iPEMS use for advanced inspection and maintenance (I/M) methods to identify high emitters

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Outline

- Introduction to Periodic Technical Inspection (PTI)
- The parSYNC iPEMS Solution
- Enhanced PTI Test Pilot – Introduction
- Comparisons of Enhanced PTI Results against Standard PTI Results
- NOx representation on the PTI Test
- In-depth Study of a High Emitting Vehicle
- Conclusions

Periodic Technical Inspection (PTI) Today

- The European Union methods of inspection and maintenance, Periodic Technical Inspection (PTI) for exhaust emissions are mostly regulated by Directive 2014/45/EU:
  - Correct performance of complex exhaust after-treatment systems are verified only by visual inspection,
  - Requires different emission tests based on vehicle engine type:
    - Positive ignition engine emissions use a certified exhaust gas analyzer to determine:
      - Gaseous emissions (CO, CO_2, O_2, HC) do not exceed OEM/vehicle type specified thresholds,
      - Lambda coefficient not outside OEM specified range, or if not specified not outside 1±0.03,
      - OBD read-out does not indicate significant malfunction.
    - Compression ignition engine emissions use certified opacity meter and protocol to determine:
      - Opacity does not exceed OEM/vehicle type specified thresholds.
- Directive 2014/45/EU is out of date:
  - No check for relevant pollutants such as NOx and PN,
  - There are concerns around the sensitivity of the smoke opacity method to detect particulate emission issues from vehicles fitted with particulate filters.

PTI Tomorrow

- Post Dieselgate, European emission measurement is progressing:
  - EU has implemented PMP and RDE protocol for vehicle type-approval testing, with measurement of CO, NO_x, HC+NO_x, PM and, from Euro-5, measurement of PN,
  - Some member states are introducing new PTI regulations in advance of EU regulation:
    - Netherlands, Germany and Belgium for PN for diesel vehicles post Euro-5,
    - The CITA NOx Taskforce are working toward the addition of NOx measurement to PTI procedures,
  - EU regulates OBM CO_2 monitoring for new vehicles from 2021, with PTI procedures to be defined.
- But there is much progress yet to be made:
  - Particulate protocol, measurement techniques & thresholds to be tested,
  - NOx protocol, measurement & threshold to be developed and tested,
  - CO and CO_2 protocol, measurement & threshold to be developed and tested,
  - Advocating EU homogeneity and building future-proof systems.
- Existing PTI equipment cannot meet the new requirements.

The new parSYNC FLEX iPEMS

Gases – CO, CO_2, NO, NO_2 + **HC and O_2**

Particulates - Ionization, Scattering, and Opacity, **with advanced temperature control**

Enhanced chiller and volatile particle removal

Hot-swap Milwaukee Li-Ion batteries for full-day of testing

Onboard display and data storage + WiFi Access-point

Full CAN + support for external sensors

Integrated GPS and Ambient Pressure, Temperature, Humidity

Integrated wireless OBD reader for LD and HD

... and still light-weight (10 kg) and installs in minutes

Enhanced PTI Test Pilot – Introduction

Aims and Objectives of the PTI Pilot Test Campaign

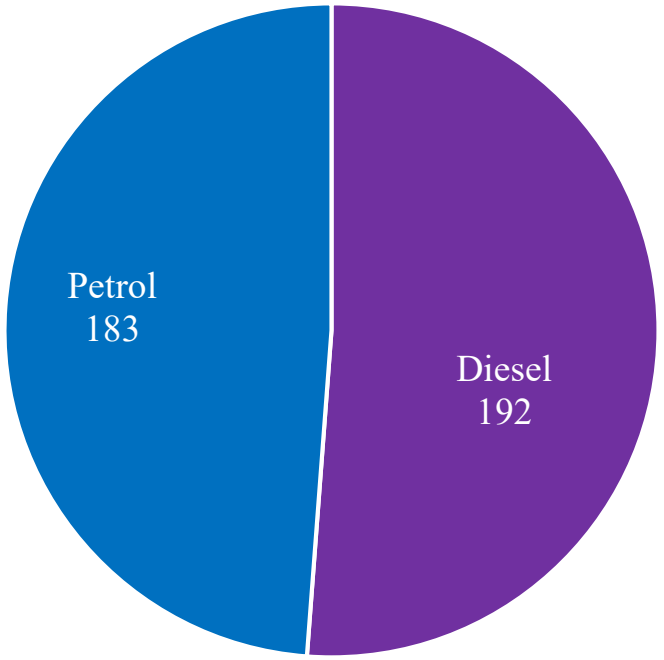
Minimize Test Time | Set Vehicle Conditioning | Check Repeatability | **Compare to current PTI** | **NOx Protocols**

Vehicle Conditioning and repeatability objectives will not be addressed in this presentation.

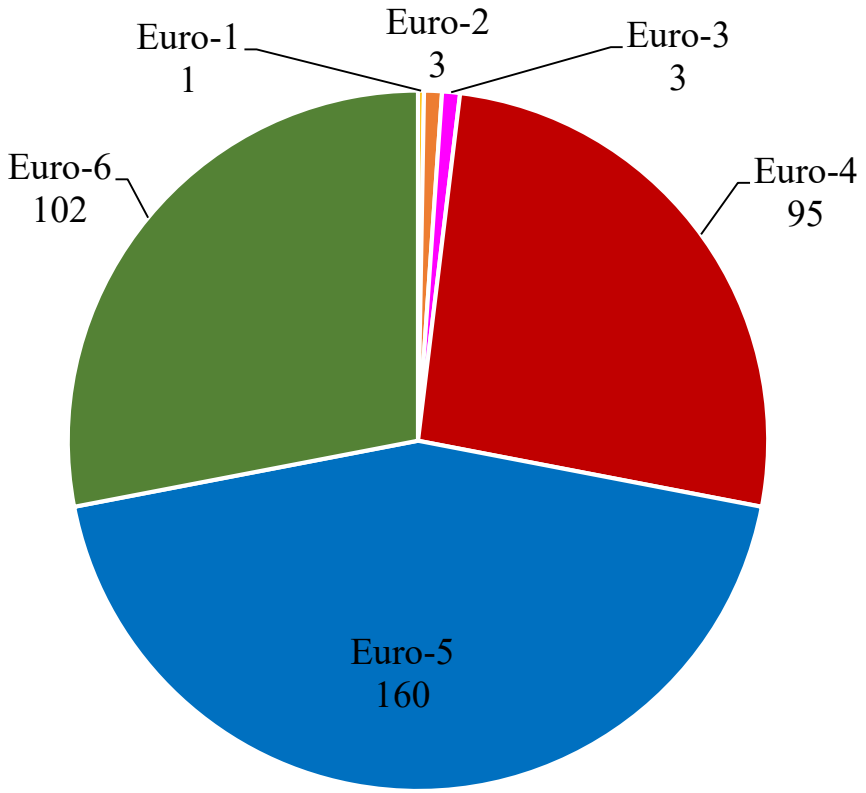
Fleet Composition – Vehicle Information

- The results presented are part of an *ongoing* trial at Opus, Sweden.
- At time of data processing, 375 vehicles had been tested (total now above 450 vehicles, and counting).

