

Using real-world dynamic PEMS data
to design effective urban air quality
improvement measures, and
to quantify the improvement

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Agenda



- Background and credentials
- Intensive PEMS testing in practice
- Nature of the tailpipe emissions problem
- Urban access control
- Traffic planning

Emissions Analytics' credentials



- Founded in 2011
- Headquartered in Winchester, with operations in London and Los Angeles
- 10 employees, currently expanding in EU
- Specialist in PEMS testing and data analysis
- 1000 vehicles tested
- Expert in high-efficiency real-world data collection
- RDE-compatible testing conducted since 2011
- Works with OEMs, Tier 1 suppliers, fuel and chemical companies, regulators, consultancies, consumer media

INTENSIVE PEMS TESTING

Benefits of PEMS

- Real on-road testing using PEMS is a powerful research method
- Authentic and cost effective
- Works on all vehicle types
- No permanent vehicle modification required
- Flexible location
- High rate of data acquisition – 1 Hertz
- Precision approaching laboratory levels



Equipment (1)

- SEMTECH-DS and Ecostar-FEM
- Portable Emissions Measurement System connects to tailpipe
 - Captures emissions for CO₂, CO, NO, NO₂, total hydrocarbons
 - At 1 Hertz
- Air temperature, pressure, humidity
- GPS for speed and altitude
- Engine data via CANBUS
- Fuel economy derived via carbon balance
- Weight addition ~95kg



Equipment (2)

- Pegasor Mi2
- Real-time tailpipe concentrations
- No filter papers
- Particle mass and number
- Sub-23nm particles

- Flexible, economic, real-world data collection
- Challenges around calibration and repeatability



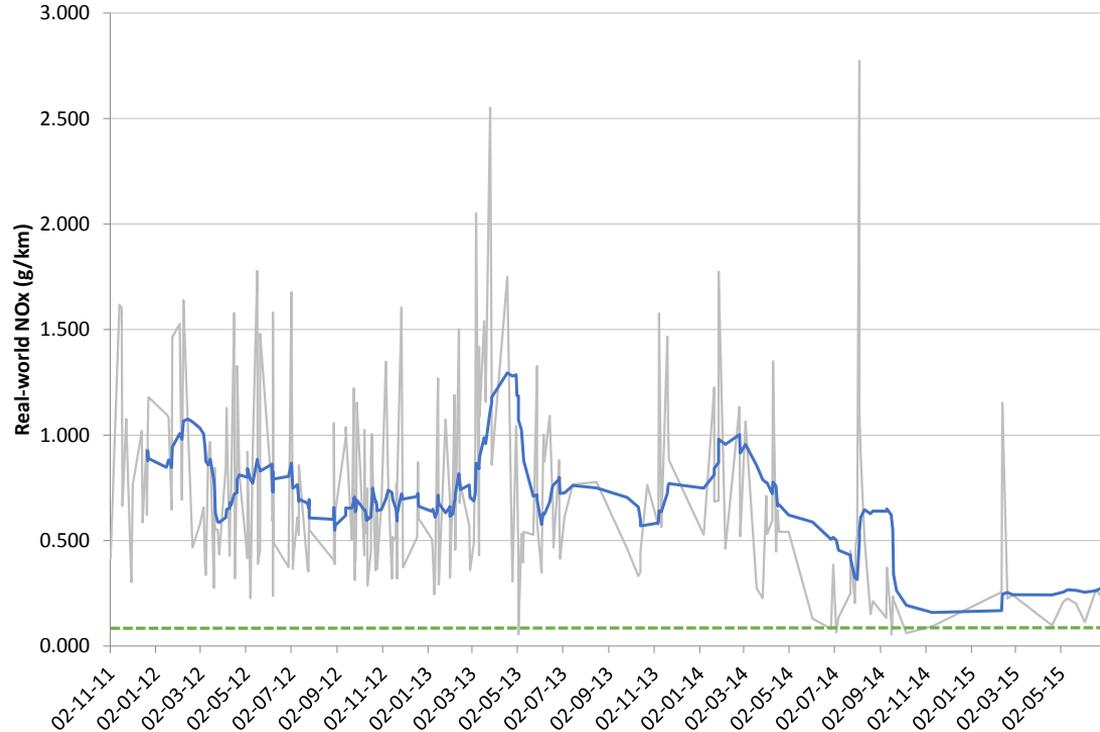
Current activity

- 200-250 passenger cars tested per year in EU and US
- Testing primarily in London, Los Angeles, Continental Europe
- New, commercially available vehicles – cars and vans
- Typically 1,000 miles+ on odometer
- Route based on typical driving
- Controlled conditions – driver, weight, ambient
- Plus specialist testing of
 - Non-road mobile machinery
 - Heavy duty commercial
 - Agricultural

