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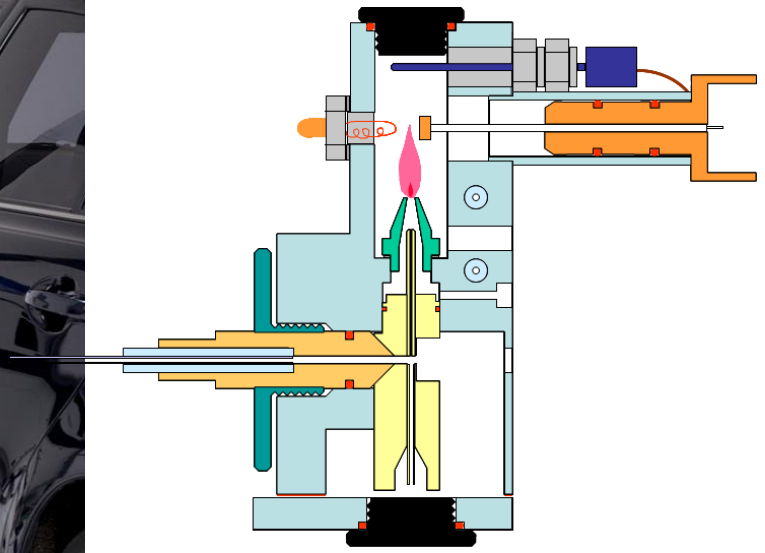
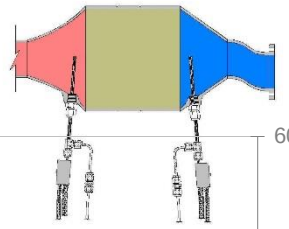
Transient RDE NOx Emissions from Gasoline and Diesel Vehicles

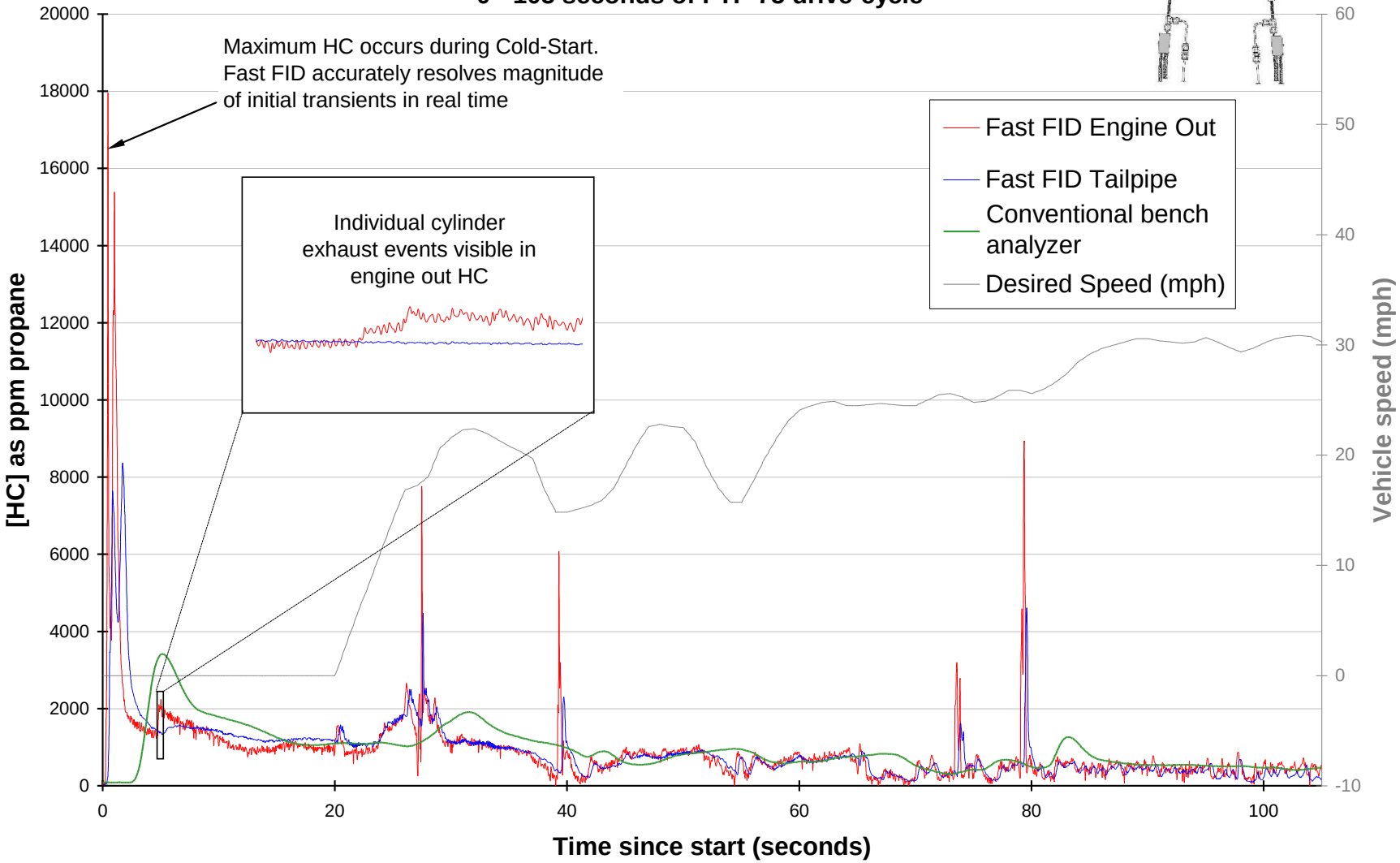
Harry Bradley

HFR500 fast FID



PFI gasoline cold start





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Fast RDE configuration

- 12V battery
- Easily changeable by customer between lab and RDE configuration
- One or two channels (on short conduits)
- Integration with other vehicle/engine parameters (lambda, speed, load) so that transient emissions can be correlated.
- Real-time calculation of cumulative gram emissions
- Cope with climatic conditions
- Durable and vibration insensitive
- $T_{10\text{-}90\%}$ response time <10ms
- Minimal changes to vehicle

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NO_x Box
CAMBUSTION FAST RDE
Accessory Box
CAMBUSTION FAST RDE
4075


J6
AF08 GVP

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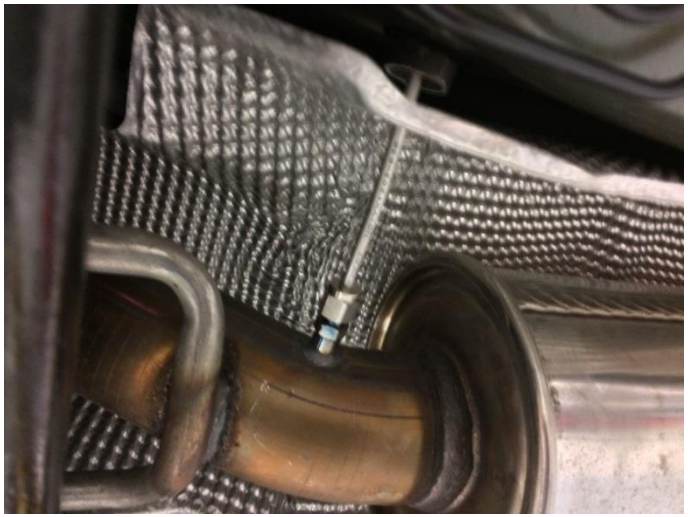
Sampling and data collection



Fast [NO] sampling point: 40mm before silencer/muffler

Engine Control Unit data recorded from vehicle's own OBD port and logged alongside fast [NO]

Software was developed to combine the vehicle's exhaust mass flow rate with the fast [NO] to provide fast cumulative gram emissions, providing insight in to the causes of short-duration emissions "spikes" which may not be visible with slower equipment.

