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Emissions from interrupted traffic flow

…and their effects on (very) local air pollution

Dr. Mark Peckham

Note*: The pdf version of this presentation lacks the original videos, but an overview including movies can be found at*

https://www.cambustion.com/products/rde

Real world Driving Emissions (RDE)

- Main challenge is transients (accel, decel & “unsmooth” driving), often <<1 second duration
- If a short-duration “spike” of emissions is produced, you need an instrument with a fast response time to measure it accurately
- Portable Emissions Measurement Systems (PEMS) have a response time of a few seconds

- Cambustion emissions analyzers have a response time of a few *milliseconds (…a thousand times faster)*

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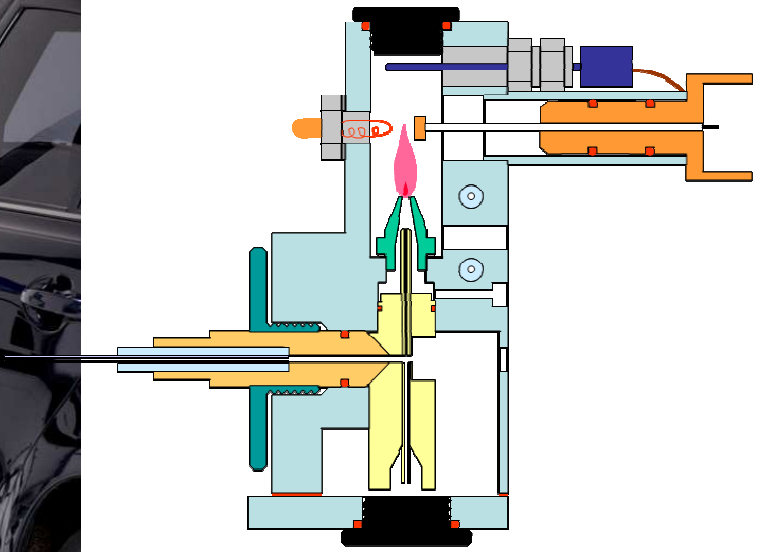
Fast response exhaust gas analyzers ($T_{10\text{-}90\%}$ ~ 1 millisecond)



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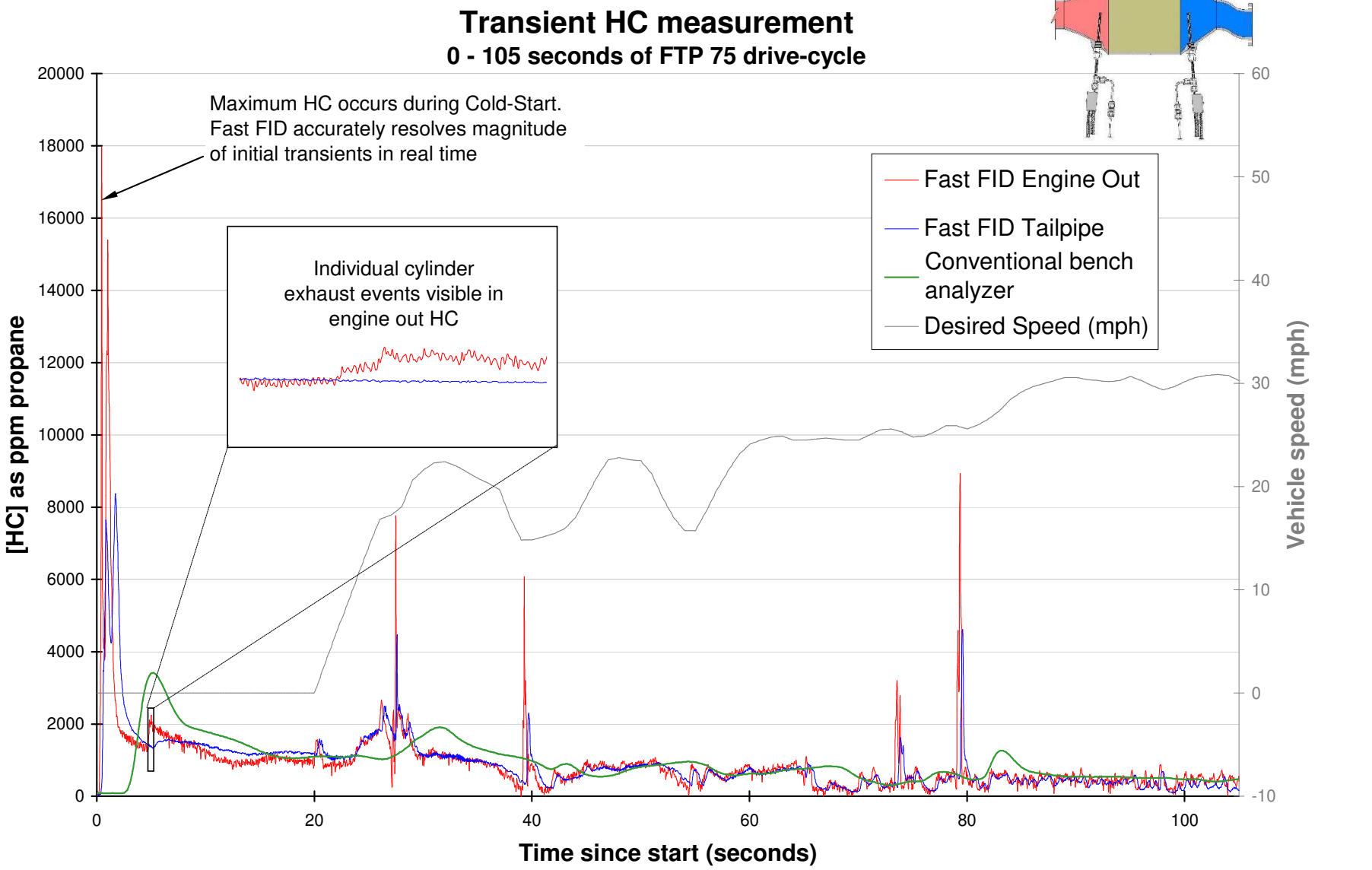
PFI gasoline cold start



