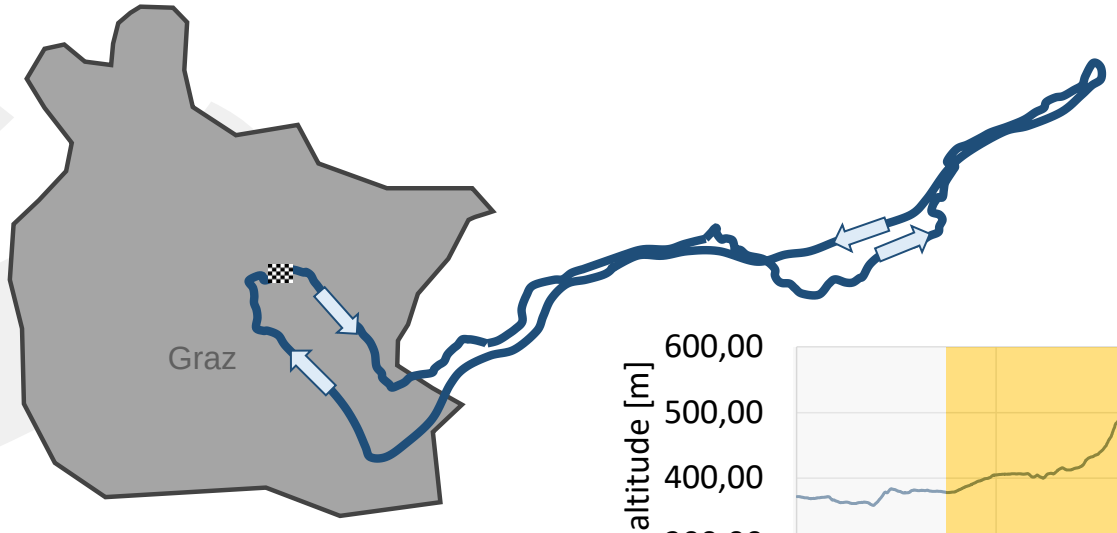
Particulate matter:

1. Black Carbon (TUG)
2. Total particle counter (TUG)
3. Size resolved particle counter (IVL/TSI)



Measurement Procedure

RDE Assessment – Trip Composition & Real Driving Cycles



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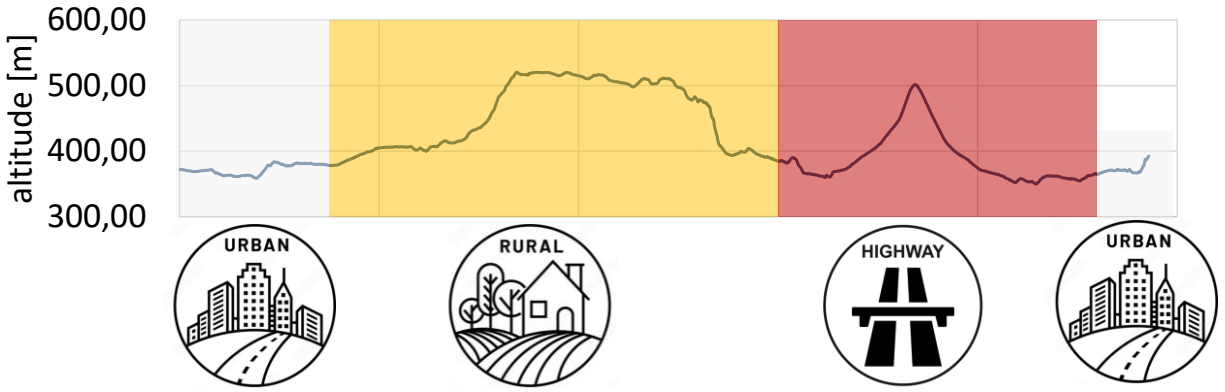
Trip is adapted to the emission category of the vehicle:

- Different max speed
- Different power/weight ratio
- Capability of highway driving
- Different driving style



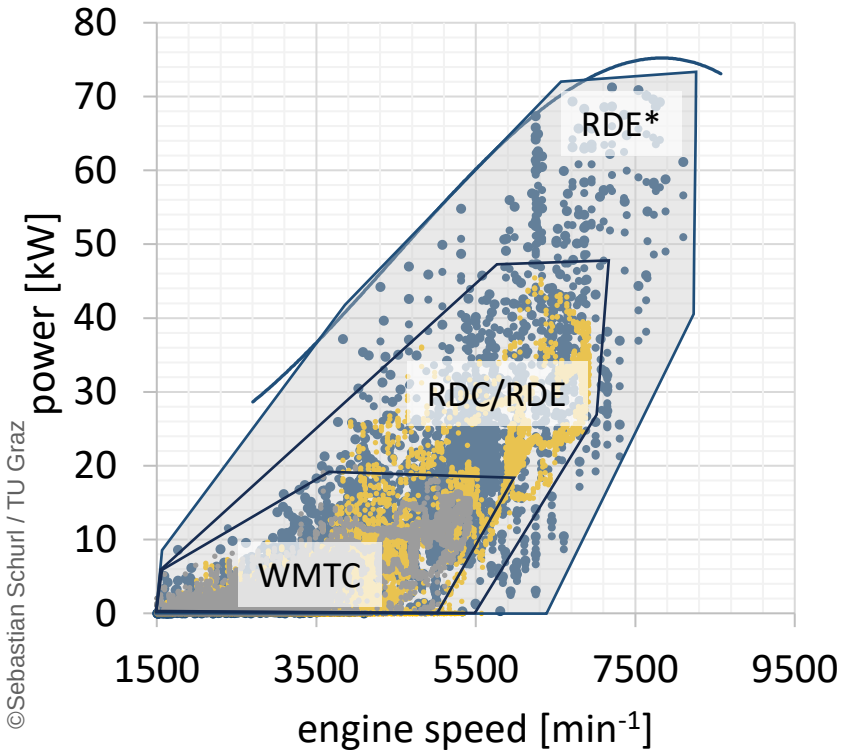
L-vehicles Emissions and Noise mitigation Solutions