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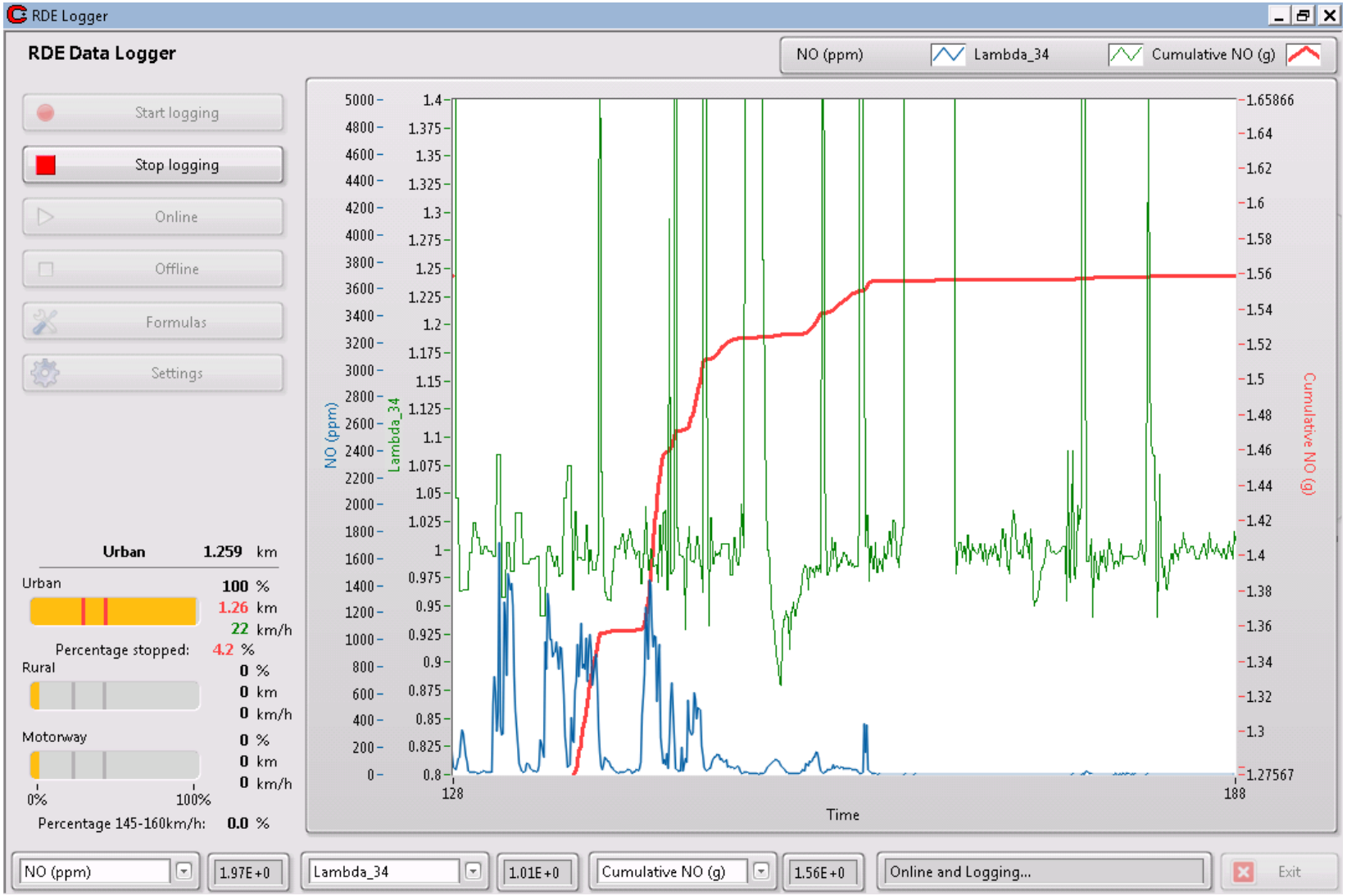
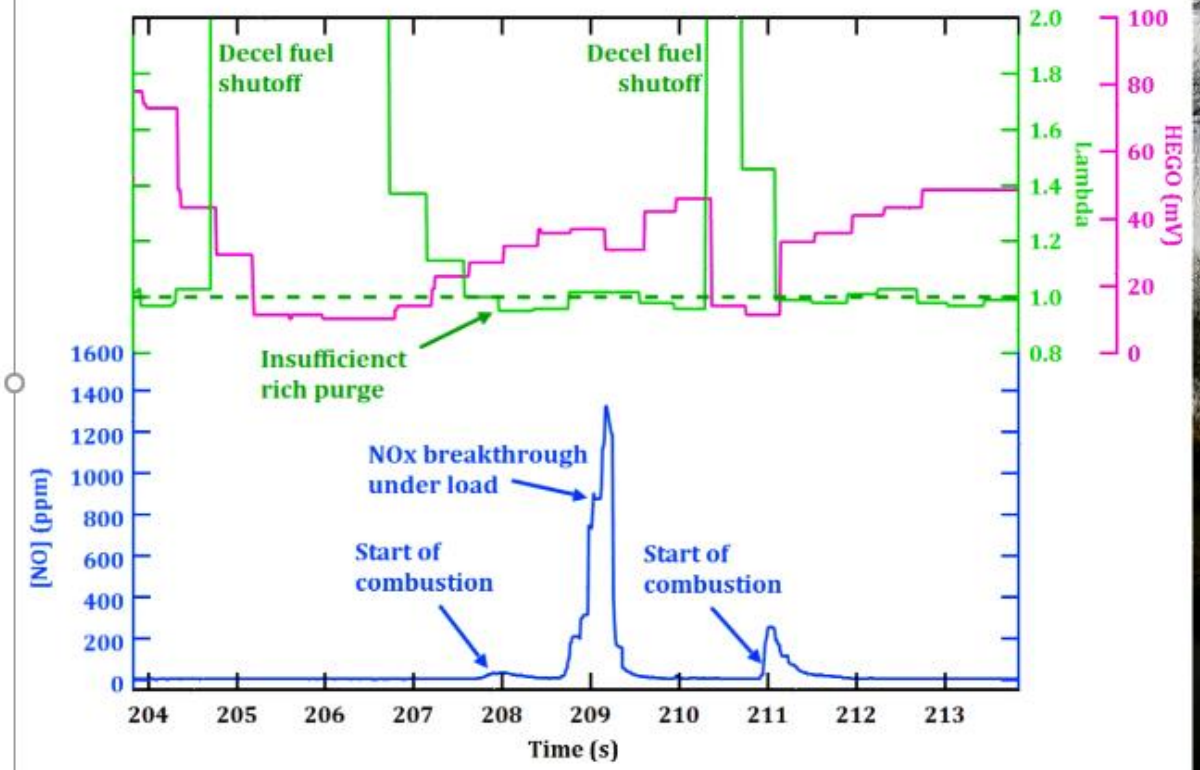
User-interface



Speed bump – Euro 4 gasoline



PEMS vs fast RDE comparison

- Testing performed at MAHLE Powertrain's EU6 emissions test facility
  - VCA certified facility

- Simulated RDE Testing performed on MAHLE Emissions Development Centre
  - RDE Limit cycle for trip dynamics and cumulative positive gradient
- MAHLE supplementing the current RDE capability in Q2 2018 with the Real Driving Emissions Centre
  - Fully climatic -40°C to +50°C
  - Full hypobaric chamber 0-5000m
  - 4WD facility

MAHLE Powertrain

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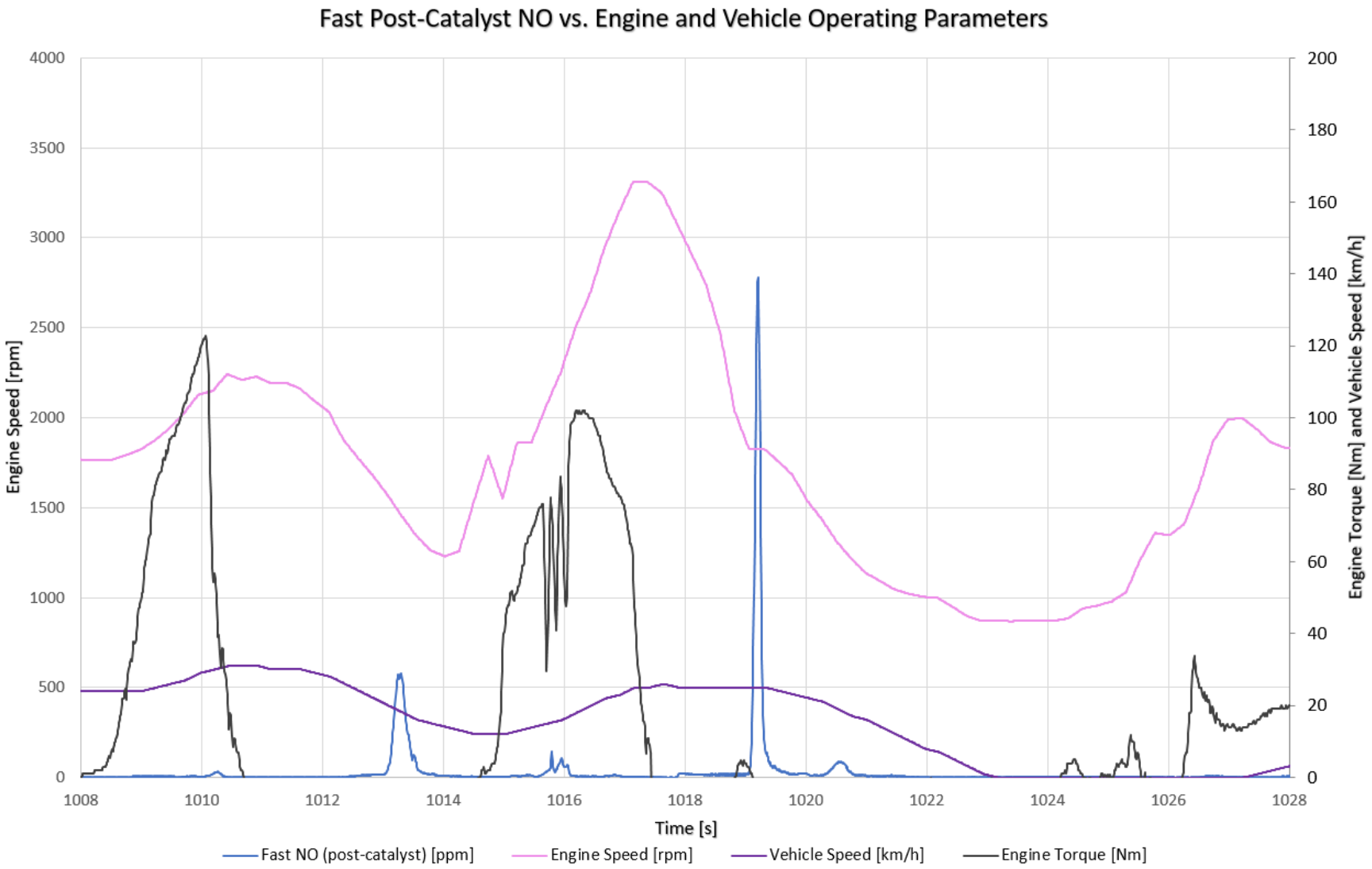
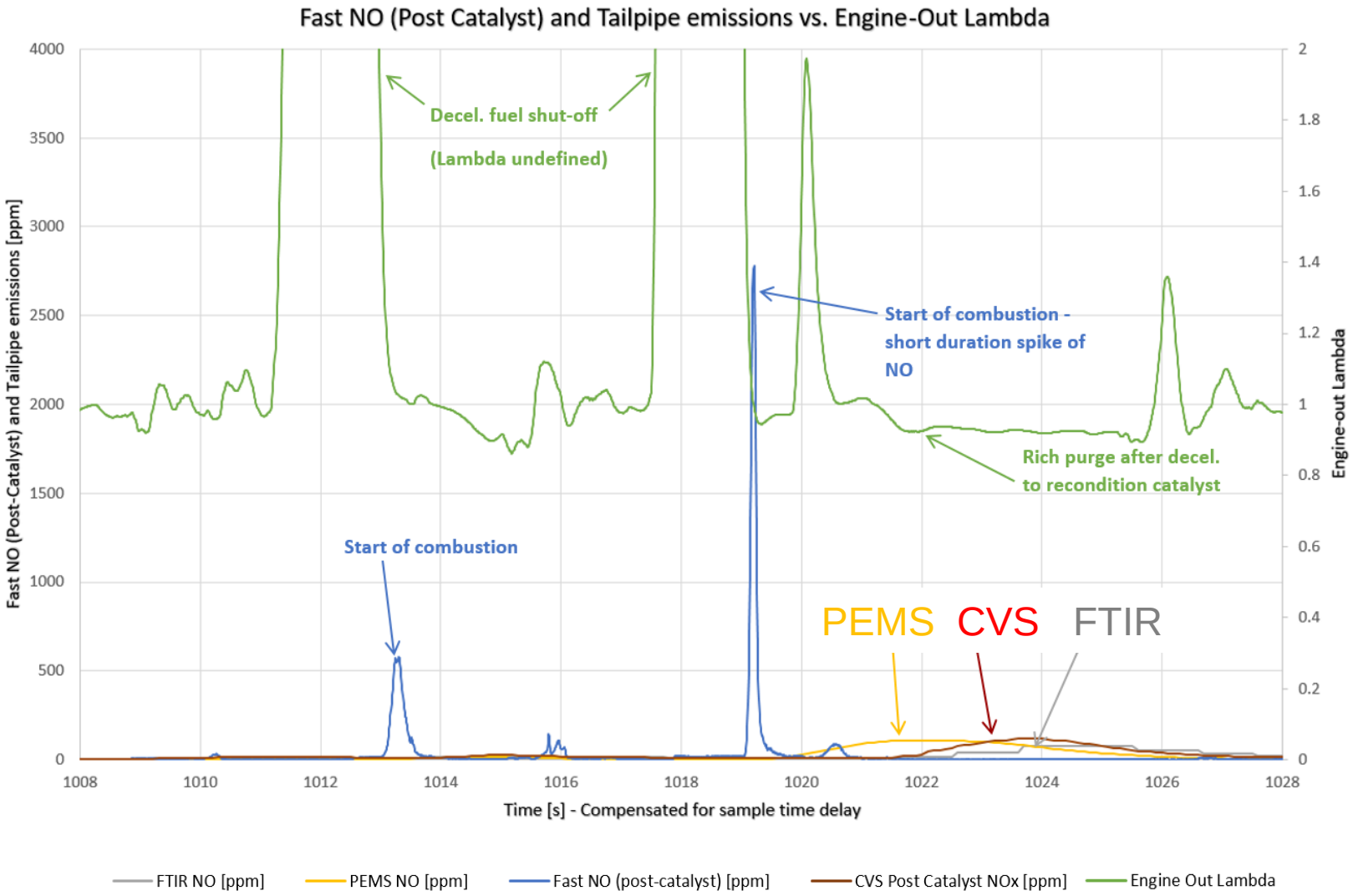
Decel. fuel shut-off - Engine Operation