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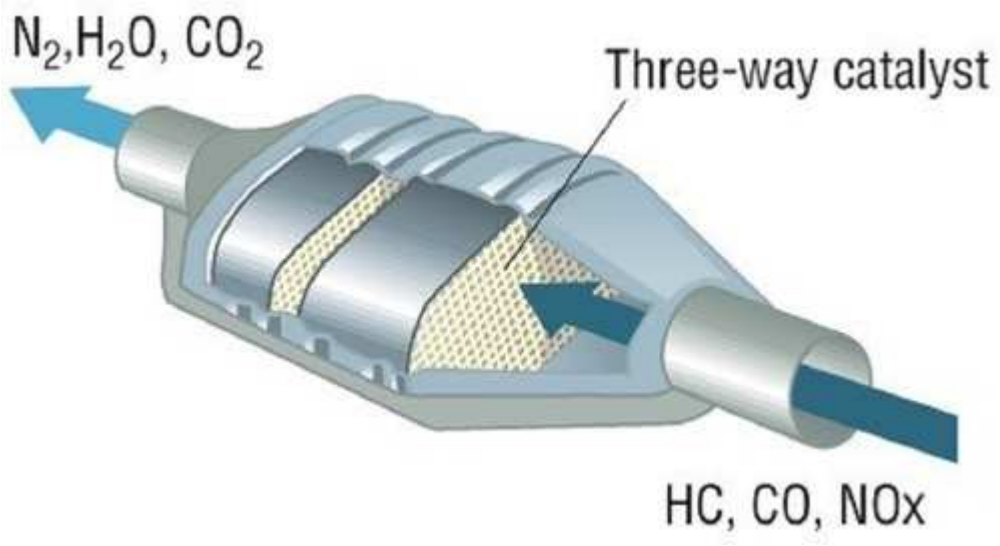
3-way catalyst for most petrol engines



- Gasoline/petrol engine perfect running conditions are with air:fuel ratio of 14.7:1. This is known as lambda = 1
- Lambda < 1 is “rich” (excess fuel)
- Lambda > 1 is “lean” (excess air)
- The 3-way catalyst requires lambda = 1 *and* needs to be *hot*!