Fuel Type of Vehicles



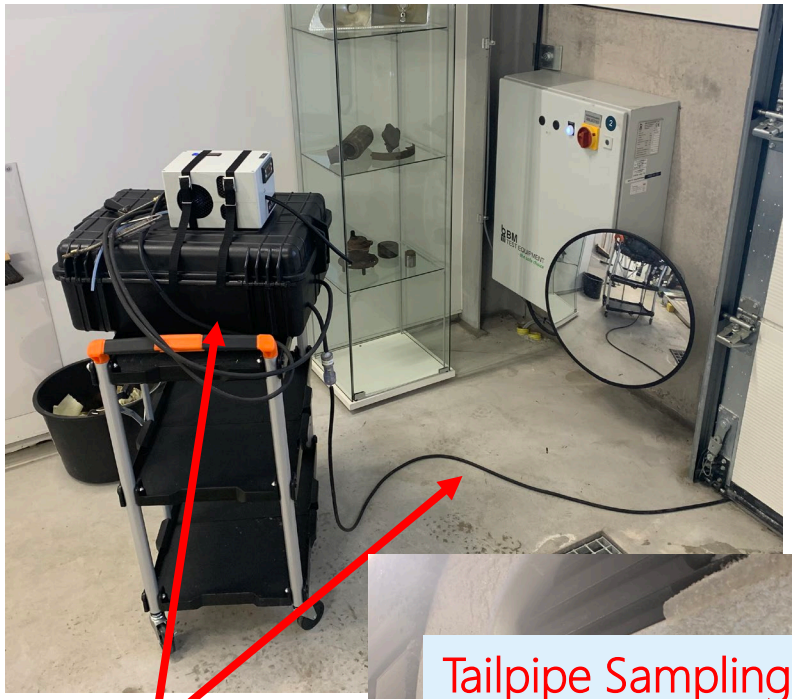
Emissions Standards of Tested Vehicles



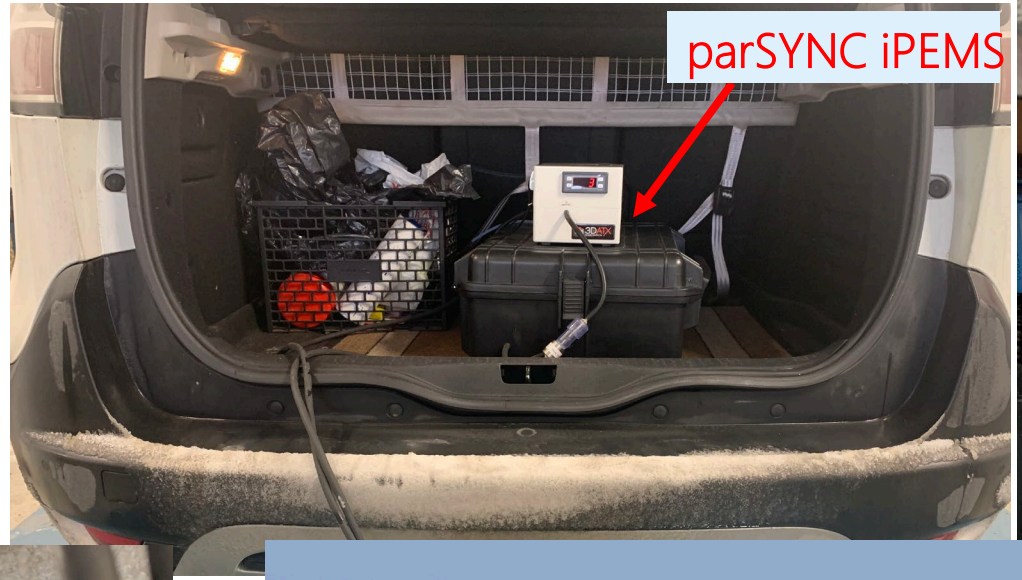
Device used - The parSYNC iPEMS

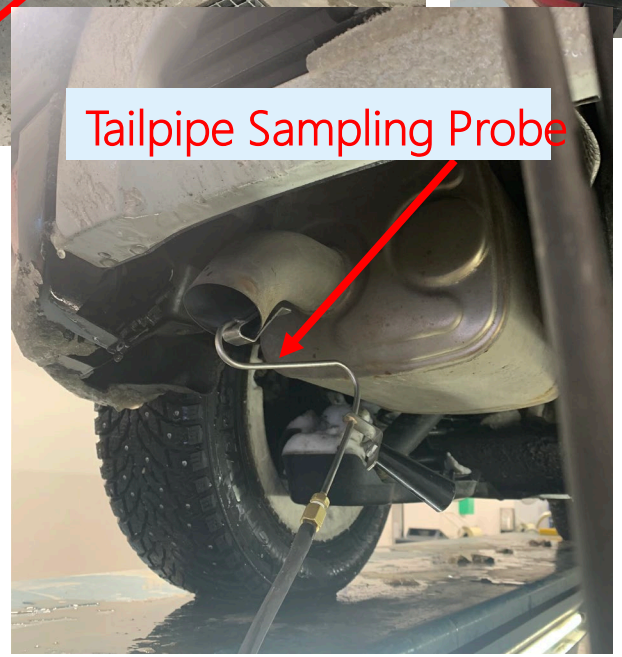
- **Lightweight & Easy To Use**
  - Total System Weight: 6.7 kg (22.1 lb)
    - parSYNC® Weight: 4.1 kg (13.7 lb)
    - CUBE™ Weight (with one battery): 2.6 kg (8.4 lb)
- **Battery Life**
  - 4-5 hours typically
- **Tier 1 GasMOD™ Sensor Cartridge**
  - Electrochemical: NO (0-5000ppm) & NO_2 (0-300ppm)
  - NDIR: CO_2 (0-20%), CO (0-15%)
- **Tier 1 Particulates Sensor Cartridge**
  - PN/PM (10 to 10,000nm = 0.01 to 10µm)