Decel. fuel shut-off with restart of combustion



MAHLE Powertrain

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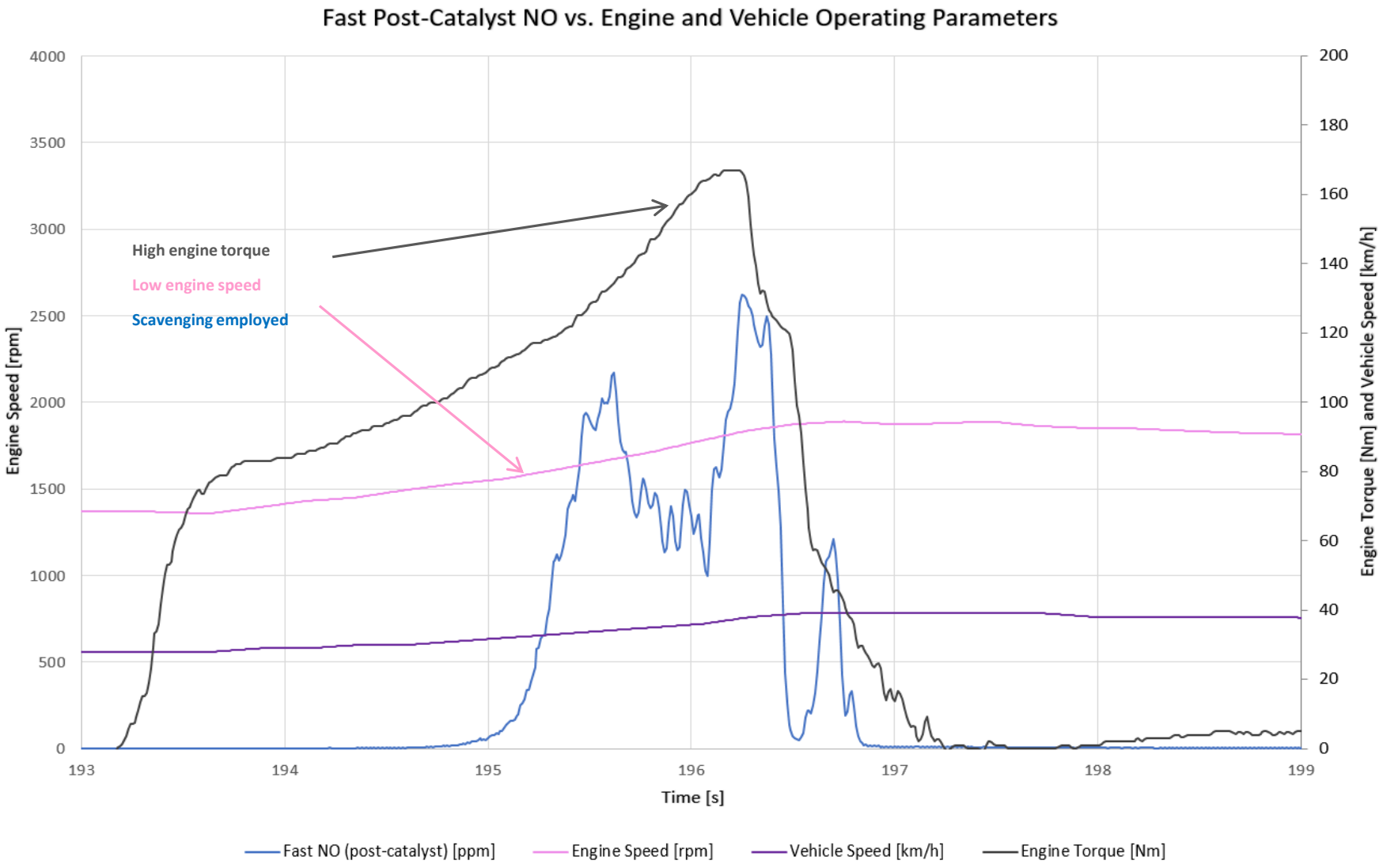
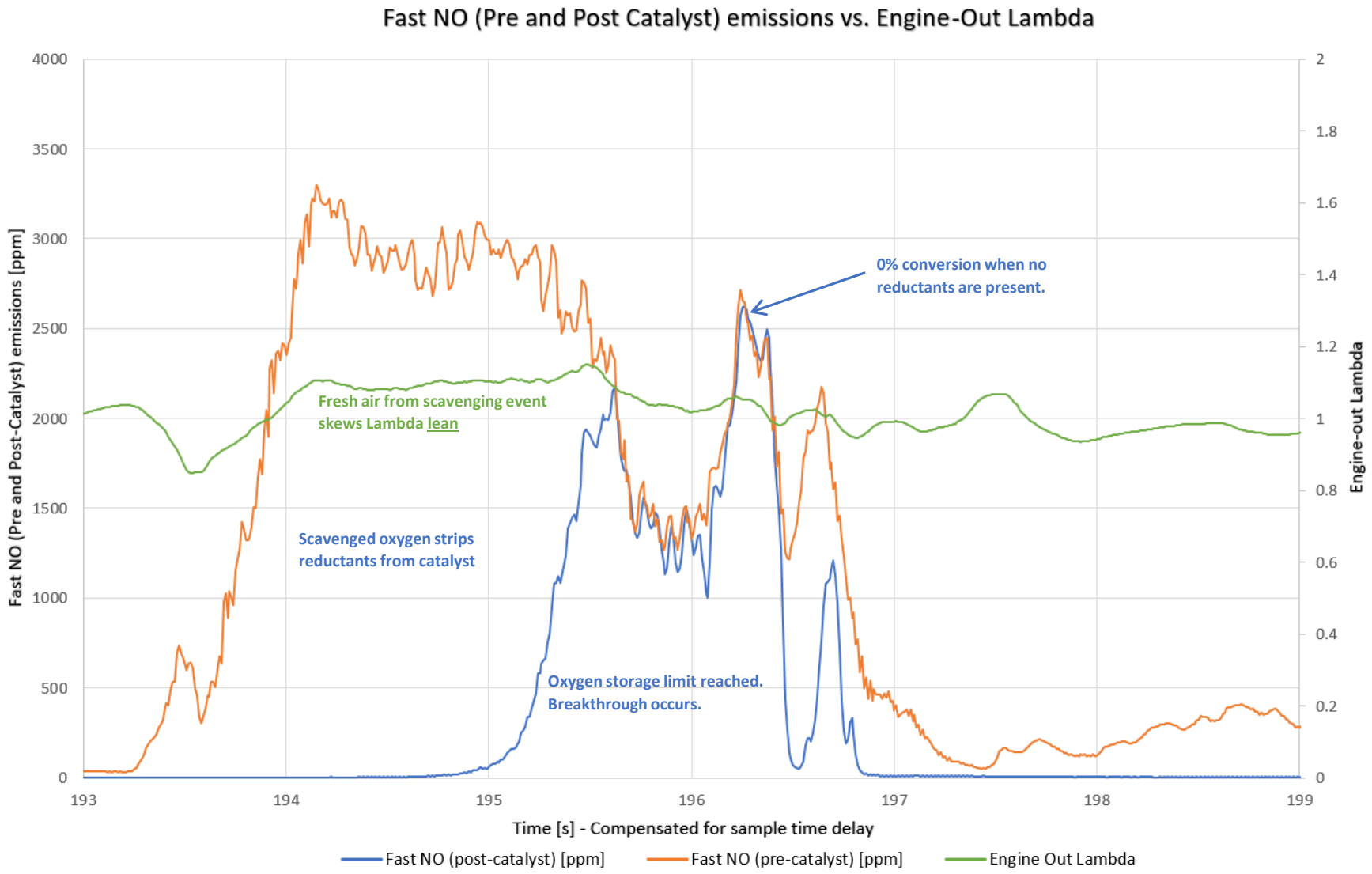
Prolonged Acceleration (Engine Operation)



Prolonged Acceleration (Fast NO)