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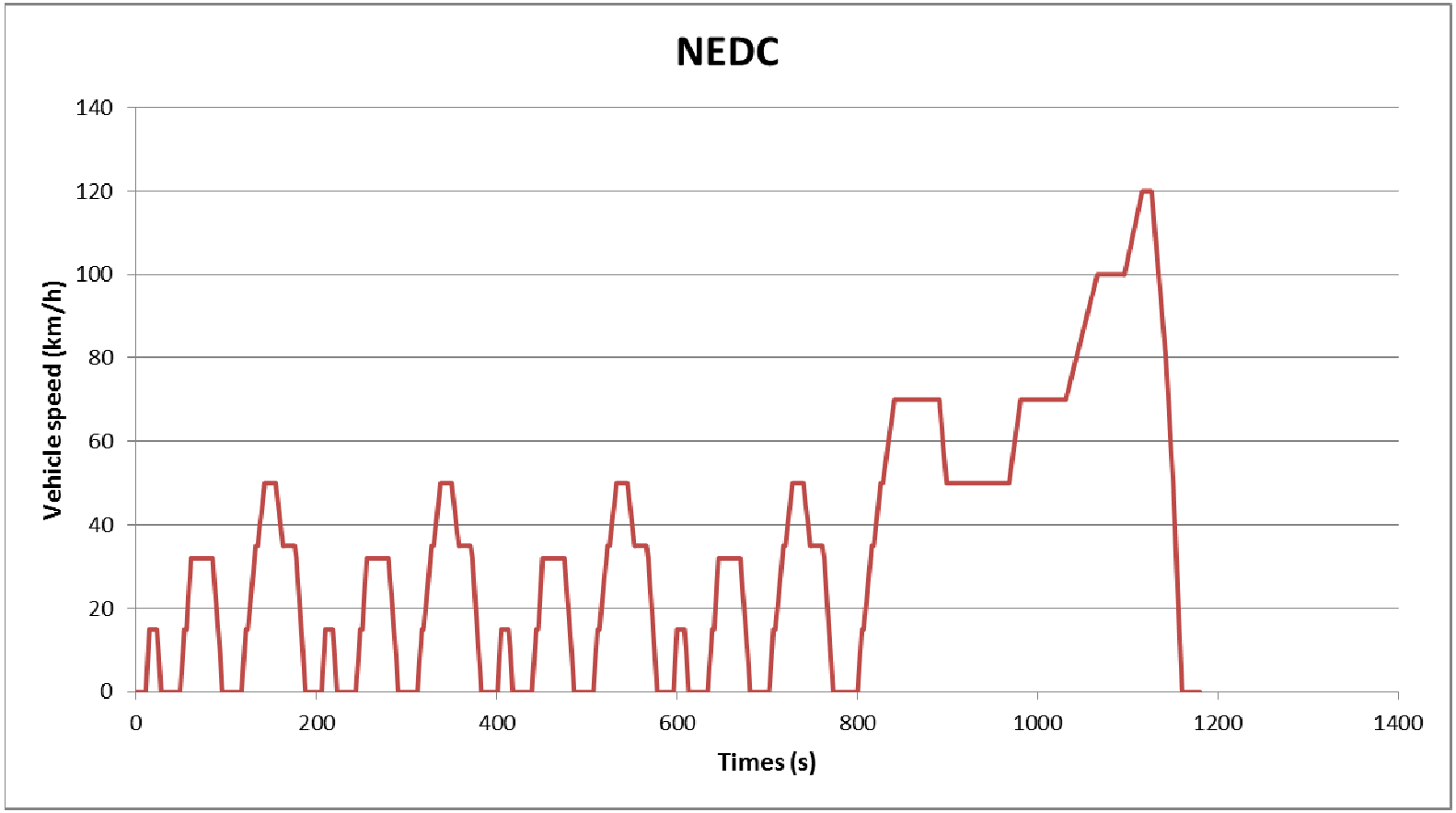
Typical engine transients

- Cold start
- Accelerations
- Decelerations (decel fuel shut-off)
- Gear changes

“New” European Drive Cycle



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Basic advantages of using *fast* on-board analyzers

- Real world driving is **full** of transients (which need fast response analysers measurement equipment)
- Two channels allows both pre- and post-catalyst measurements simultaneously – checks catalyst conversion efficiency
- Easy and accurate correlation with Engine Control Unit (ECU) parameters
- When combined with accurate GPS, $T_{10\text{-}90\%}$ = 10ms at 30mph corresponds to 14cm resolution whereas typical on-board analyzers with $T_{10\text{-}90\%}$ = 3 seconds yields 42m resolution