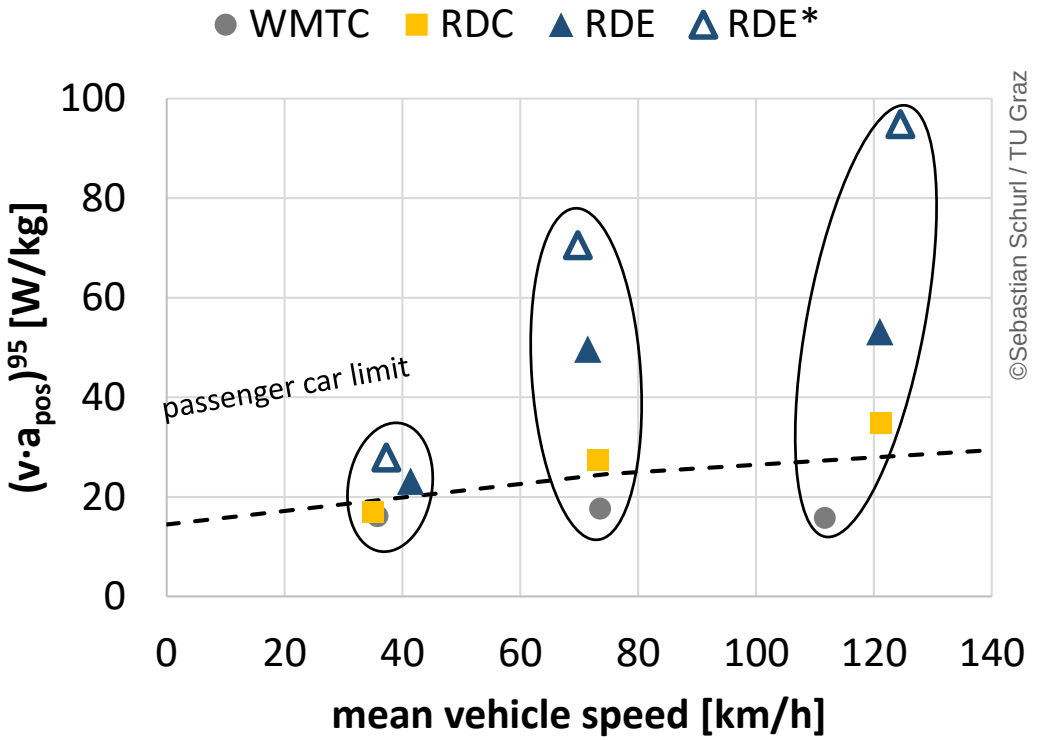
First Results

- Comparison between lab and on-road tests
- Type Approval measurements
  - Average fleet emission
  - WMTC results for selected sub-categories and emission classes
  - RDC results for selected sub-categories and emission classes
- On-road
  - Results for selected sub-categories and emission classes

Measurement Procedure

Comparison Lab Tests & On-Road Tests*





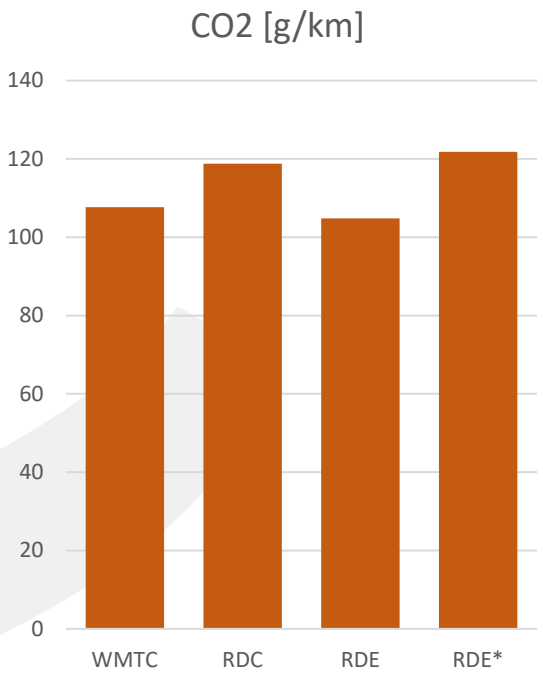
L3e-A3 vehicle

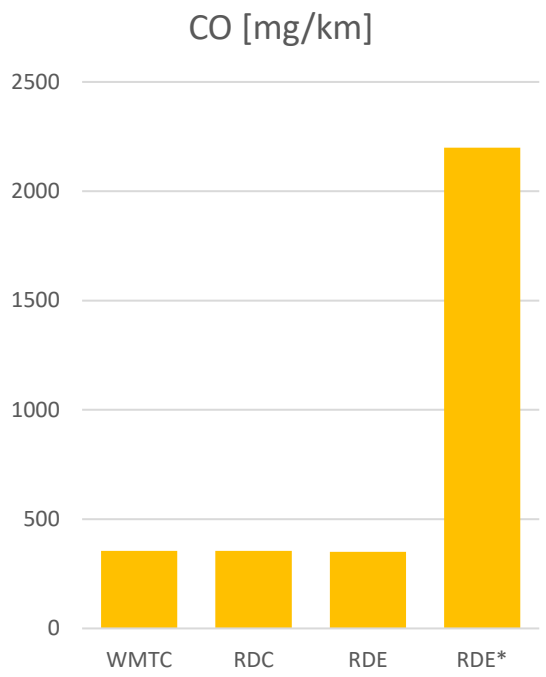
LENS L-vehicles Emissions and Noise mitigation Solutions