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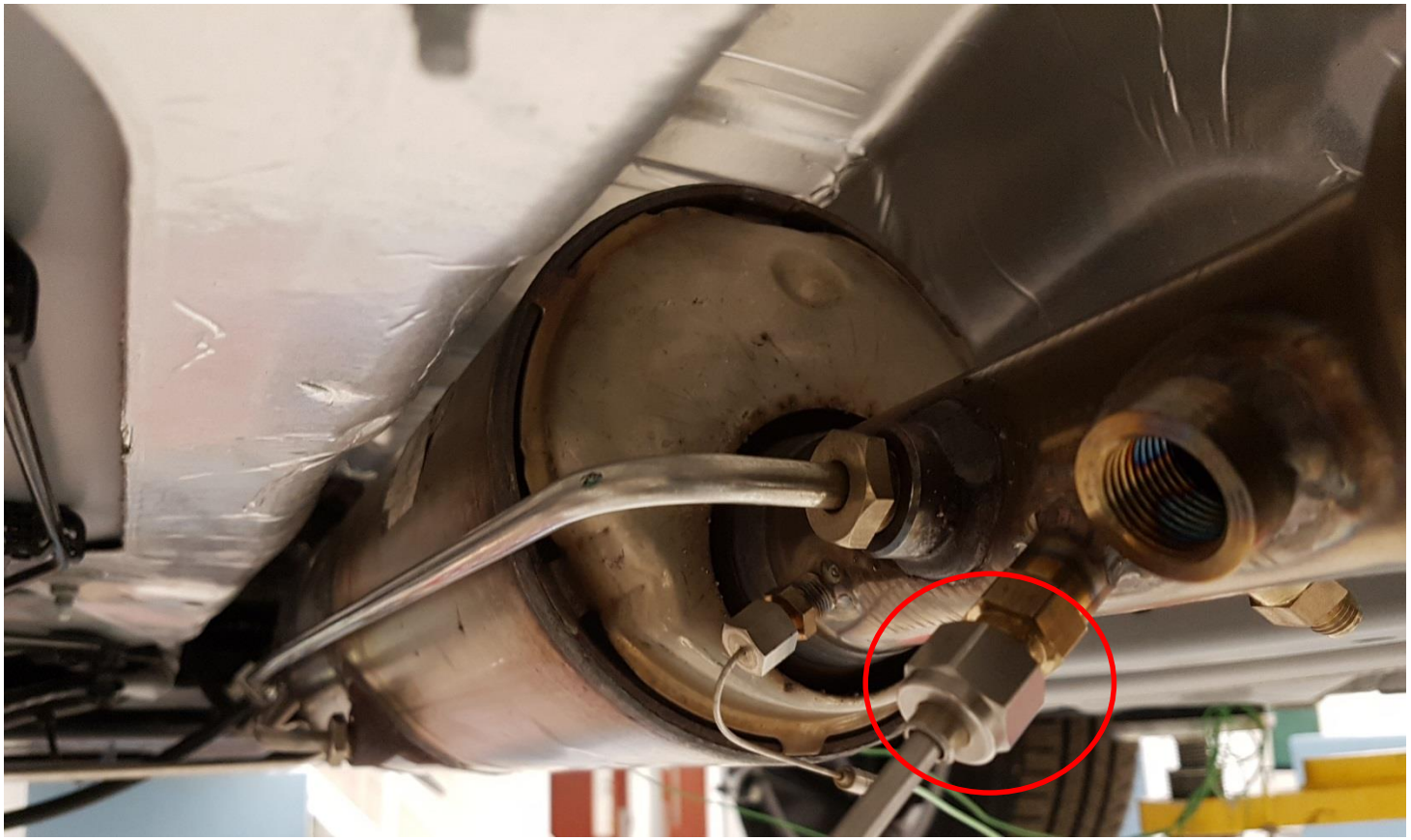
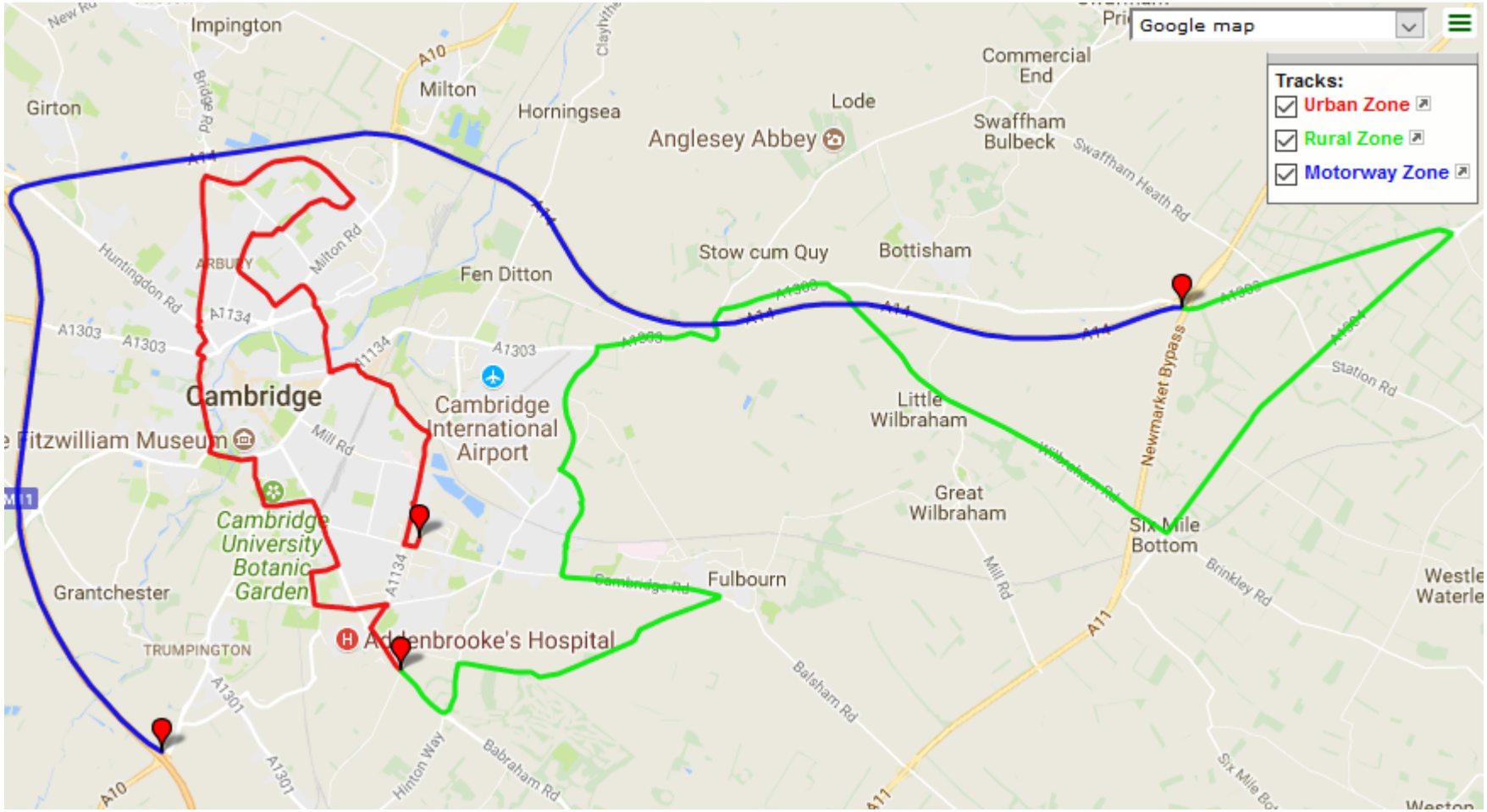
Euro 6 diesel

Sampling point post-SCR



Cambridge RDE route



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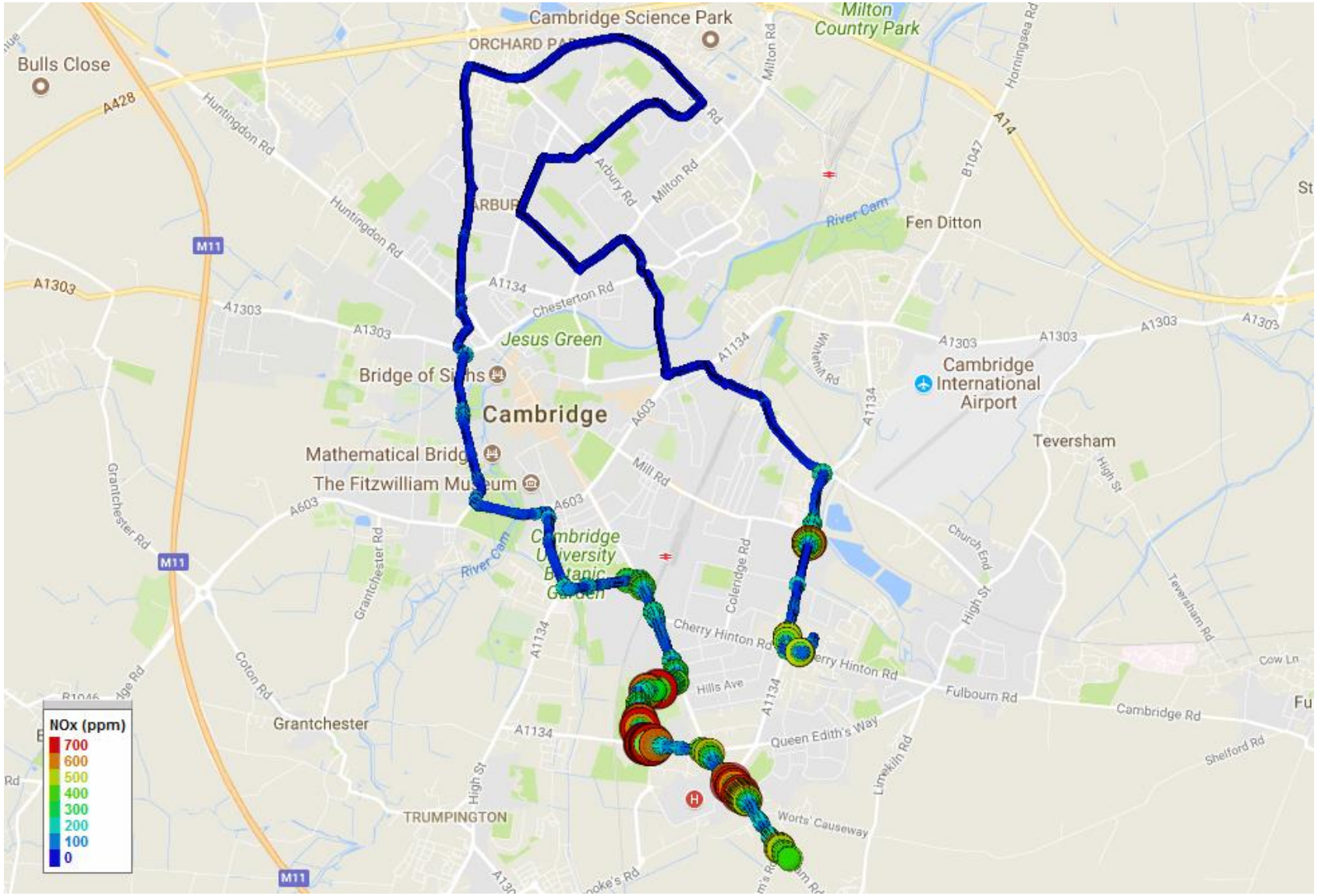
General overview test 1 - Urban