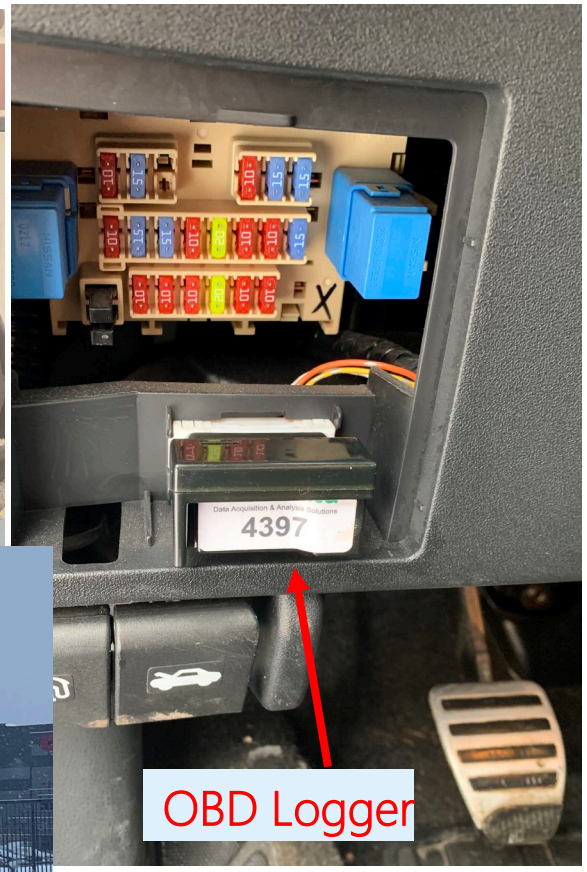
Test Setup



parSYNC warmup and zeroing while vehicle is being prepared

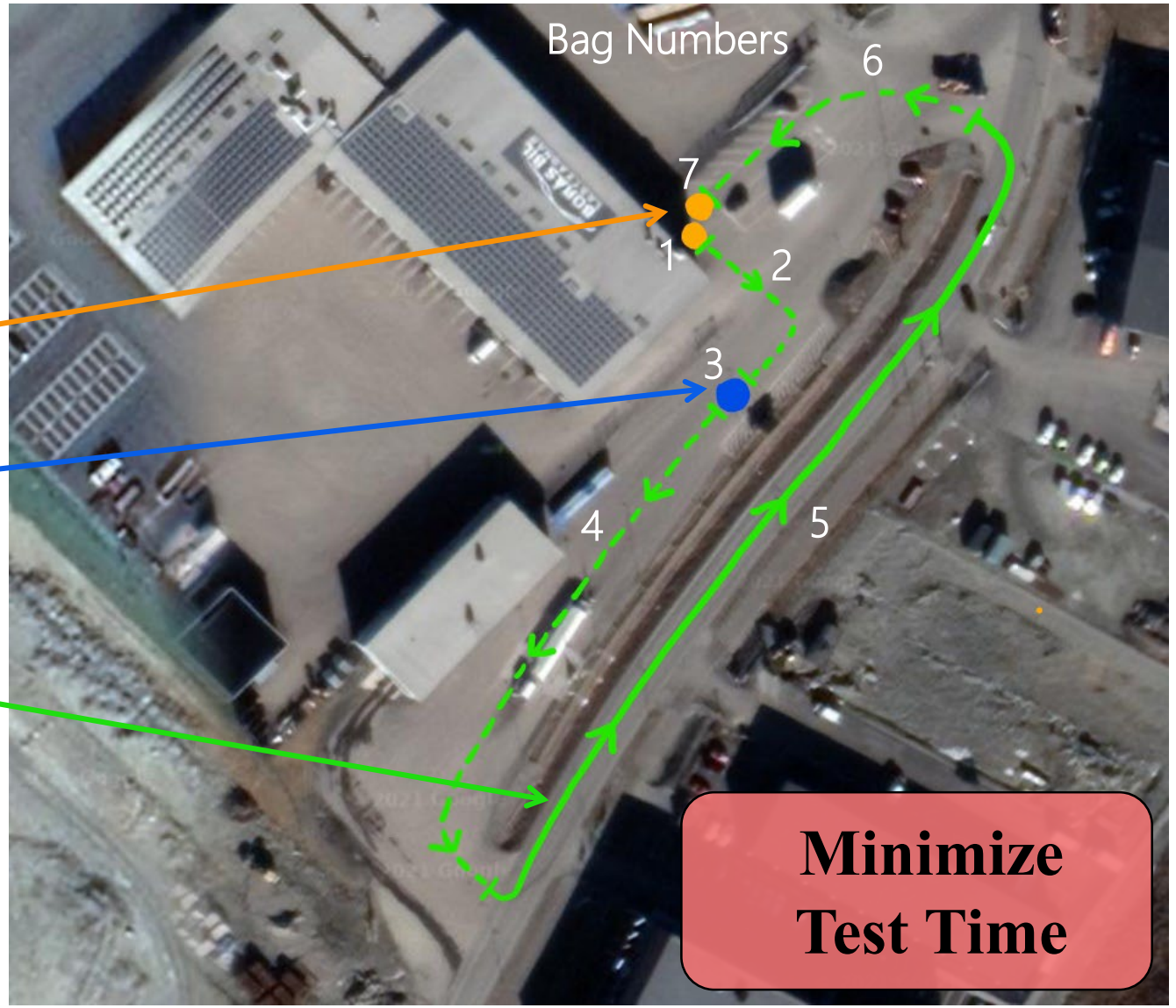






Final Test Protocol– Extra 5 Minutes onto PTI

Bag No.	parSYNC Location	Description
0	Bench	Sample clean air while parSYNC is on the bench.
Zeroing	Bench	Zero the parSYNC. Idle the vehicle.
0	Vehicle	Move parSYNC to vehicle. Sample exhaust gas for ~10 seconds.
1	Vehicle	PN protocol – 60 seconds of idle – conducted while car is at garage
2	Vehicle	Drive to emissions shed
3	Vehicle	NOx High Idle – Follow standard PTI protocol for gasoline and diesel vehicles
4	Vehicle	Drive to NOx Acceleration test start point
5	Vehicle	NOx Acceleration – *Idle for 10 seconds*, then accelerate quickly to 30 kph, then brake normally (not hard) to a complete stop, *idle for 10 seconds*
6	Vehicle	Drive back to garage.
7	*Vehicle*	*PN protocol – 60 seconds of idle*
8	Bench	Disconnect parSYNC. Sample clean air for at least 60 seconds.
Zeroing	*Bench*	*Zero the parSYNC.*