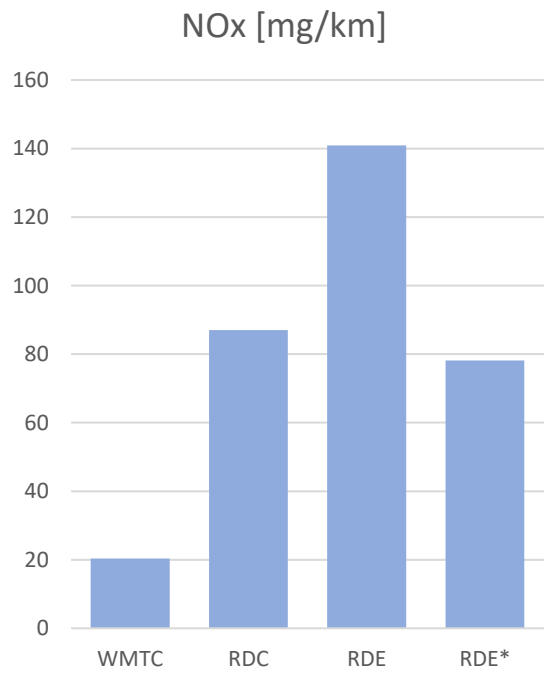
*one vehicle

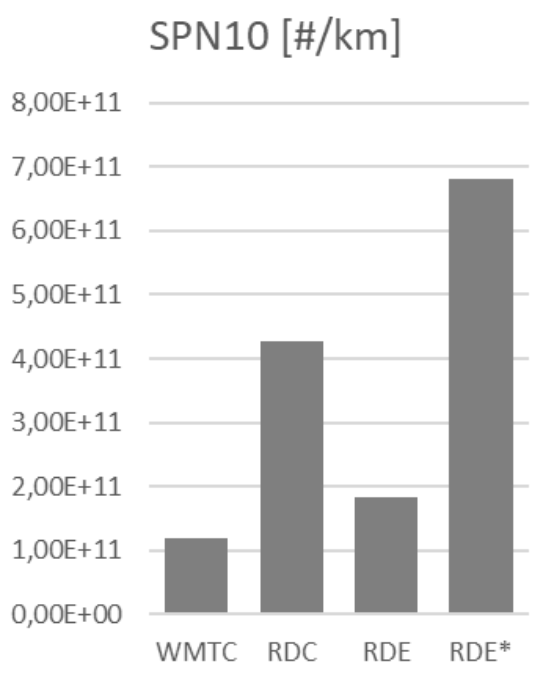
First Results

Impact of test type on emission – L3e-A3 vehicle*









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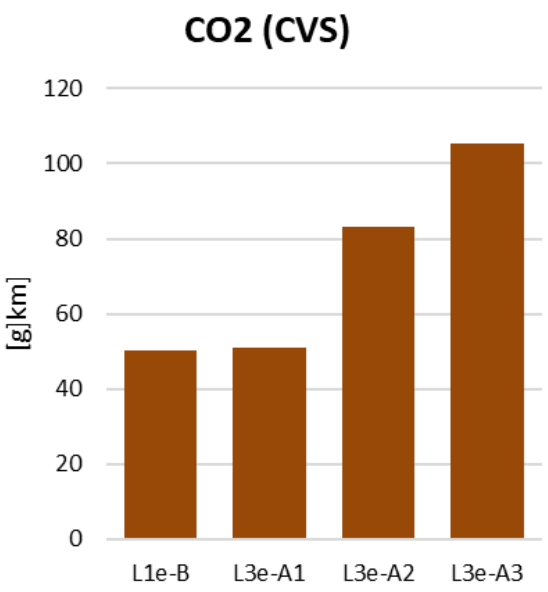
Class L3e-A3 / Euro 5

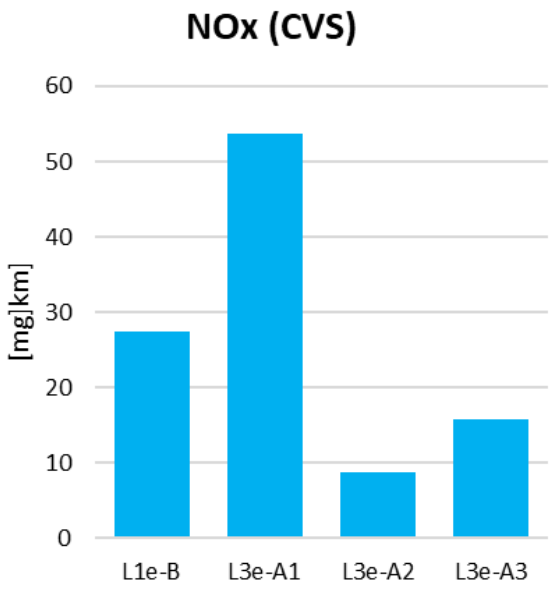
LENS L-vehicles Emissions and Noise mitigation Solutions