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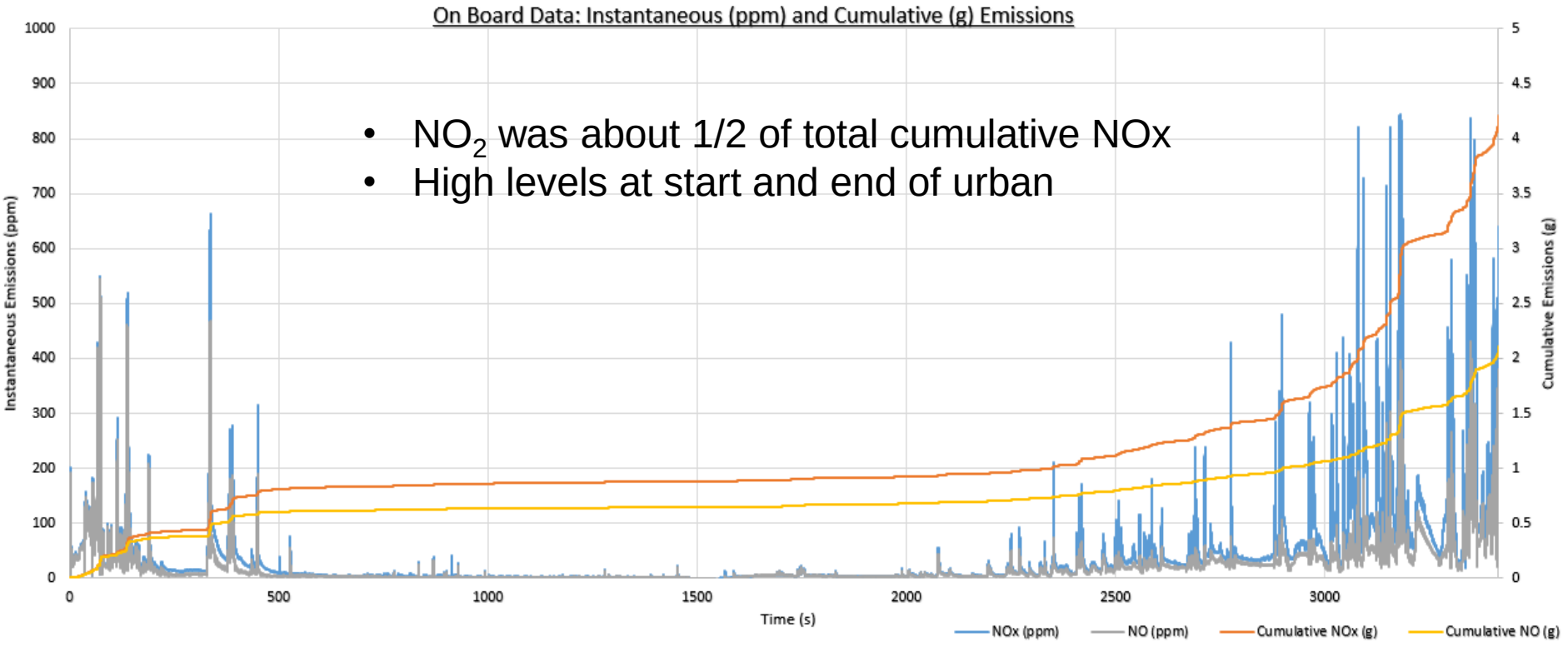
RDE cumulative NO and NOx test 1 - Urban



- NO_2 was about 1/2 of total cumulative NOx
- High levels at start and end of urban

Cumulative NOx	Cumulative NO	Distance
Total: 4.082 g	Total: 2.032 g	Total: 20.466 km
0.199 g/km	0.099 g/km	
LIMIT: 0.08 g/km	**Conformity:**	**2.48x limit**

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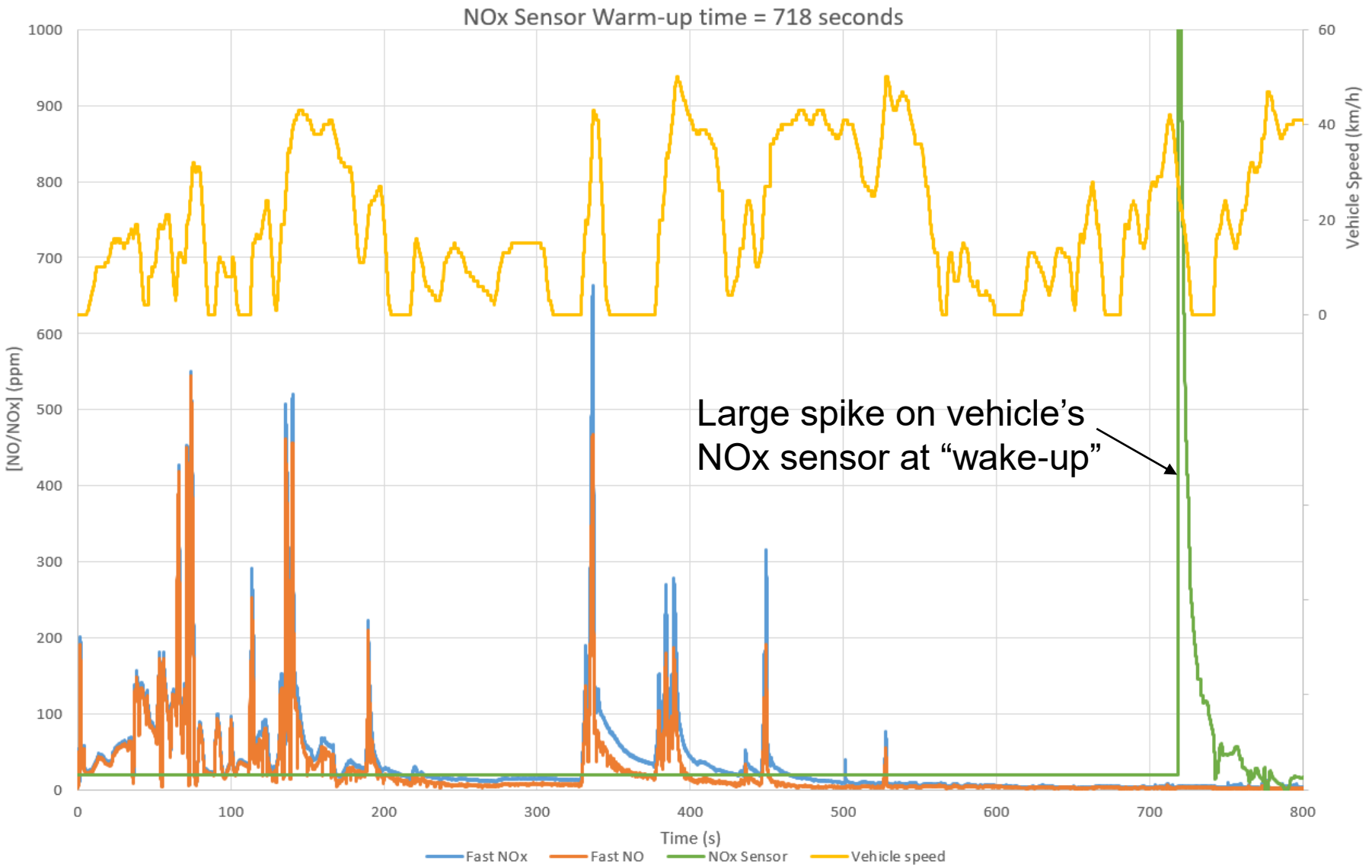
SCR system activating from cold



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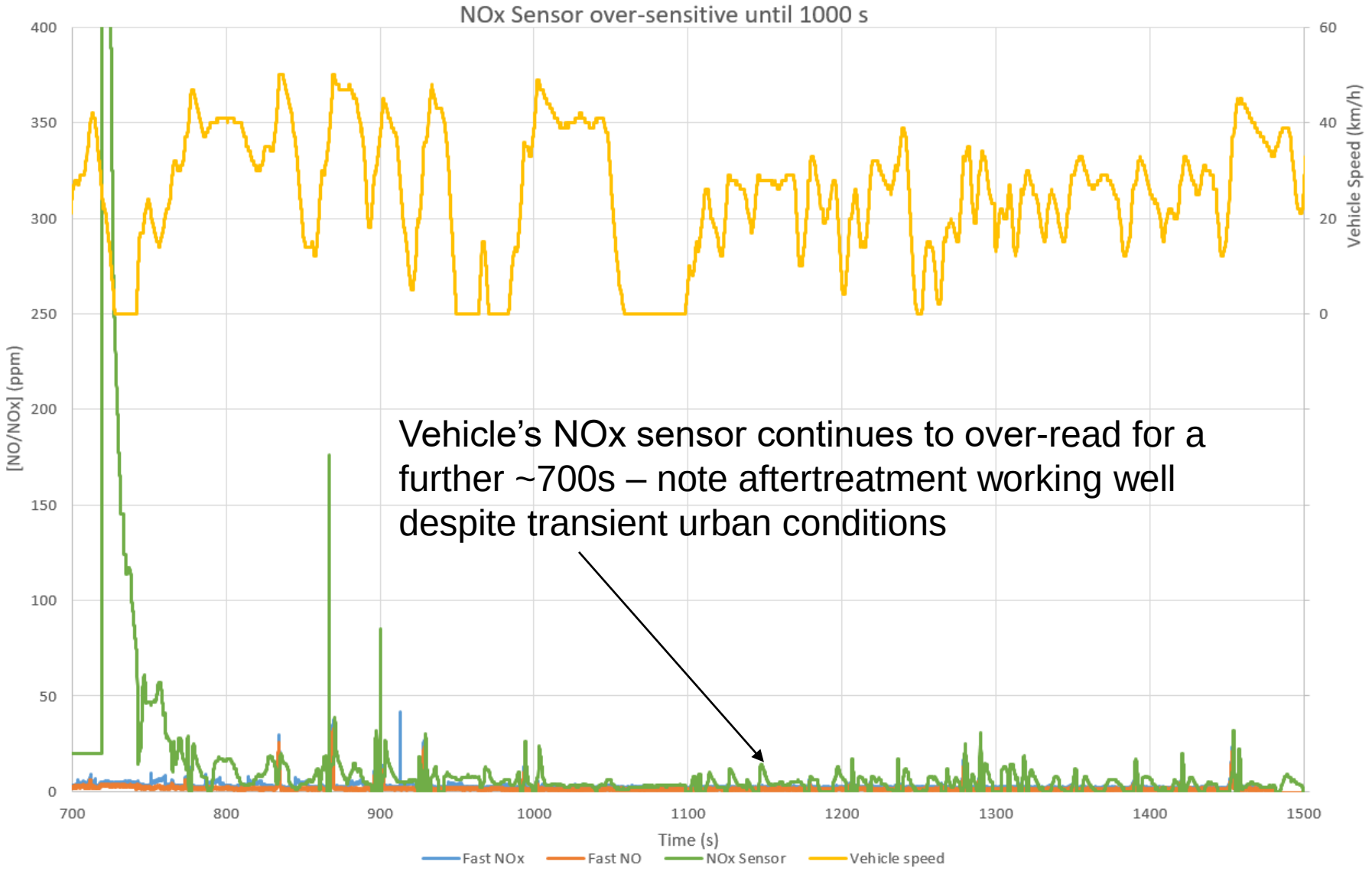
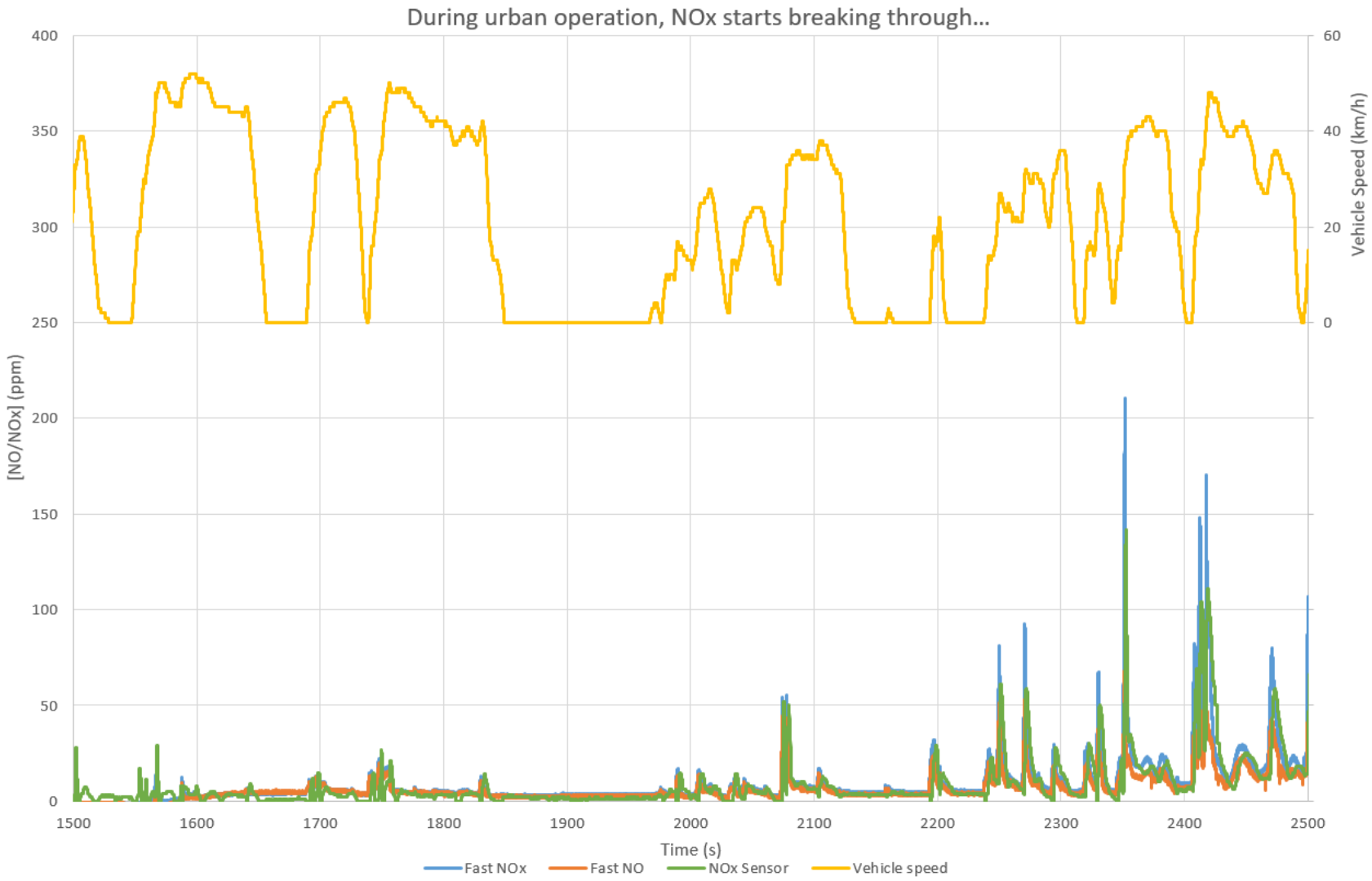
SCR NOx sensor settling time