THE TAILPIPE PROBLEM

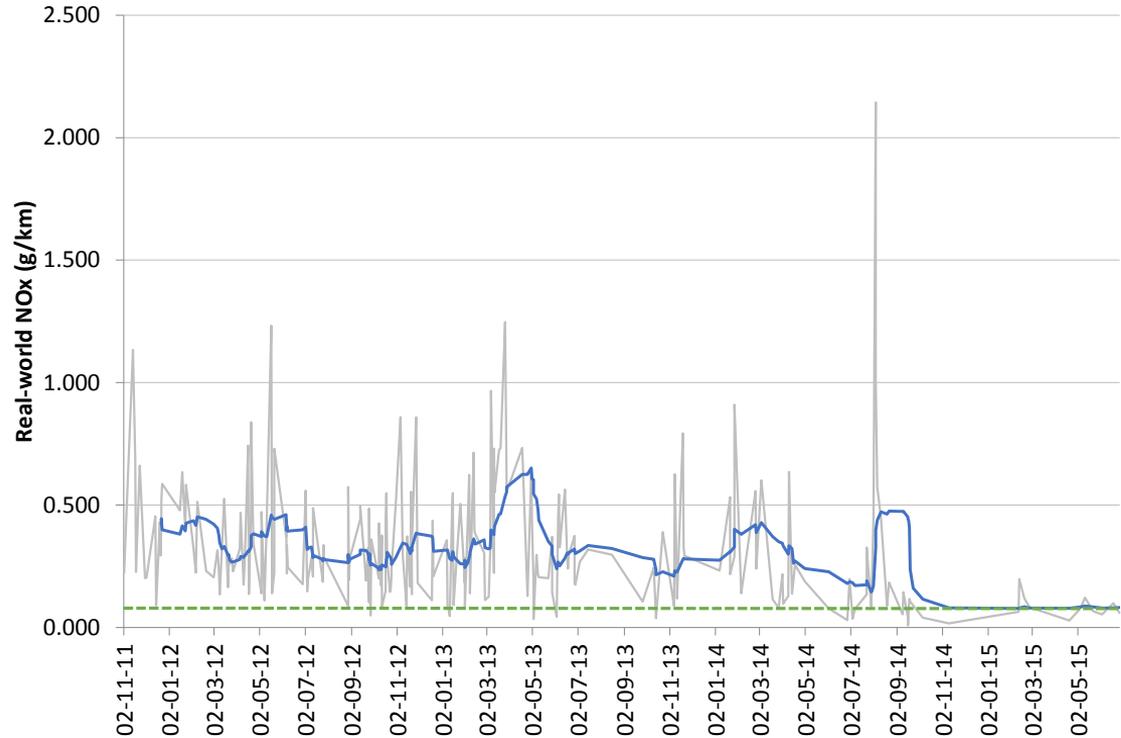
NO_x latest trends

- Euro 5 and 6 diesels
- Rolling 12-month average of exceedance factor
- Step-change improvement from Q2 2014
- But recent trend less clear
- 5 have met standard
- Spikes due to 4x4s



NO₂ latest trends

- Not regulated
- But important for road-side pollution
- Latest results suggest NO₂ levels meet total NO_x regulated level on average
- Very low fNO₂ is possible with certain after-treatment systems