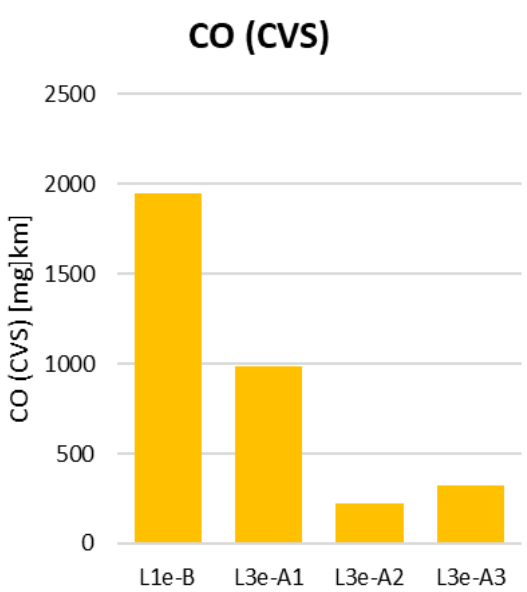
*one vehicle

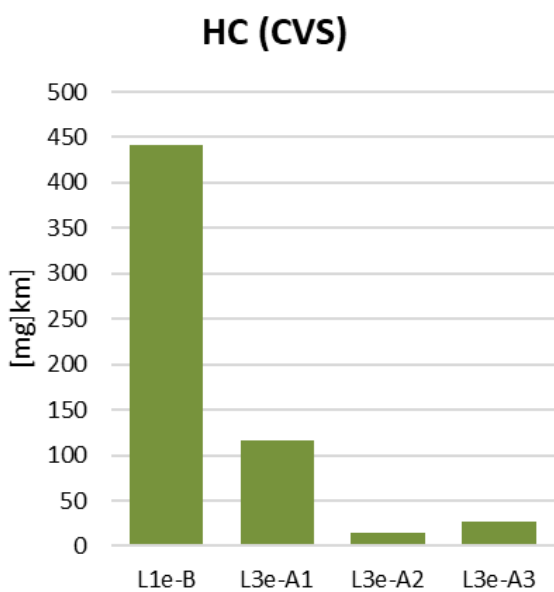
First Results

Average Fleet Emission*









Euro 3-Euro 5 Leg. Emission test

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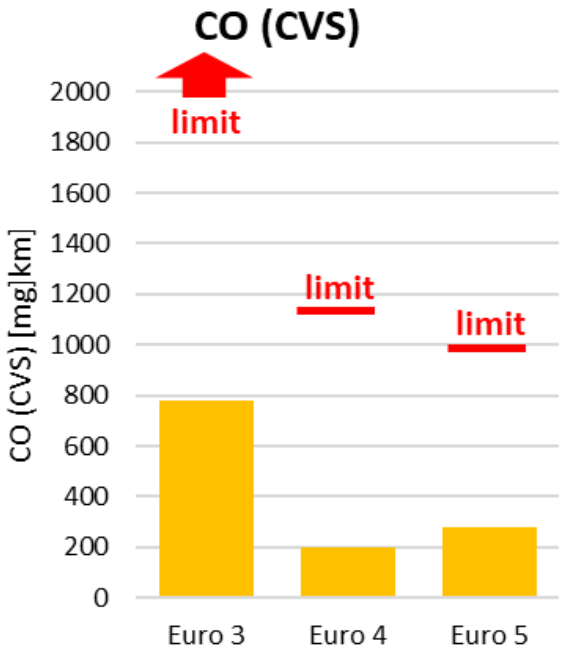
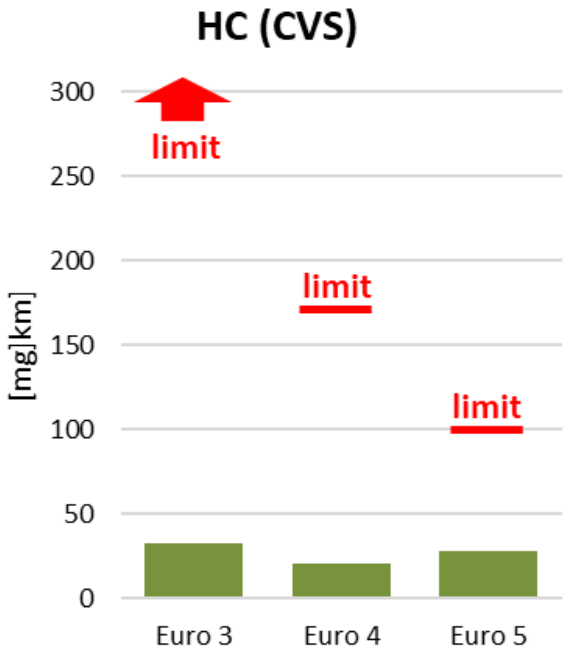
L-vehicles Emissions and Noise mitigation Solutions

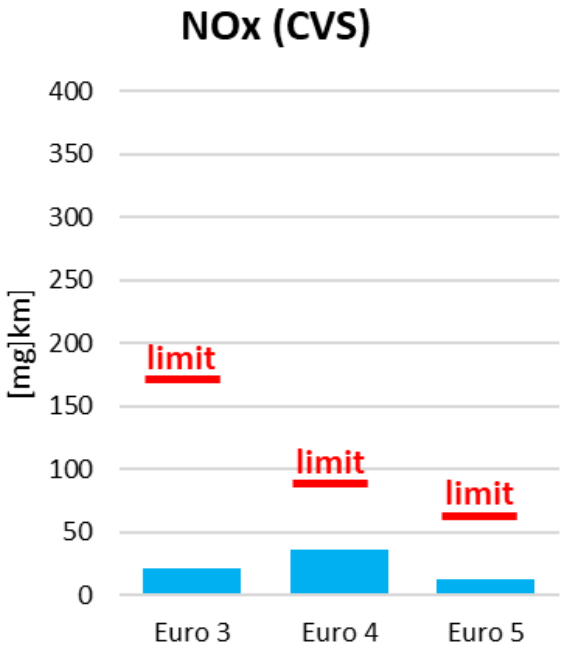
*selected part of LENS measurements

Selected Results

Comparison emission classes L3e-A3 Type Approval tests*







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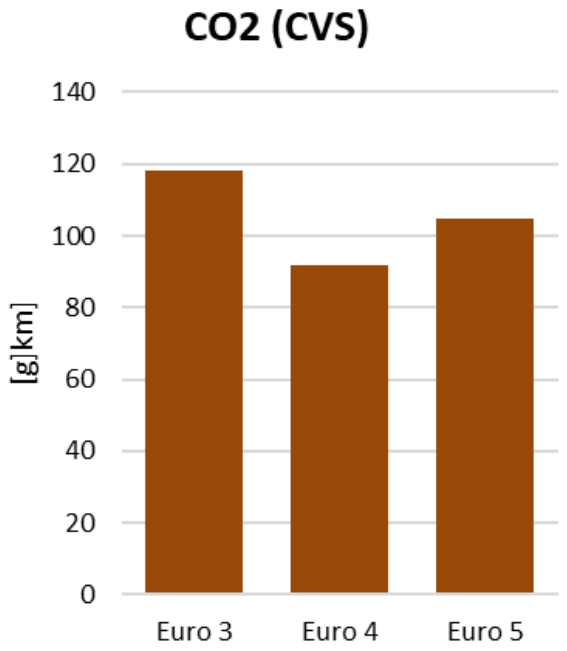
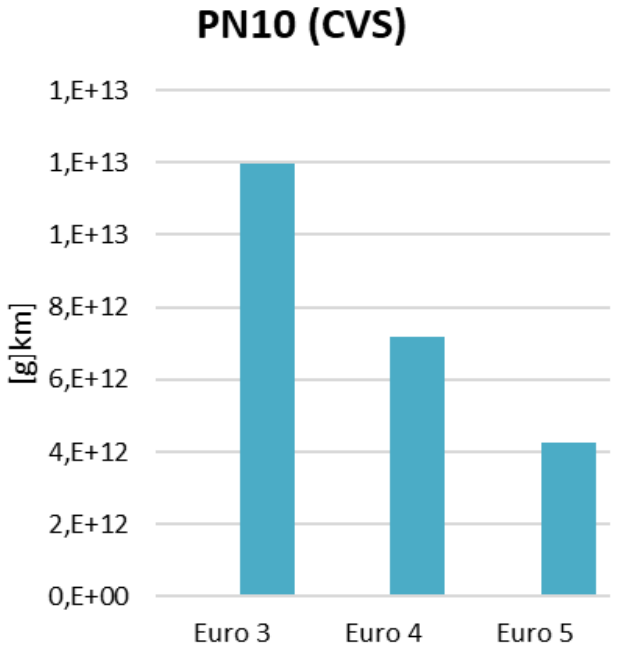
L-vehicles Emissions and Noise mitigation Solutions