NOx breakthrough begins later on urban section



2017 Euro 6 gasoline plug-in hybrid
(vehicle available courtesy of Byron Mason, Loughborough University)

Cambridge “Air quality” route

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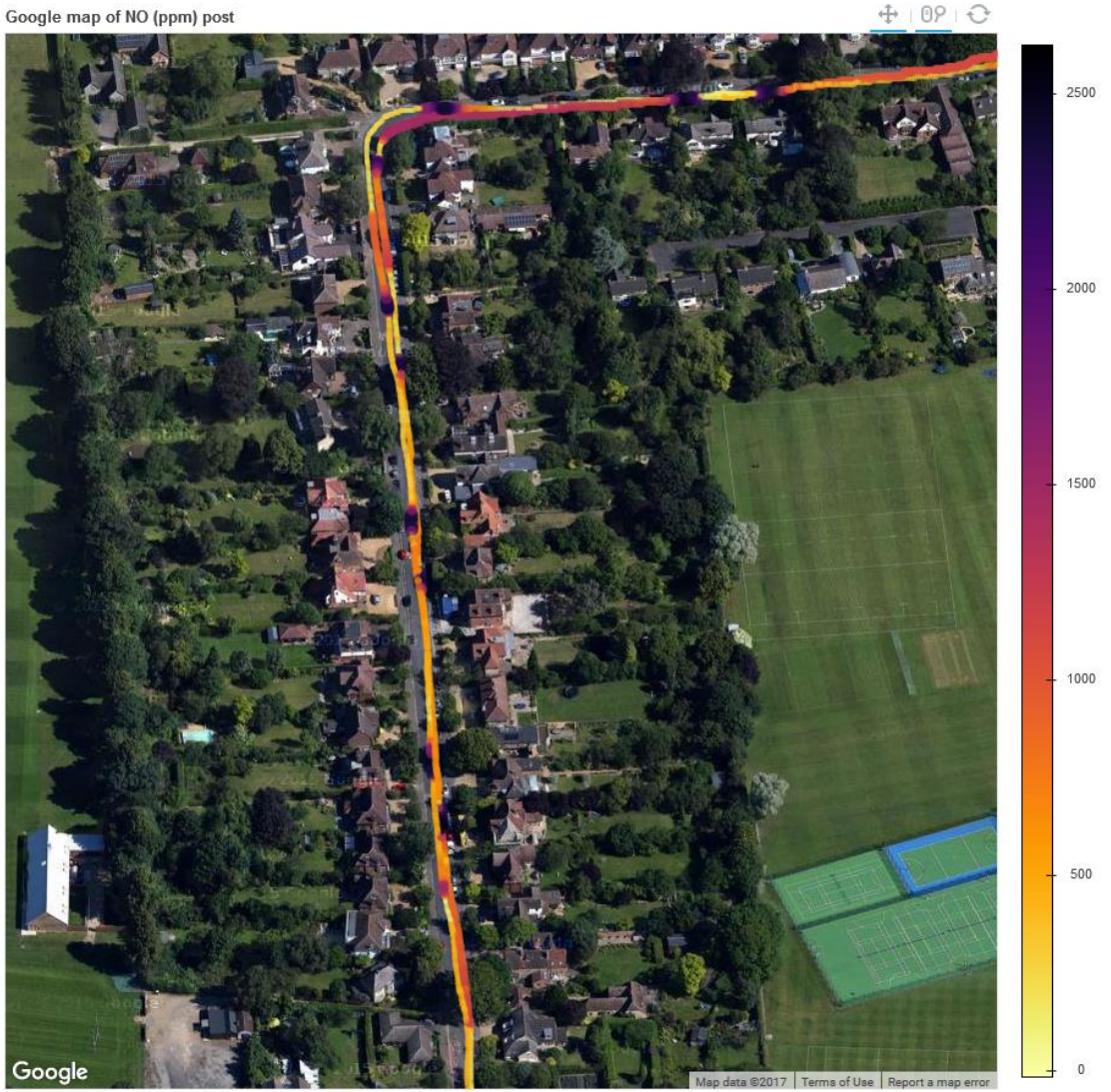
Focus on 2 major transients sections



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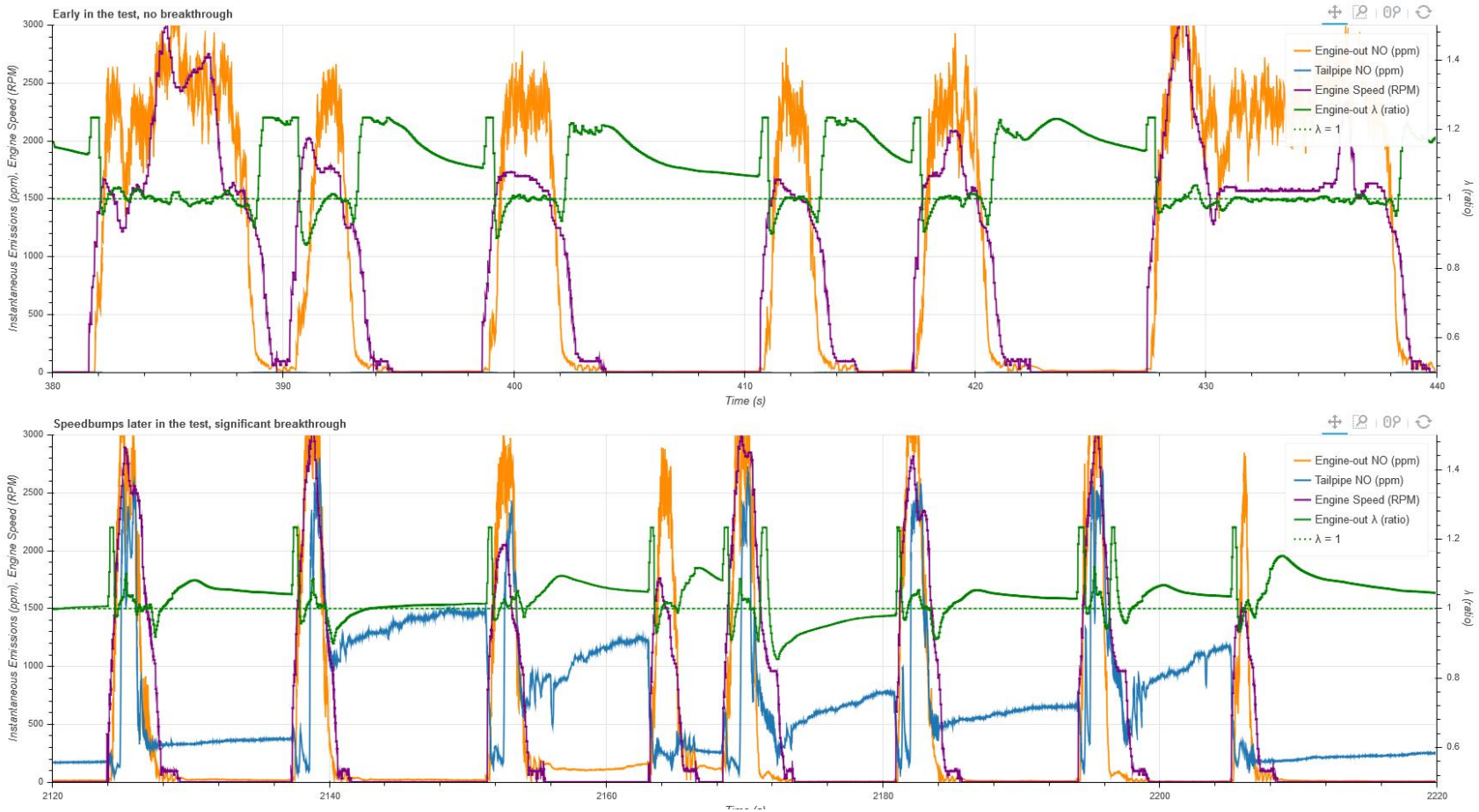
Comparison of two transients