NO_x key statistics

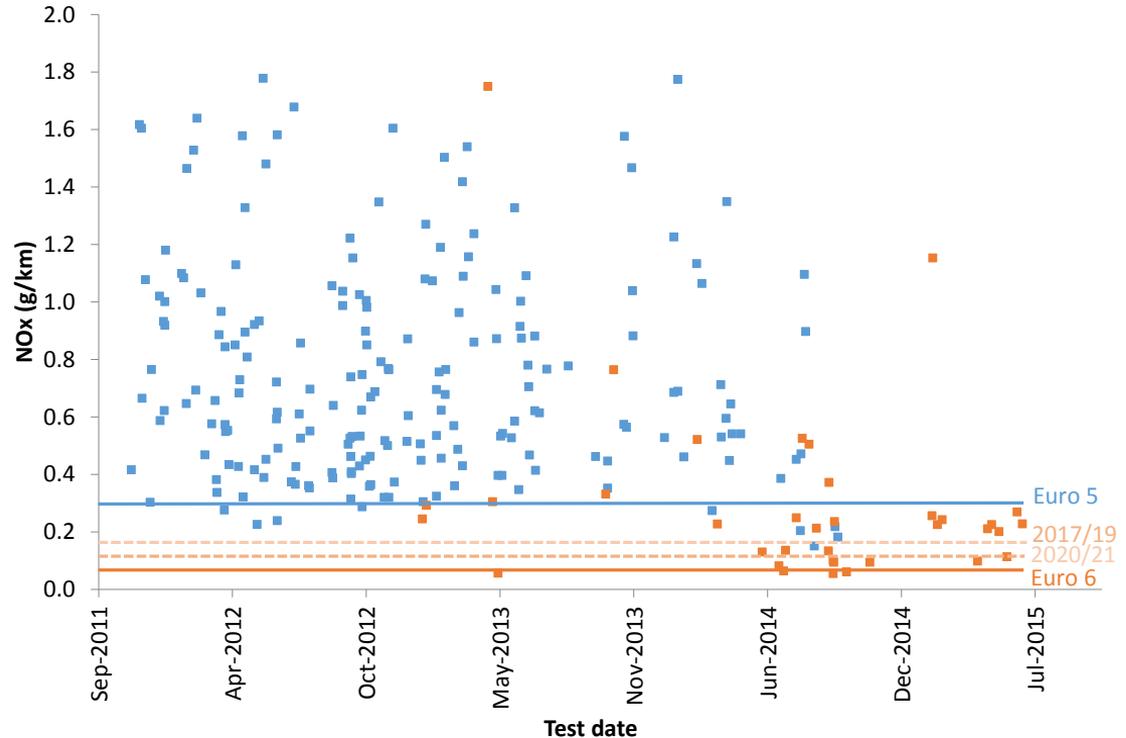


- From Emissions Analytics' database, at OEM level
- Based on 410 tests
- Diesel Euro 6 emissions falling – down from 5.1 conformity factor in Q1

	Diesel Euro 5	Diesel Euro 6	Gasoline Euro 5/6
Real-world NO _x (g/km)	0.773	0.299	0.049
Average Conformity Factor	4.3	3.7	0.8
fNO ₂ – minimum %	27	17	0
fNO ₂ – mean %	44	48	24
fNO ₂ – maximum %	66	80	72
fNO ₂ % – standard deviation	14.5	19.4	27.7

Will Real Driving Emissions help?

- Conformity factor initially 2.1 – 168 mg/km
- Further increased by exclusions due to boundary conditions – details TBD
- PEMS test-to-test variability of 30%, so OEMs will need to target ~129 mg/km
- 29% of Euro 6 diesels already meet this limit



AIR QUALITY RATINGS

Vehicle accreditation scheme (1)



- Vehicle rating scheme based on their real-world NO_x emissions
- Using existing database and test programme
- To apply across European Union
- Non-statutory complement to new Real Driving Emissions regulations
- But will also
 - Discriminate between high and low emitters, rather than just pass/fail
 - Factor in NO₂ emissions
 - Be updated for each model year to keep up with new calibrations
- Ratings will be published and put in the public domain
- Manufacturers and consumer media can adopt as independent, voluntary standard
- Similar to EuroNCAP

Vehicle accreditation scheme (2)



- Advisory Board to review methodology on on-going basis, including
 - Imperial College, London
 - University of Cambridge
 - King's College, London
 - International Council on Clean Transportation
 - Planned launch in early 2016
 - 100 Euro 6 cars to have been tested by then
- Robust, independent standard needed to measure and incentivise actions to bring about air quality improvements