*averaged data, selected part of LENS measurements

Selected Results

Comparison emission classes L3e-A3 Type Approval tests*





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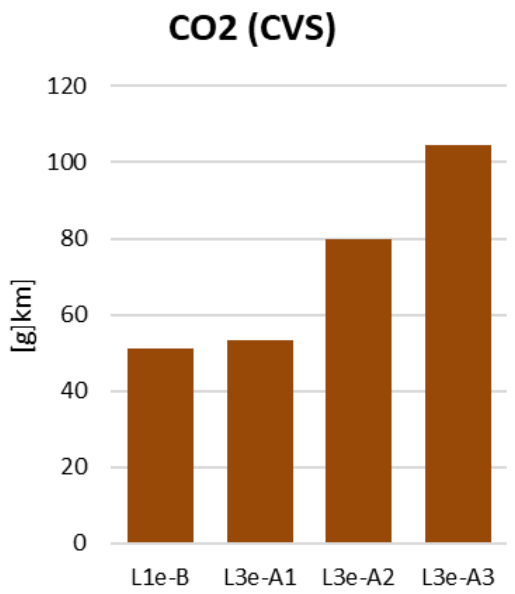
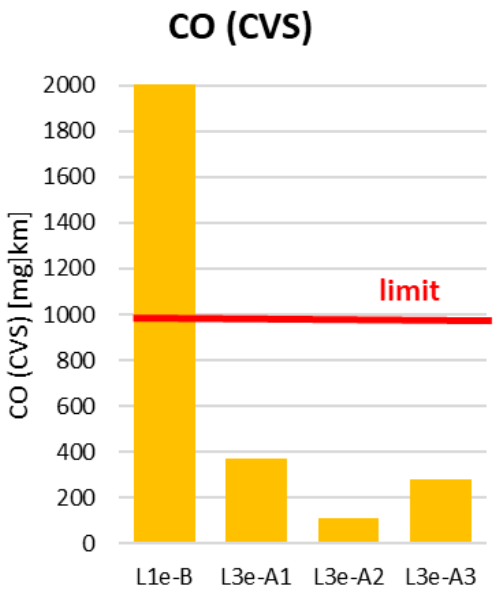
L-vehicles Emissions and Noise mitigation Solutions

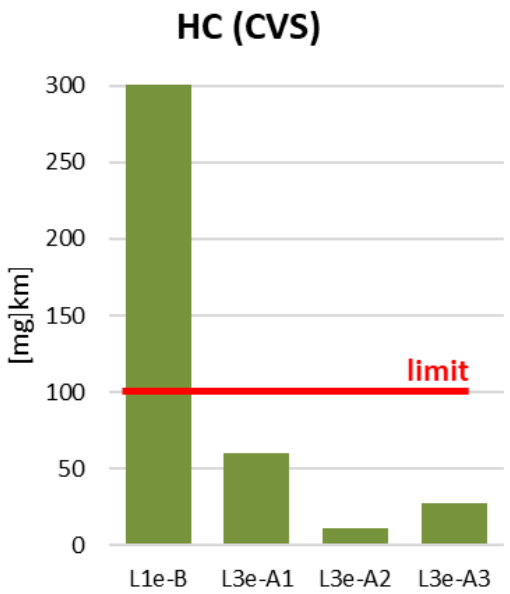
*averaged data, selected part of LENS measurements