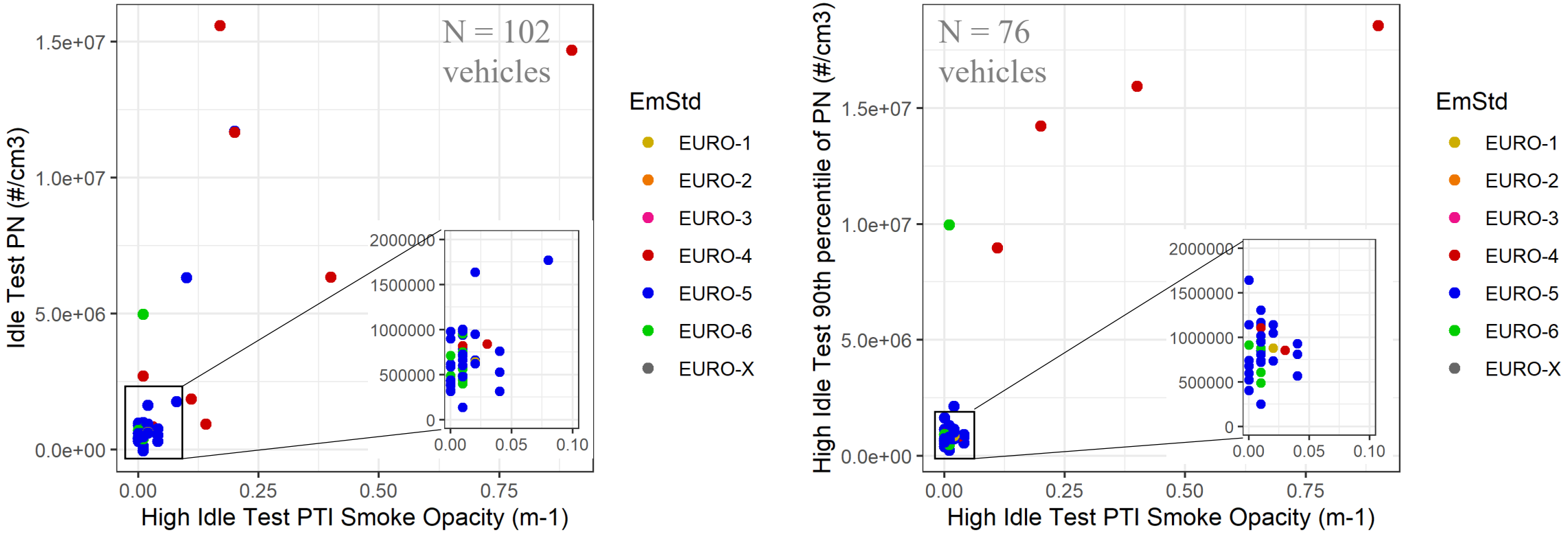


PTI Pilot Data – Comparisons of Enhanced PTI Results against Standard PTI Results

Compare to current PTI

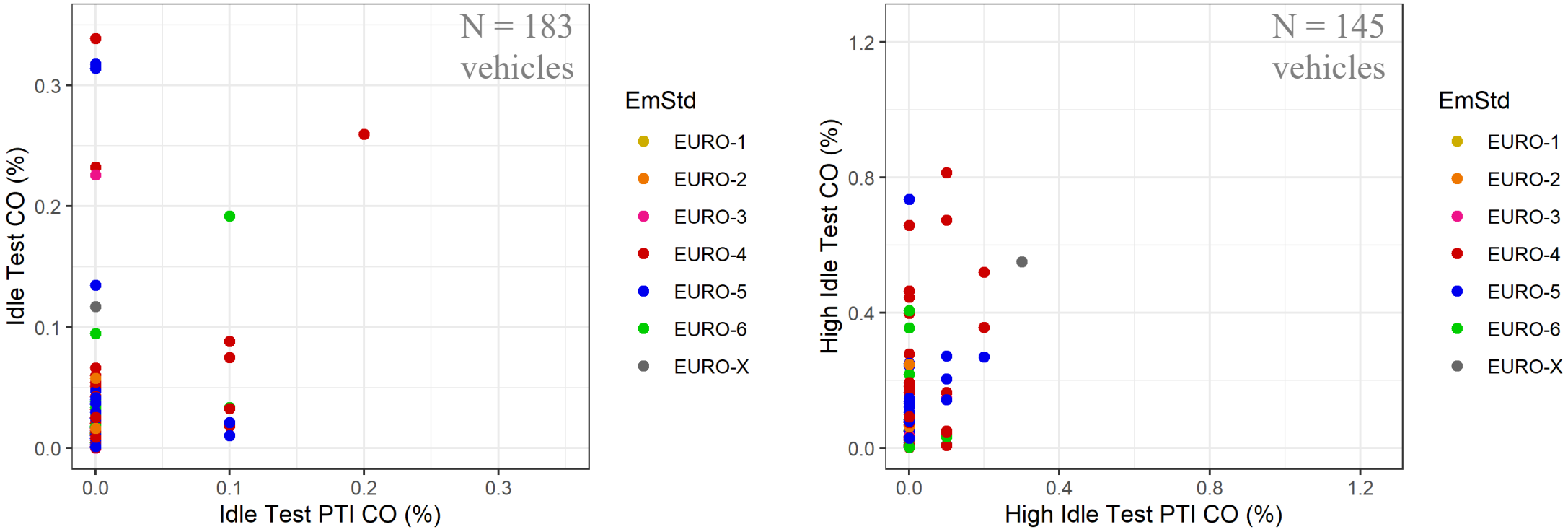
Comparison of Enhanced PTI PN against Current PTI Smoke Opacity

Some correlation seen between PN and smoke opacity from Idle and High Idle tests, but only for the highest emitters



Comparison of Enhanced PTI CO against Current PTI CO

Poor correlation seen between CO from Idle or High Idle, and PTI Idle and High Idle CO. PTI CO sensor simply reports “0.0” for most readings.