URBAN ACCESS CONTROLS

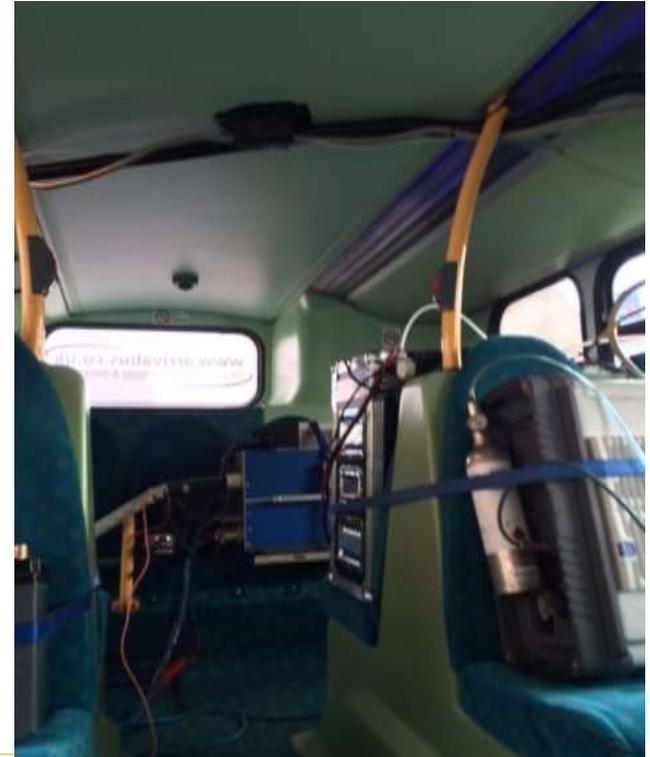
Access criteria

- How to specify the rules for access, or entry charges?
- Using Euro 6 may not be tough enough, as it does not
 - Discriminate between Euro 6a/b and Euro 6c – former currently 299 mg/km
 - Discriminate within Euro 6c – 168 mg/km limit in reality
 - Place on a scale
 - Include NO₂
- Accreditation rating scheme could allow stricter limits and fine-tuning
- Could derive specific rating for urban-only driving
- PEMS testing can be expanded in order to
 - Rate durability of after-treatment systems
 - Validate effectiveness of retrofits
 - Test emissions of light commercial vehicles carrying load

PEMS to validate retrofits

- Clean Bus Technology Fund test work
- Retrofit of efficient climate control and tailpipe NO_x abatement system
- Double decker buses
- Tested on real in-service route, with stops
- Fuel economy, GHG and NO_x emissions, particulate number and mass

- Do these retrofit strategies reduce NO_x in real-world operations?
- Are there any unintended consequences for fuel economy, other emissions and particulates?



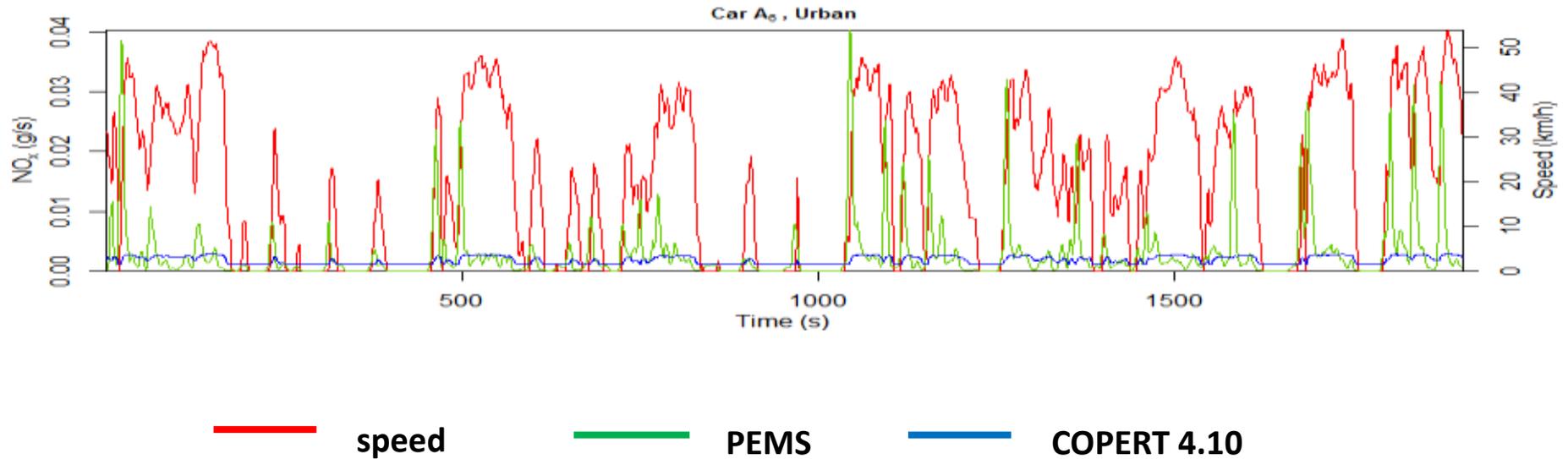
Light commercial vehicle testing

- New test programme to launch in 2015, to be expanded in 2016
- Real on-road comparative testing of vans
- First Euro 6 van just tested
- Different road mixes and driving styles
- Variable payload
- Comparative results to be published in key van media
- Likely future extension of accreditation programme