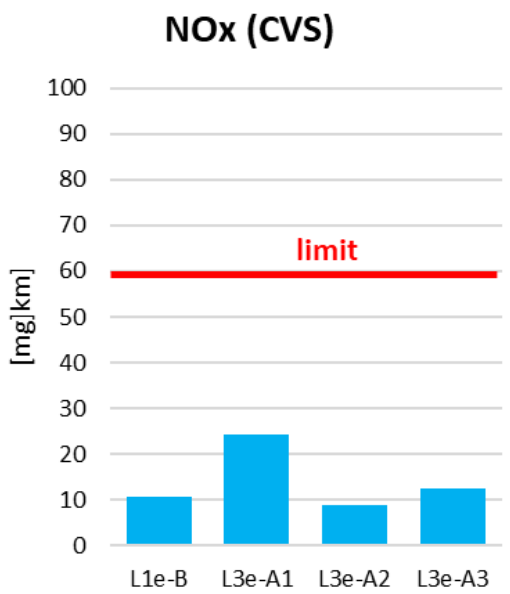
Selected Results

Fleet emission Euro 5







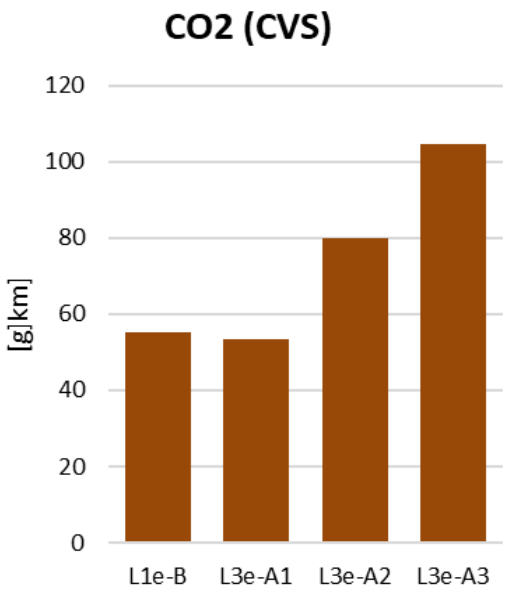


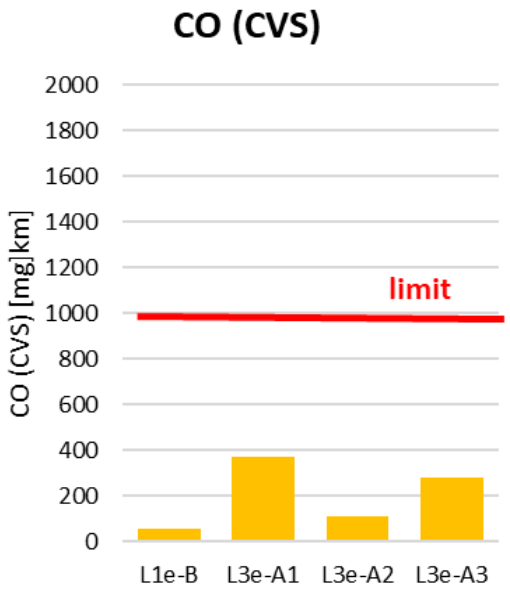
LENS L-vehicles Emissions and Noise mitigation Solutions

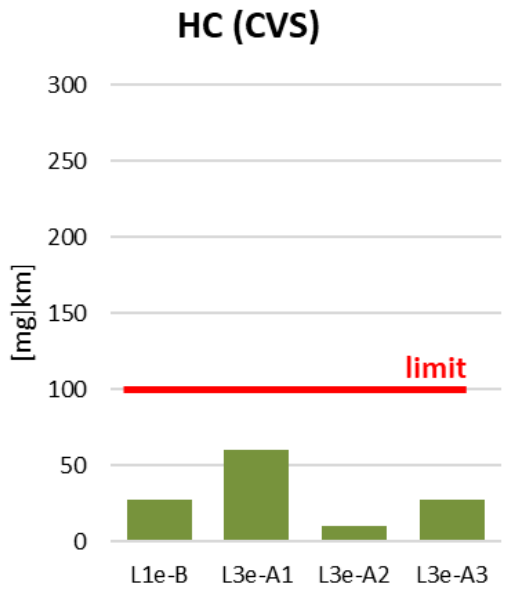
*averaged data, selected part of LENS measurements

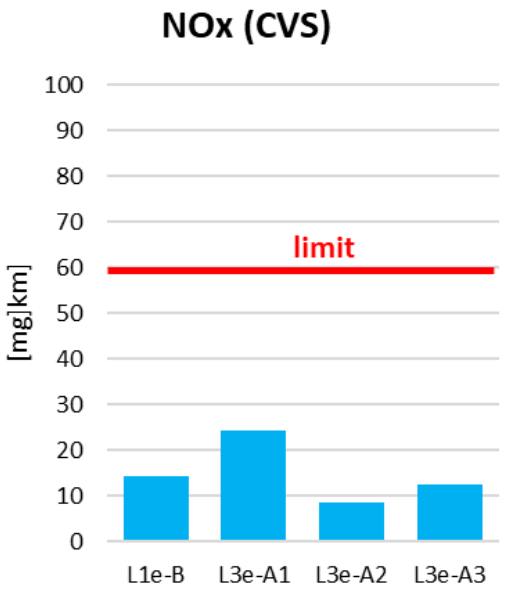
Selected Results

Fleet emission Euro 5*/**







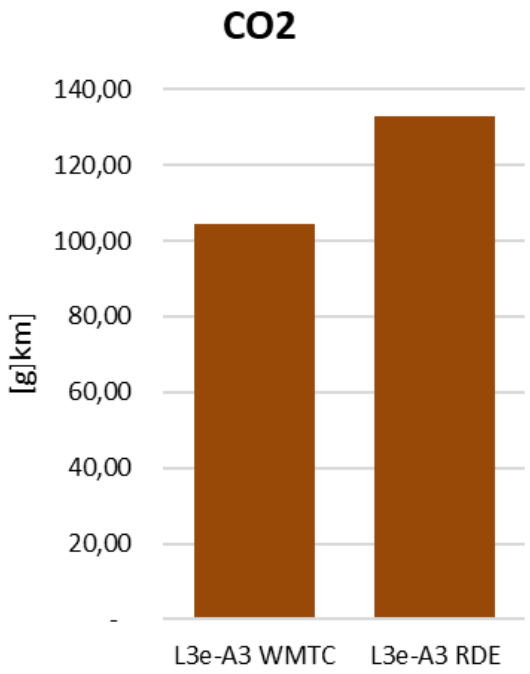


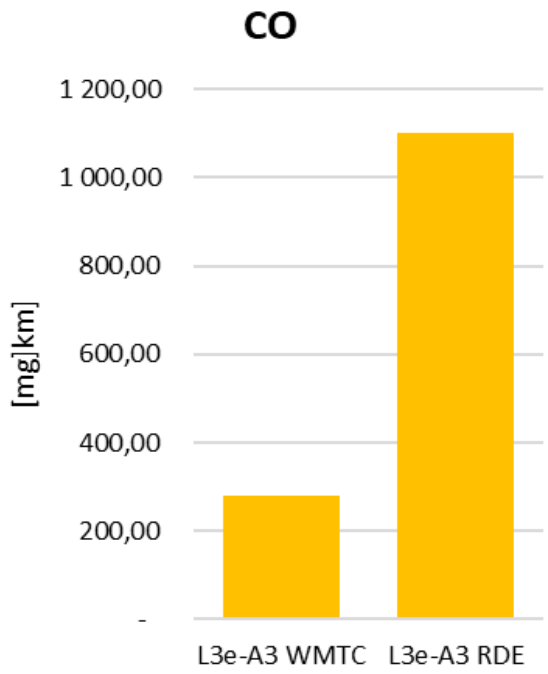
LENS L-vehicles Emissions and Noise mitigation Solutions