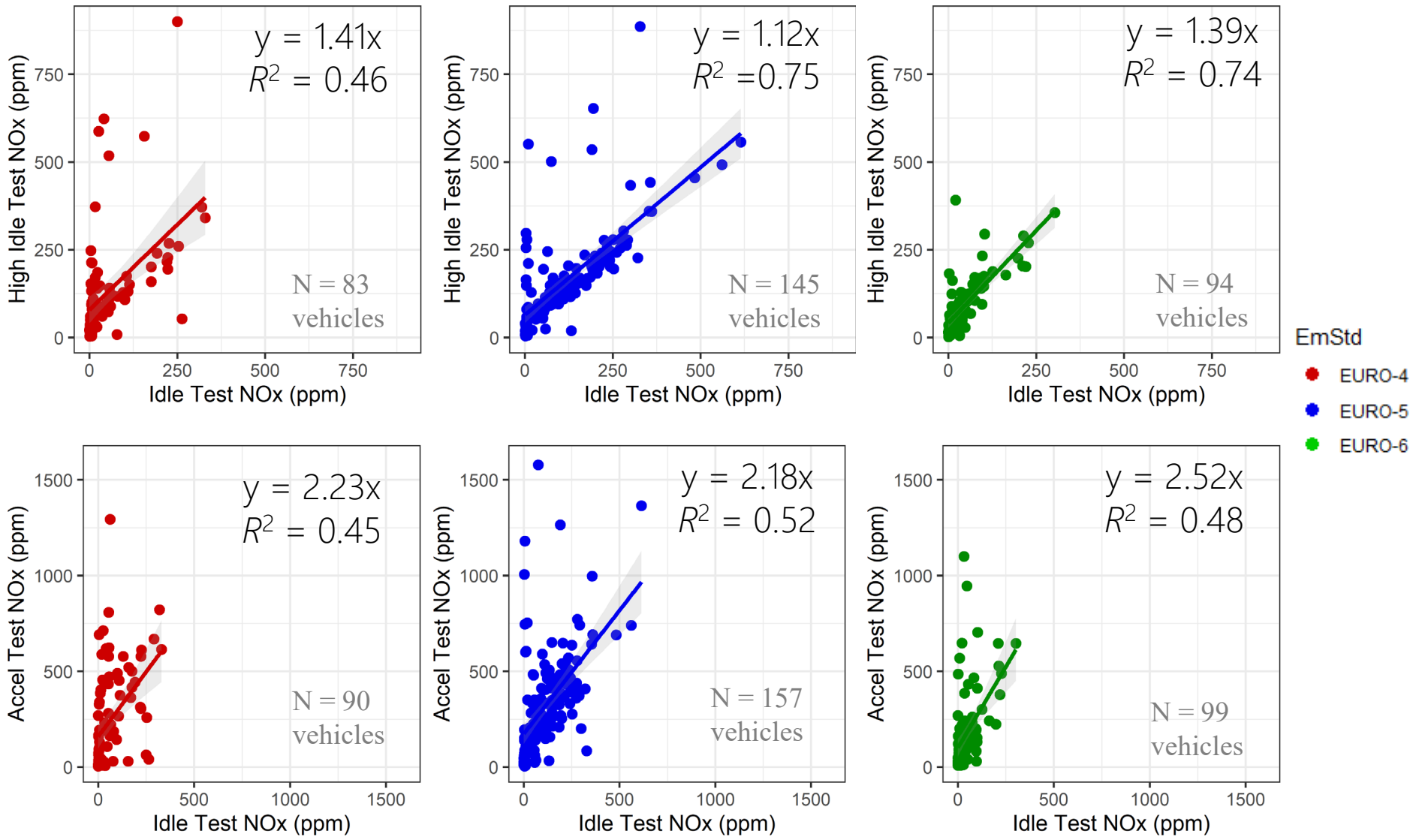
NOx Representation on the PTI Test

NOx Protocols

Comparing NOx results between different test types

What type of protocol is sufficient?

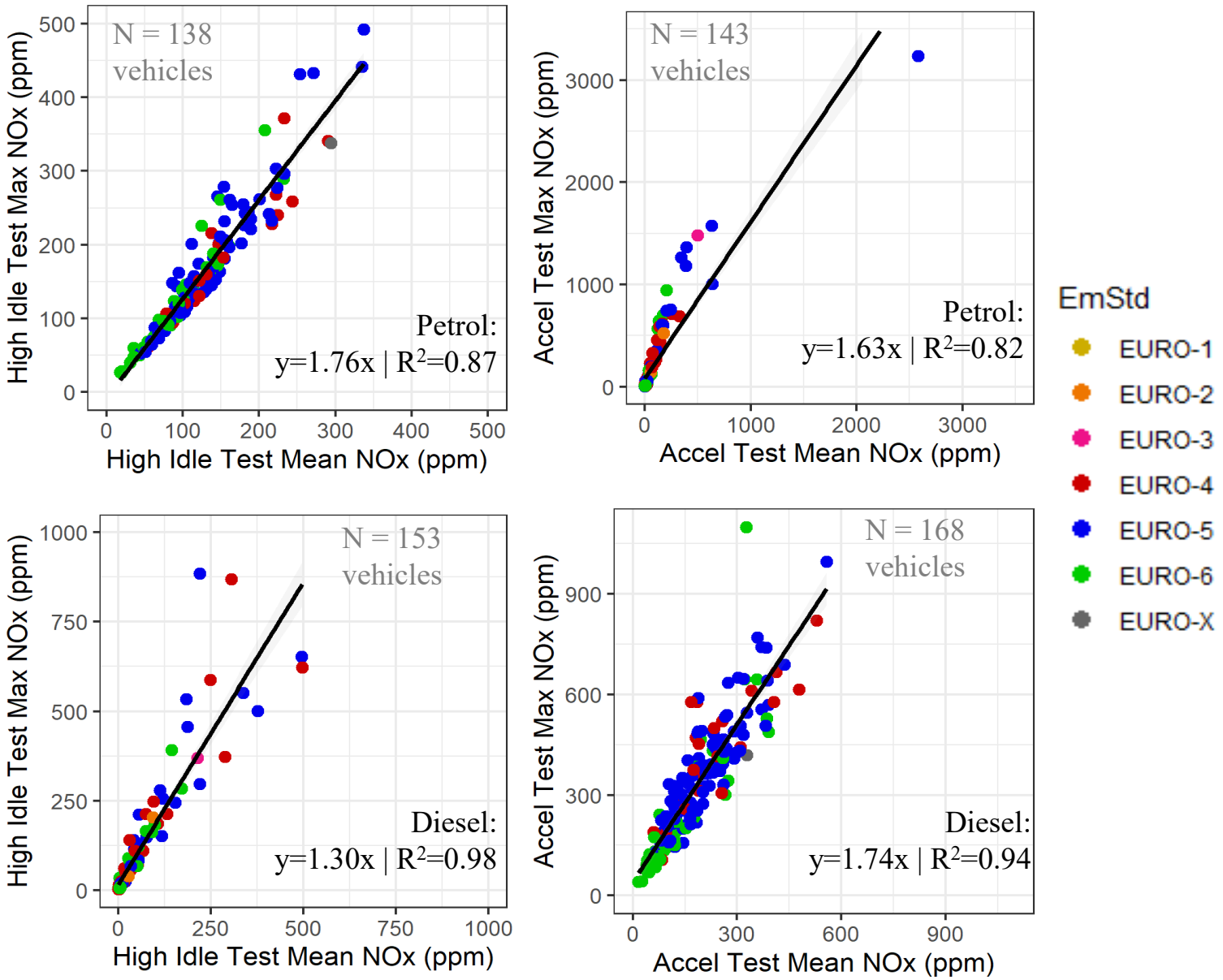
Idle test misses some higher emitters – indicates a loaded test is required for NOx.



Relationship between Average and Peak NOx Values

Strong correlations suggest average and maximum values could be interchangeable.