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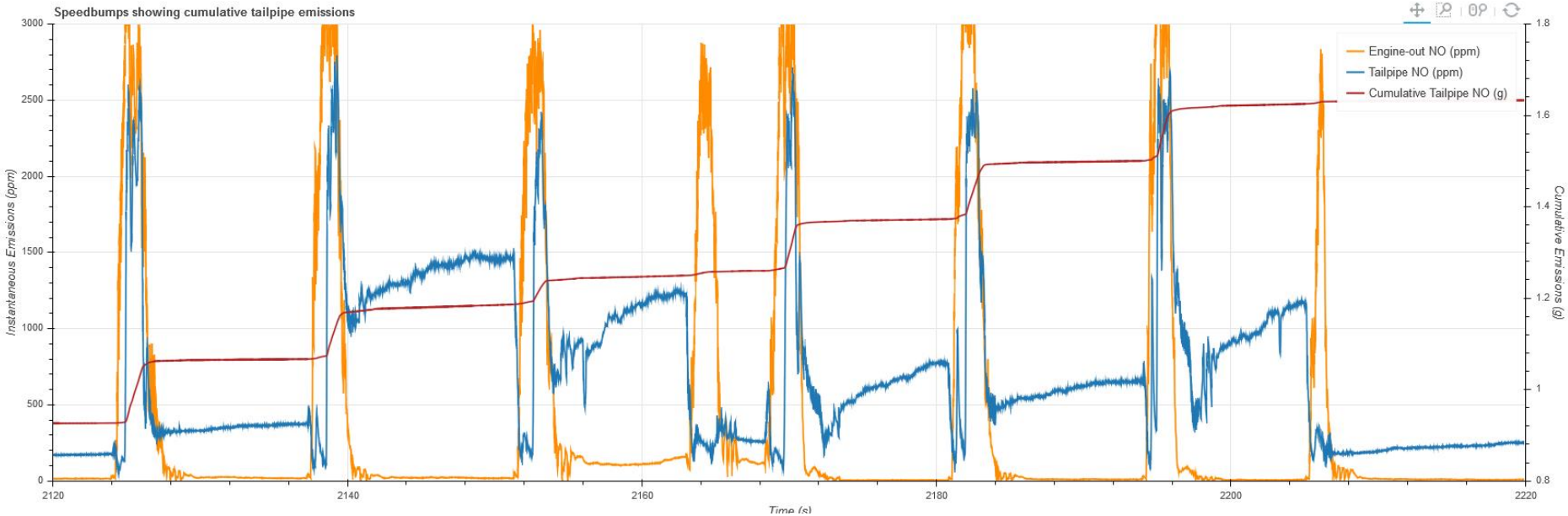
Cumulative mass calculated from OBD exh mass flow



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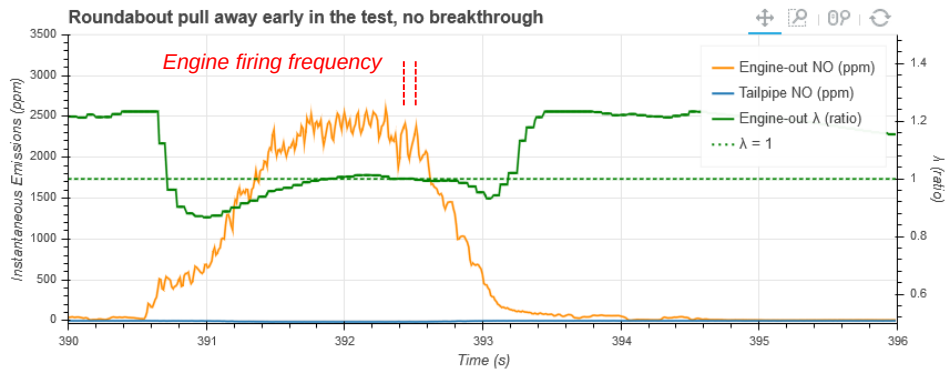
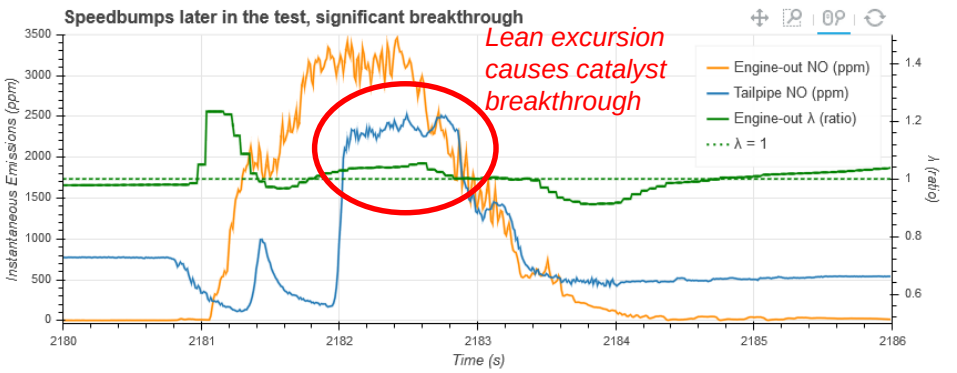
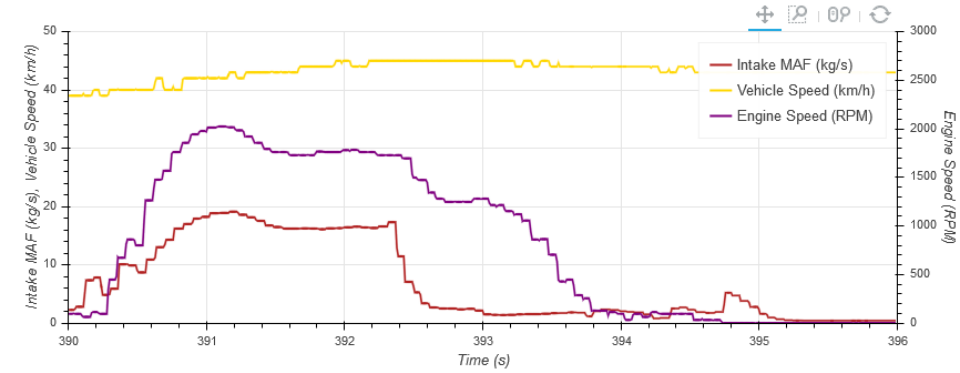
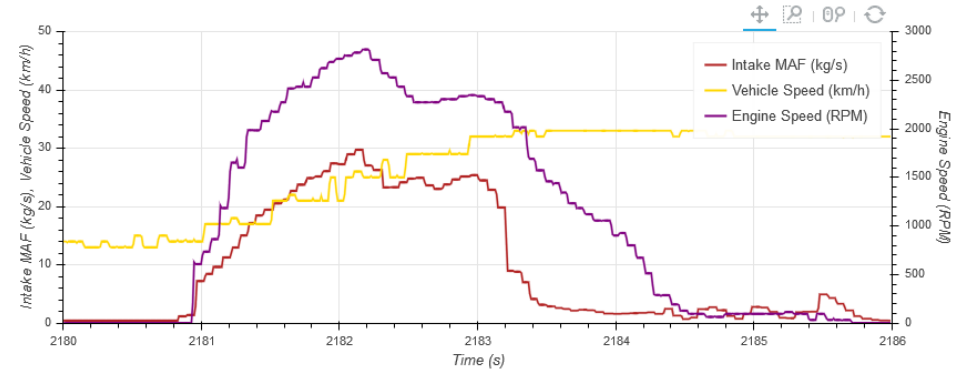
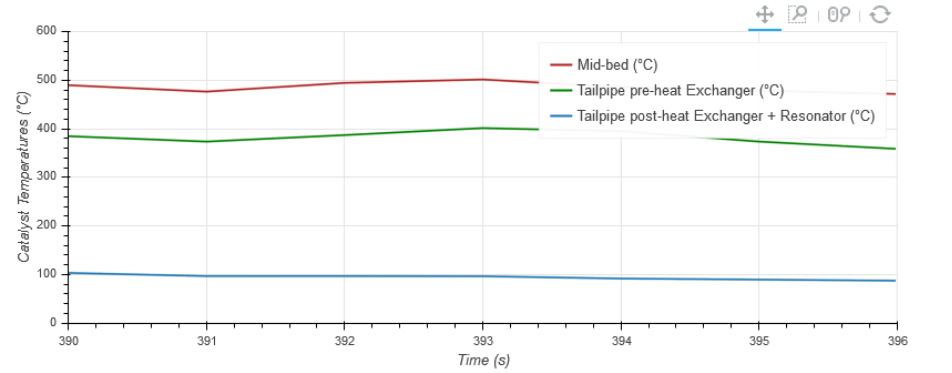
Comparison of two transients in detail