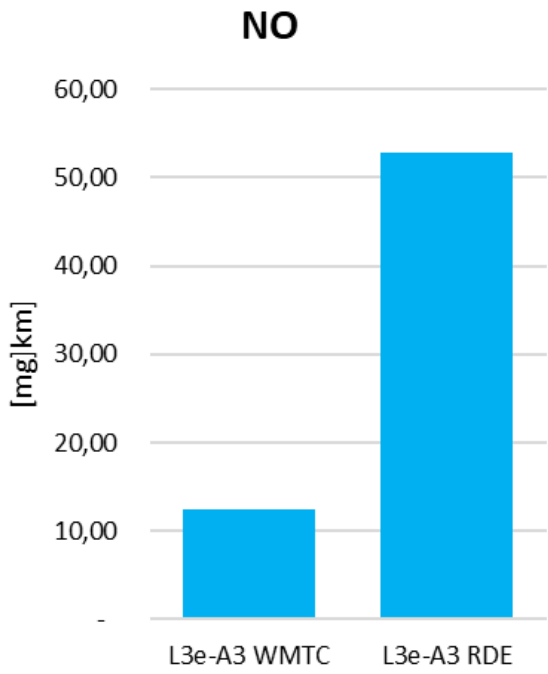
*averaged data, selected part of LENS measurements
** wo high emitters (2-stroke)

First Results

RDE Emission average comparison Lab Tests & On-Road Tests*







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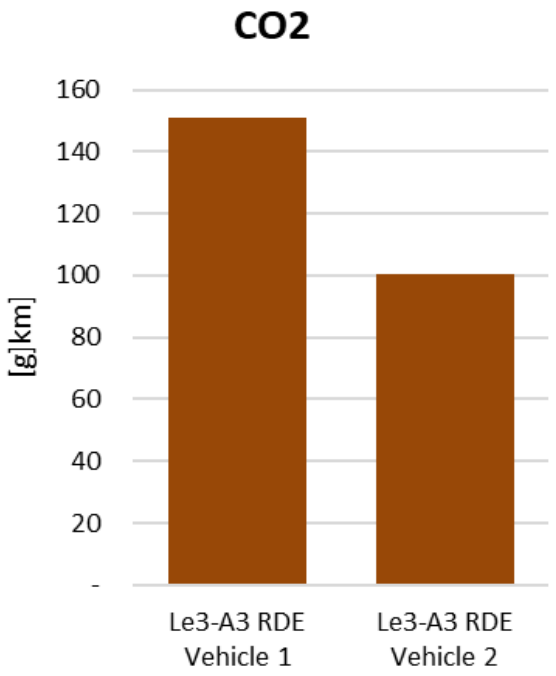
Class L3e-A3 / Euro 5

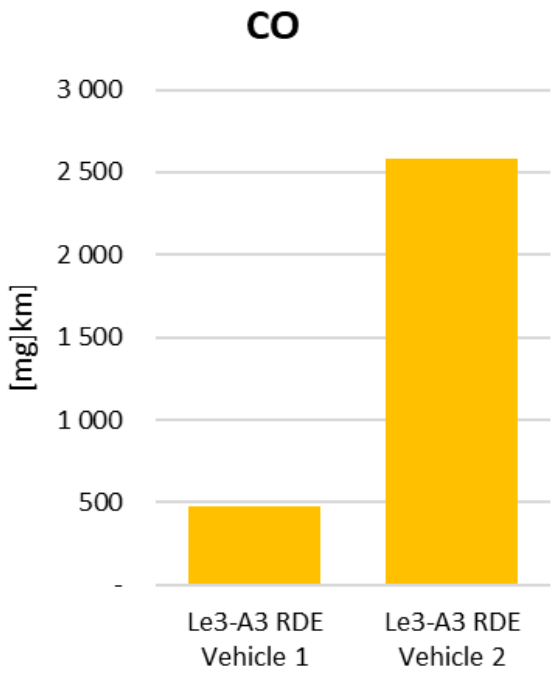
LENS L-vehicles Emissions and Noise mitigation Solutions