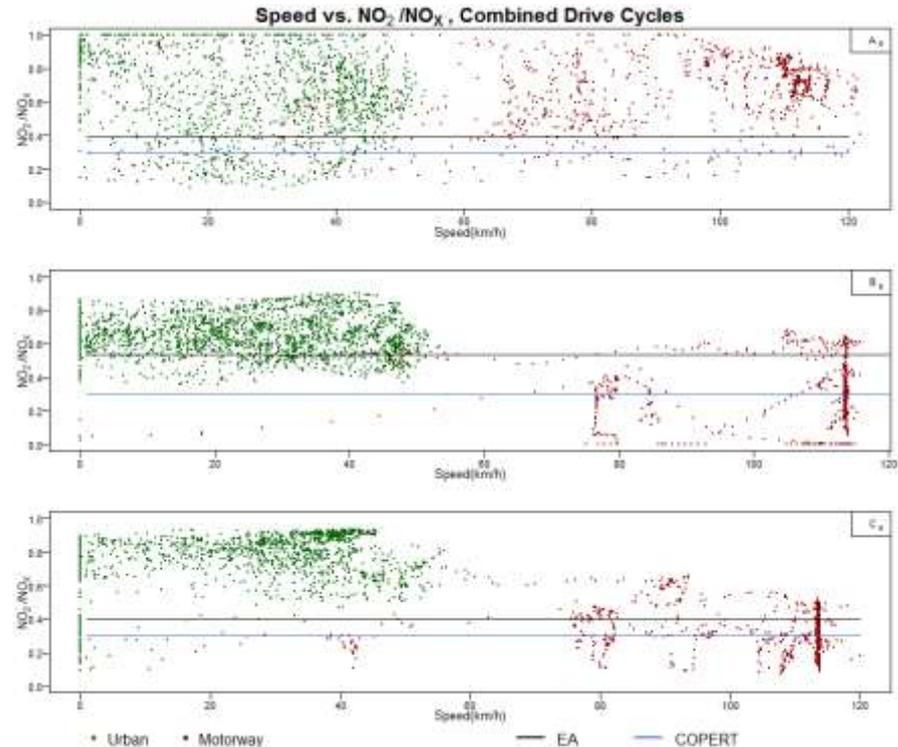
TRAFFIC PLANNING

Limitations of speed-dependency



Use PEMS data to improve models

- COPERT v4.11 assumes a ratio of 30% for Euro 6 diesel cars
- Danger of meeting NO_x target but not solving air quality problem
- COPERT consistently underestimates primary NO_2 emissions in urban areas where public exposure is greatest
- Implies high primary fraction of NO_2 in urban areas, up to ~90%
- Not inherently about PEMS data, but need representative sample due to inter-vehicle emissions variability



Scenarios for PEMS testing



- 20 mph speed limits
 - 20 mph steady-state better than 30 mph transient, but worse than 30 mph steady
 - Speed humps
 - Questionable for emissions, fuel economy, noise and wear-and-tear
 - Bus prioritisation
 - Passenger loading has to be high to compensate for second-order effect on traffic flow in space-constrained urban areas
 - Out-of-hours deliveries
 - Significant opportunity for emissions reduction and fuel saving
 - Traffic light phasing
- Smooth traffic flow often the common factor
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Summary



- Real-world PEMS data can play a key role in improving urban air quality
 - With real-world rating of tailpipe NO_x, more sophisticated urban access controls are possible
 - Accreditation can complement the new regulations to make policy more effective
 - PEMS testing can efficiently cover all categories of vehicle, to ensure no “blind spots”
 - As a complement to access controls, better traffic engineering can contribute to reduced NO_x
 - PEMS data can be incorporated further into traffic models to set realistic factors, represent the car parc better, and show acceleration-dependency of tailpipe pollutants
- Relying exclusively on Euro 6 regulations, even with PEMS, is not necessarily sufficient

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