The average can be used if OBD data is available, but peak value can be used otherwise (with suitable pass/fail limits).



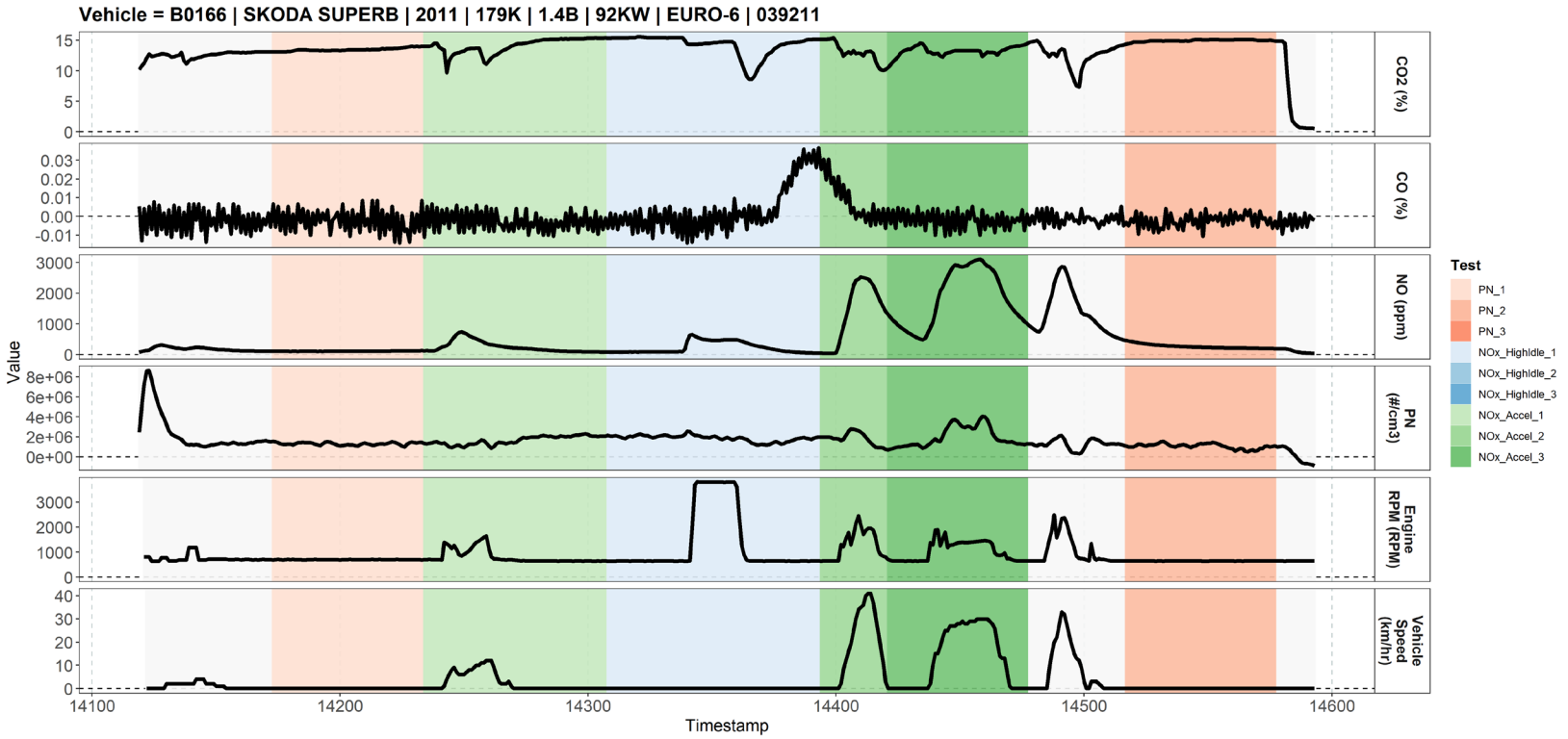
Identification of a High NOx Emitting Vehicle

NOx Protocols

Vehicle with Anomalously High NO Emissions

One petrol vehicle had anomalously high NO emissions

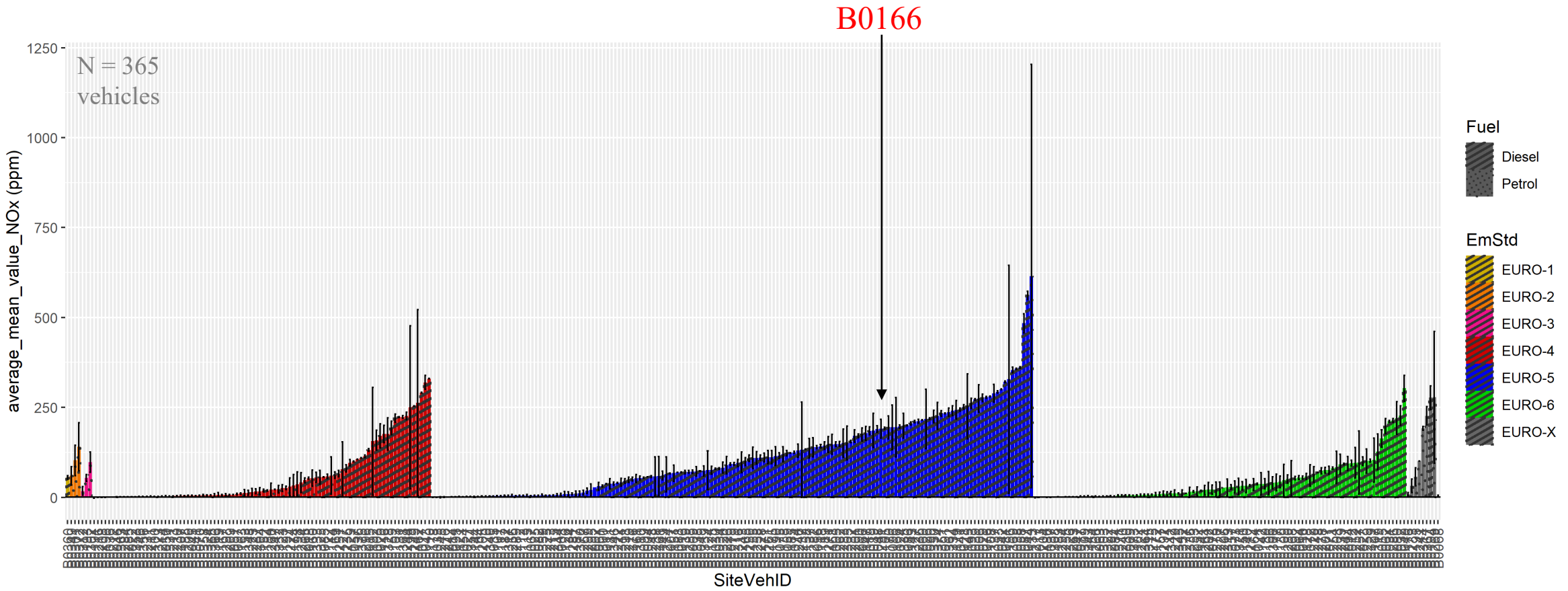
SiteVehID	Make	Model	Model Year	Odometer (km)	Engine Size (L)	Fuel Type	Engine Power (kW)	Euro#
B0166	SKODA	SUPERB	2011	179	1.4	Petrol	92	Euro-5