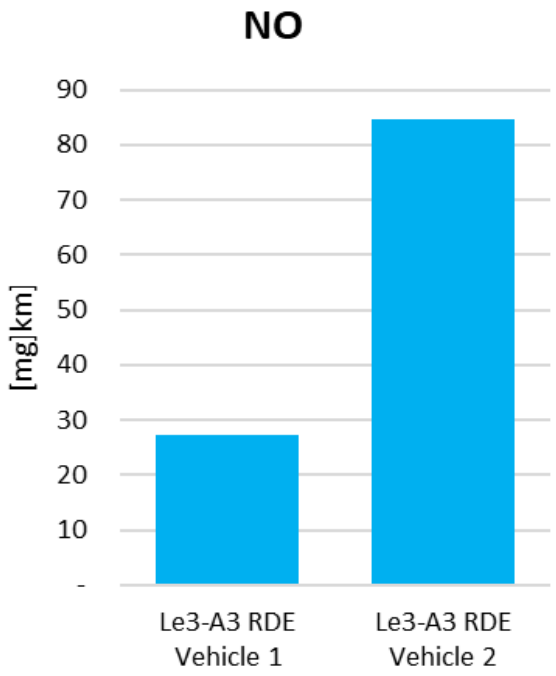
*part of LENS measurements

First Results

RDE emission Min / Max On-Road Tests*







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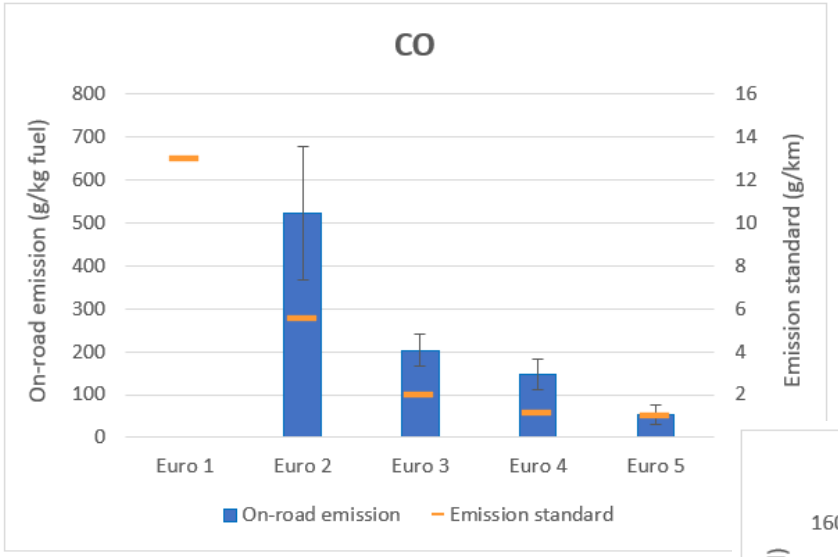
LENS L-vehicles Emissions and Noise mitigation Solutions

*part of LENS measurements

First Results

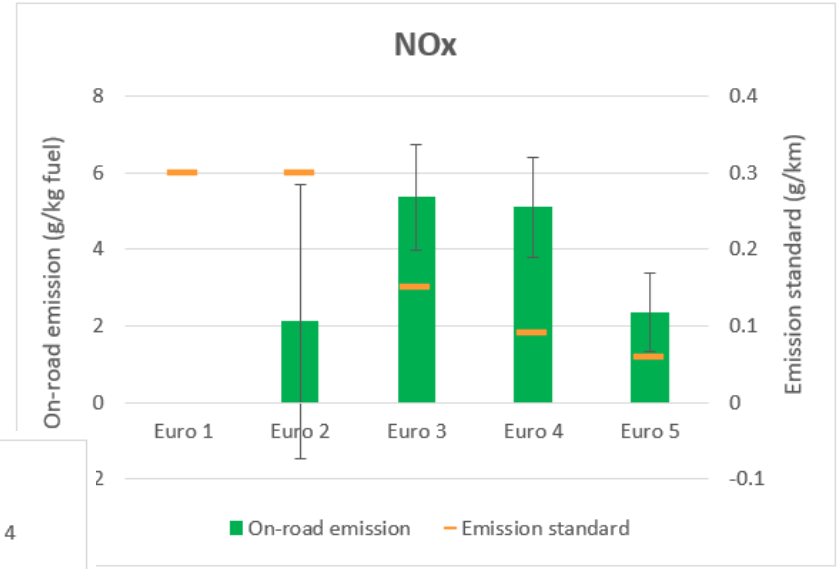
Roadside (remote emission sensing) measurements



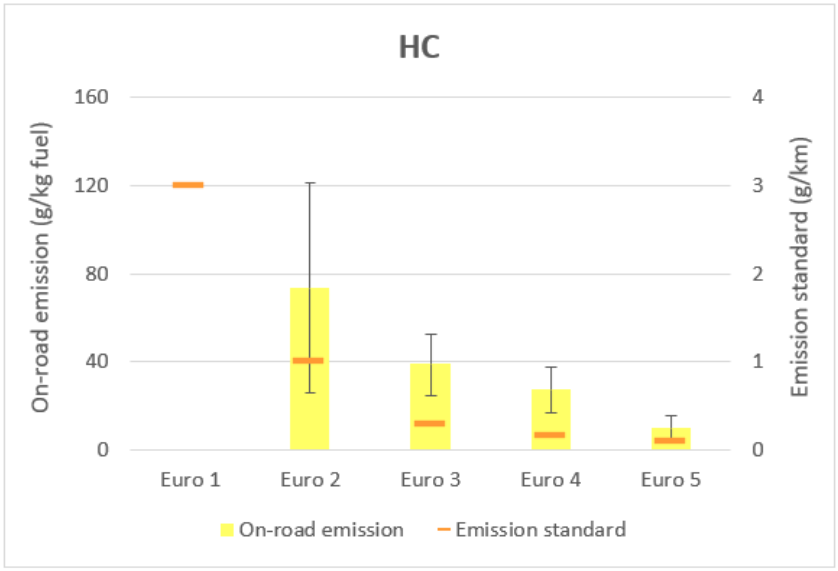
% drop from Euro 2 to Euro 5	
Emission standard	-82%
On-road emissions	-87±8%

≈500 LVs measured in Leuven, Paris and Barcelona

Evolution of measured on-road fleet average emissions vs evolution of Euro limits



% drop from Euro 3 to Euro 5	
Emission standard	-60%
On-road emissions	-48±32%



% drop from Euro 2 to Euro 5	
Emission standard	-90%
On-road emissions	-68±28%

L-vehicles Emissions and Noise mitigation Solutions

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Preliminary Conclusions

Exhaust gas emission measurement

- Only selected commercially available PEMS equipment suitable for bigger motorcycles
- Equipment with restricted significance possible for smaller vehicles. Further development and commercialisation necessary.
- Crux: assessment of the exhaust mass flow, especially for low cylinder number
- Lab measurements with real world driving traces possible for lower power demands --> smaller vehicles

Preliminary Conclusions

Fleet emission I

- Type approval vs. On-road measurement
  - Difference between TA emission and on-road emission levels
  - Influence of driving style
- Type approval measurements
  - Average fleet emission well below the limits
  - Outliners partly way over or considerably below the limits

Preliminary Conclusions

Fleet emission II

- On-road emission
  - LV fleet average on-road emissions seem to be reduced in the same pace as the Euro emission limits
  - Big difference between high-emitters and low-emitters
  - Big challenge for roadside instruments to measure LV pollutant emissions

Thank you for your attention!

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This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101056777

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