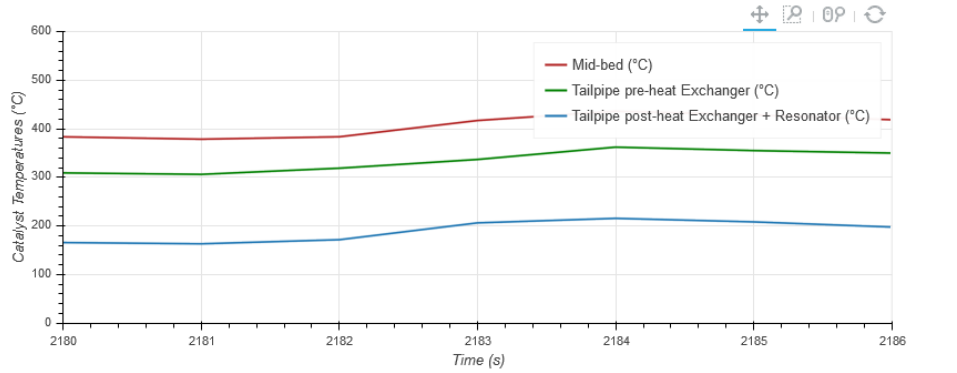












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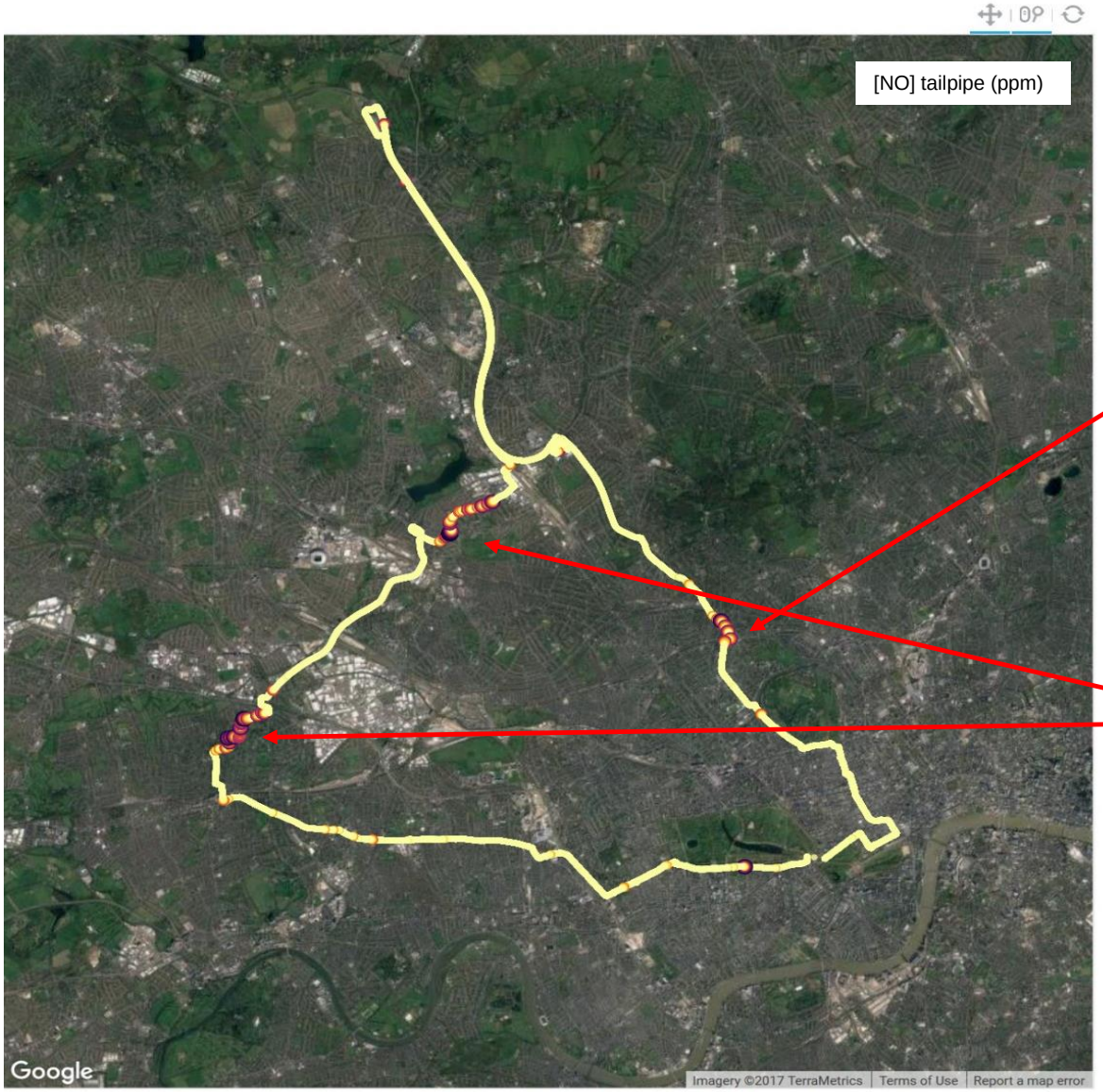
TfL West London Route with PHEV vehicle



Generally very good for NOx emissions, but…

Trouble at Swiss Cottage

…and in West London over speed bumps

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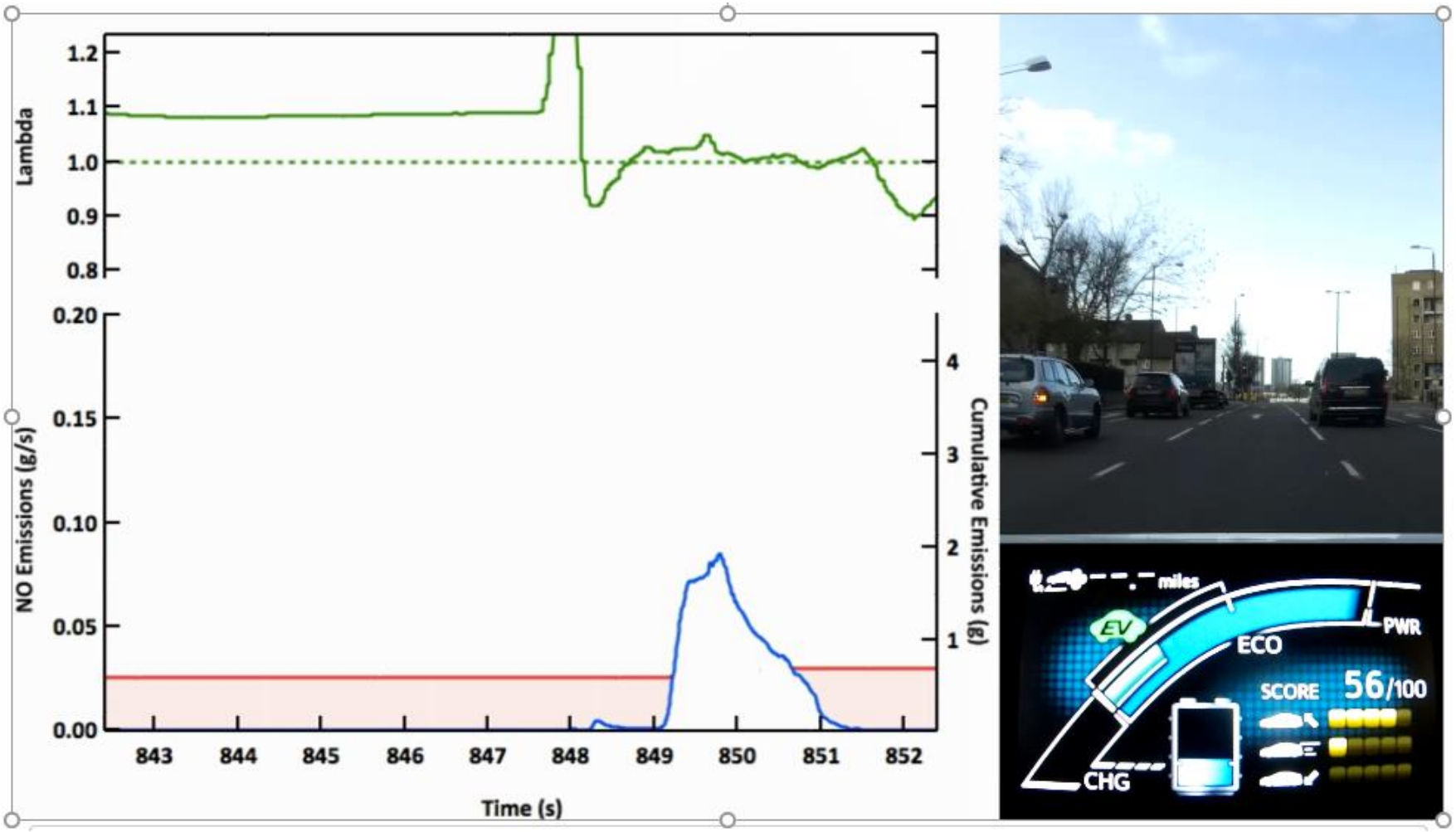
What to watch for in videos…

- During accelerations, engine start delayed first by electric traction
- Engine switch-on causes “PHEV cough”
- Lambda shows PFI lean excursion causing NOx breakthrough
- Engine off/on frequently (especially over consecutive speed bumps)
- Best viewed with *audio on* (poor quality but helps perception of electric vs engine split)

Swiss Cottage



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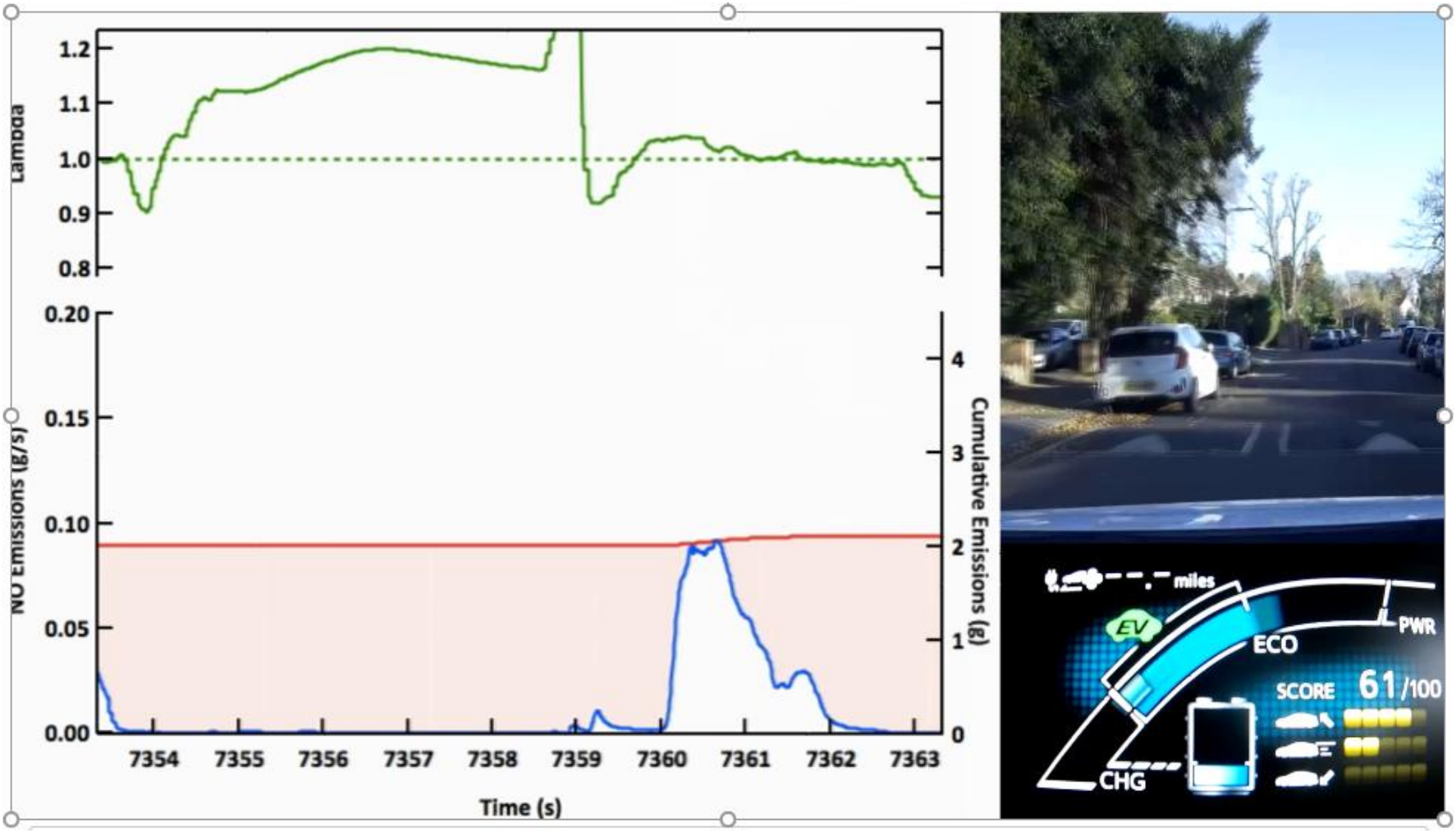
West London residential speed bumps



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Are vehicle comparisons valid?

PETROL EURO4

DIESEL EURO5

DIESEL EURO6

PHEV
PETROL EURO6

Variations in climate, congestion, battery state of charge etc. will greatly affect the above – treat comparisons with great care!

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In conclusion

- Engines & vehicles are generally getting cleaner
- RDE presents unpredictable transients
- Fast response analyzers can measure transient emissions and correlate these with other engine parameters
- Observed emissions issues are solvable using conventional means

Contact details

For full version of these slides including videos, please contact…

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