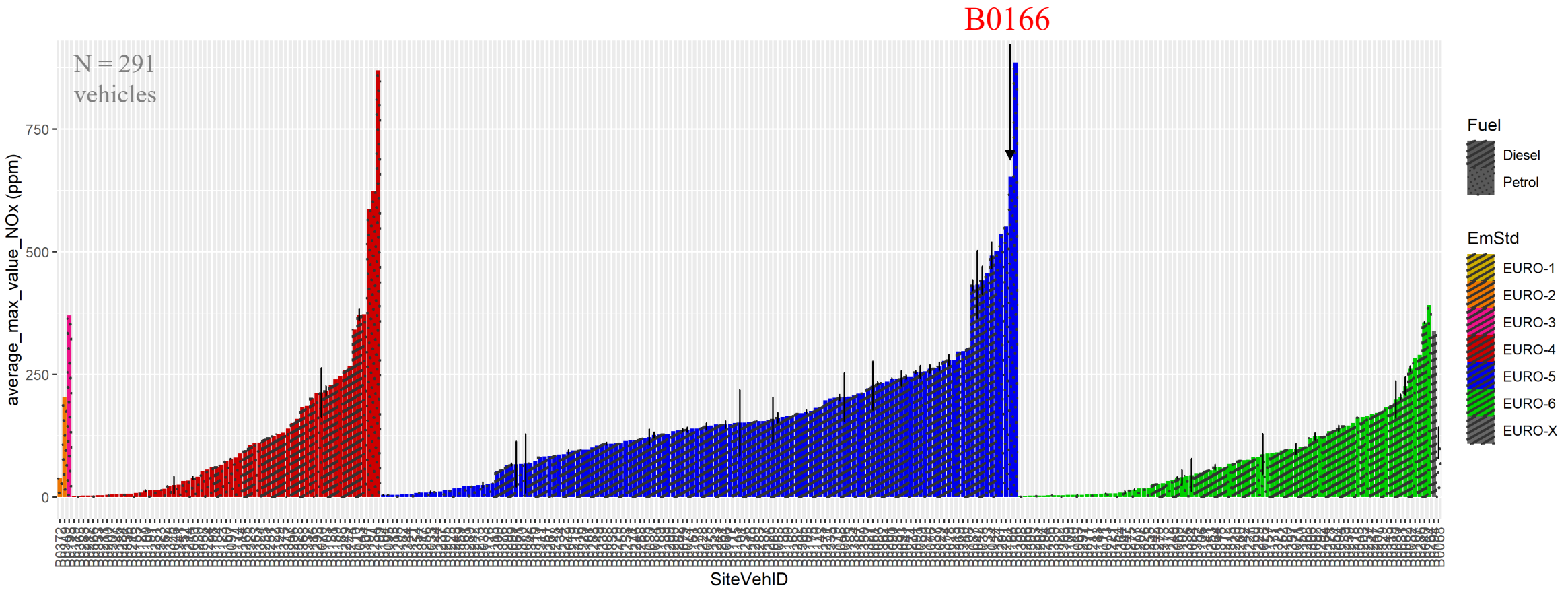
No clear reason for the high emissions was identified, (low OBD information availability).

The vehicle passed its official PTI test with low emissions of other (measured) pollutants.

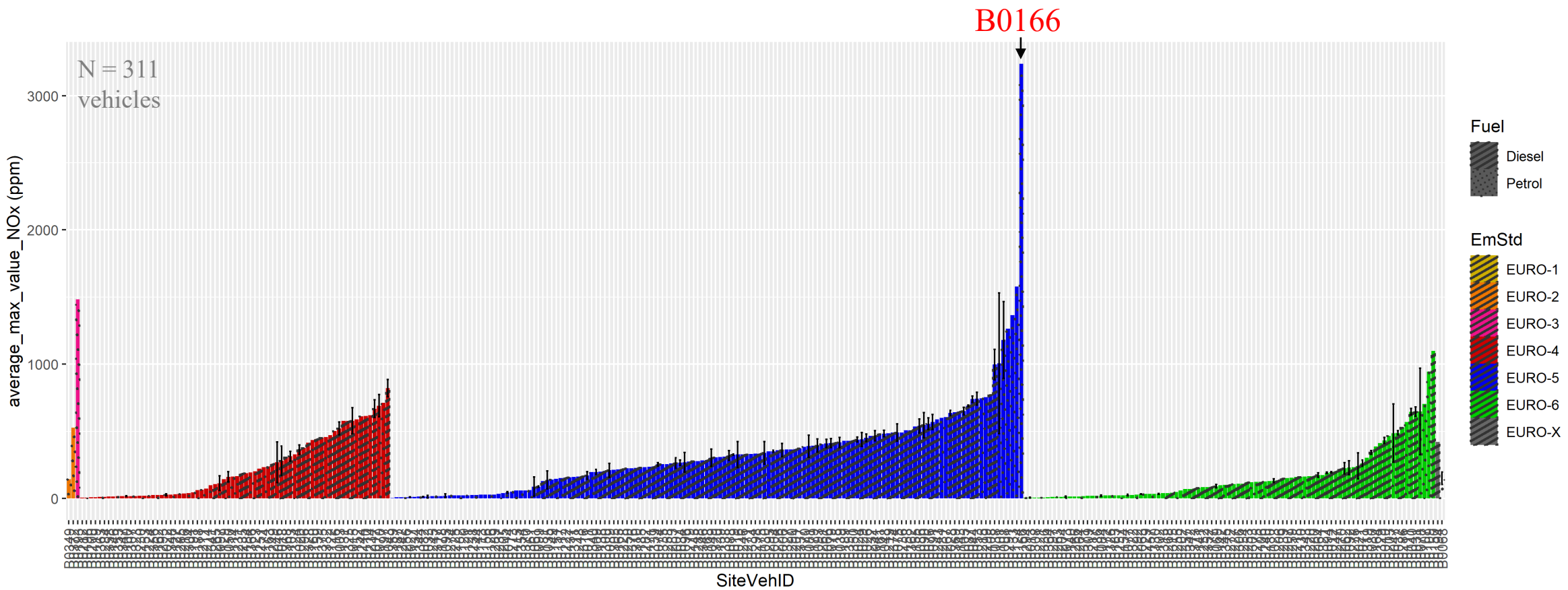
Idle Test – Mean NOx Concentrations



High Idle Test – Max NOx Concentrations



Acceleration Test – Max NOx Concentrations

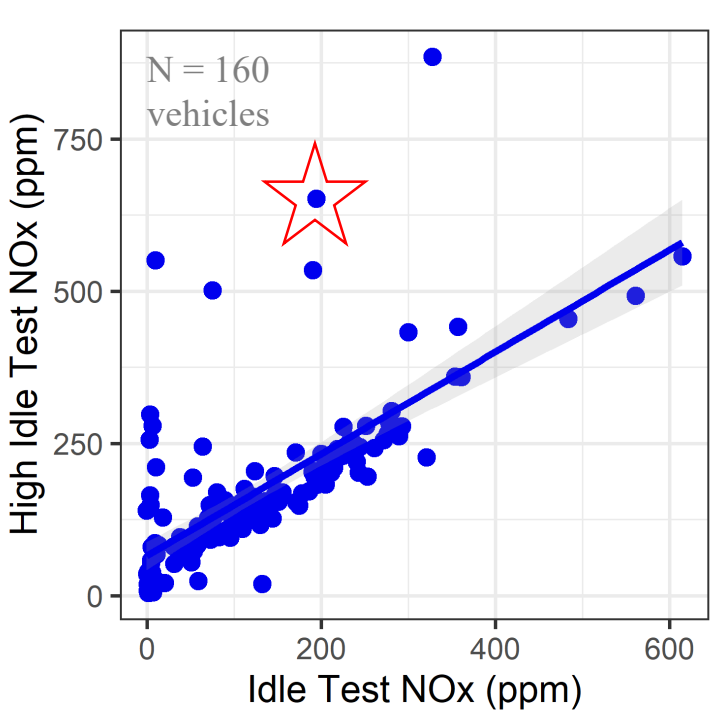


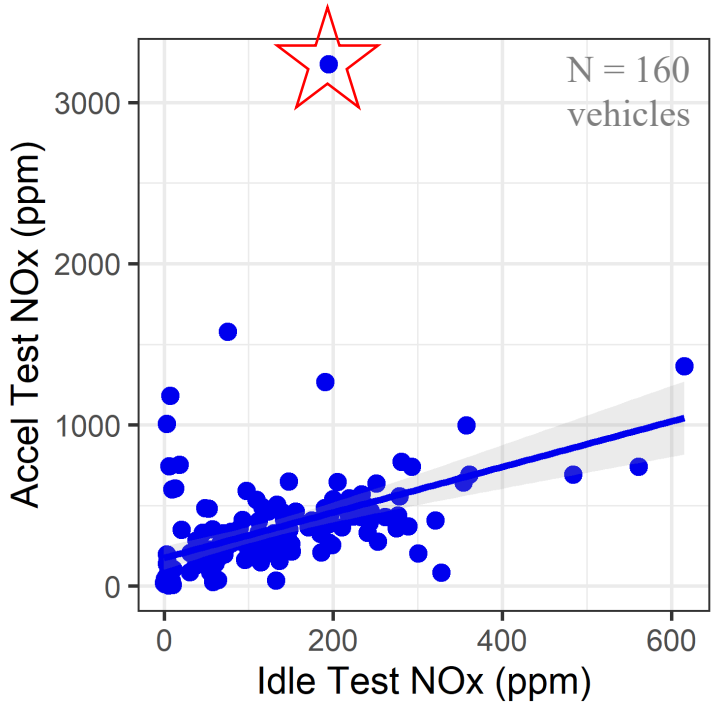
Vehicle with Anomalously High NO Emissions

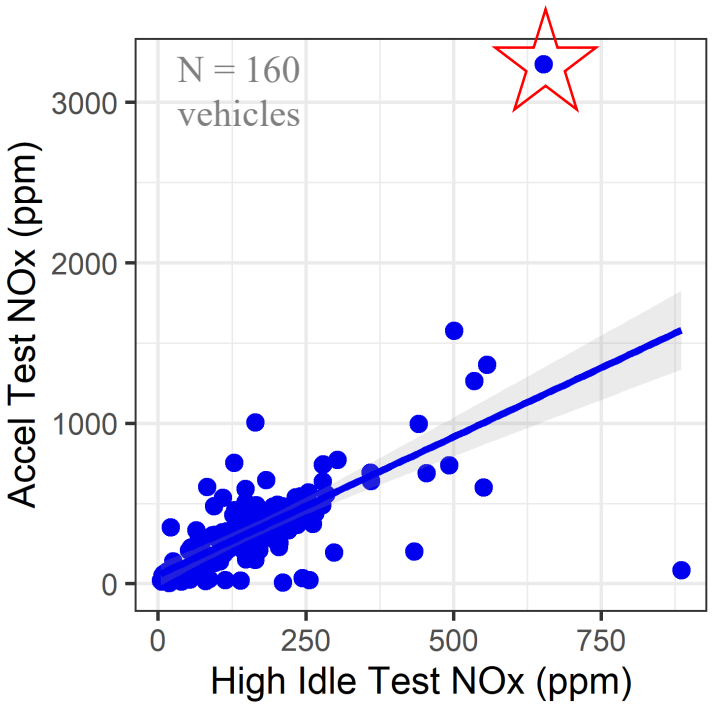
How well do the NOx tests represent this high emitter?

The vehicle does not present as high-emitting on the Idle test, but is the greatest emitter on the High Idle test and Acceleration Test.

The Acceleration test is the one that highlights the emissions to the greatest magnitude above the rest of the Euro 5 vehicle fleet.







Conclusions

- Additional time for Enhanced PTI addition to current PTI protocol is only 5 minutes with use of an iPEMS.
- Some positive correlation seen between smoke opacity and PN results for vehicles tested, but only for the highest emitters
- Poor correlation was seen between CO results. This is mainly due to reduced sensitivity of current PTI CO measurement equipment
- A loaded test is required for NOx measurement.
- NOx has good agreement between mean and max value on the 2 loaded test types (high idle and acceleration) – indicates interchangeability between methods.
- A high emitting vehicle was identified most clearly by a dynamic acceleration test. A high idle test was also able to identify this vehicle as a high emitter (a low idle test was not) – supports need for a loaded NOx test.

Thank you for listening

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Further Info

For full 1Hz traces of the tested vehicles:

PTI Pilot Parts 1 and 2: https://3datx.com/ptipilot/

PTI Pilot Part 3 (in-progress): https://3datx.com/request-reports/