NO, Box
CAMBUSTION FAST RDE
Accessory Box
CAMBUSTION FAST RDE
4075


J6
AF08 GVP

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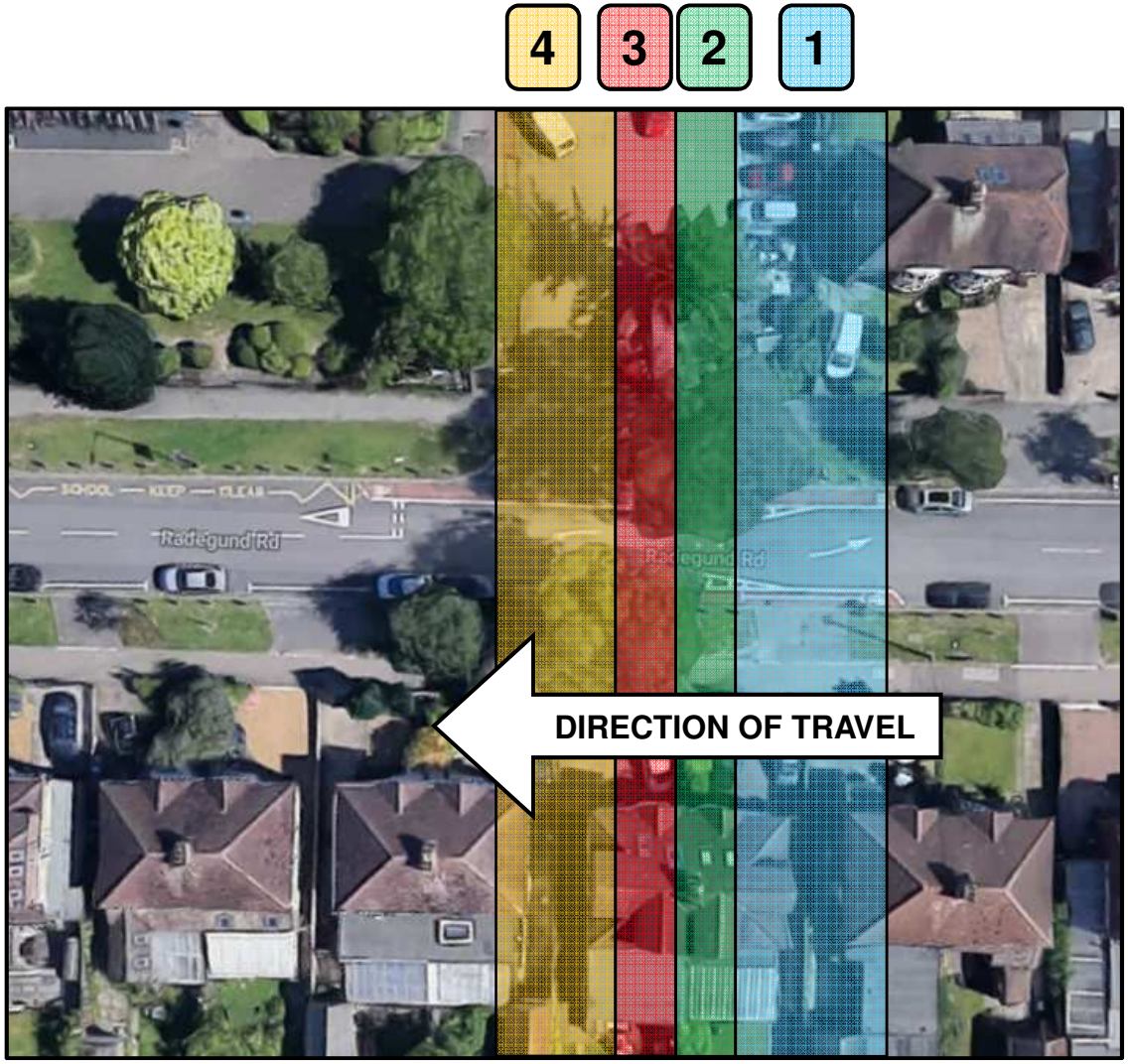
Negotiating the humble speed bump!

1. Decelerate, combustion stops
2. Clutch in and engine starts (idle)
3. Accelerate away from speed bump
4. Change up gear and head for speed limit



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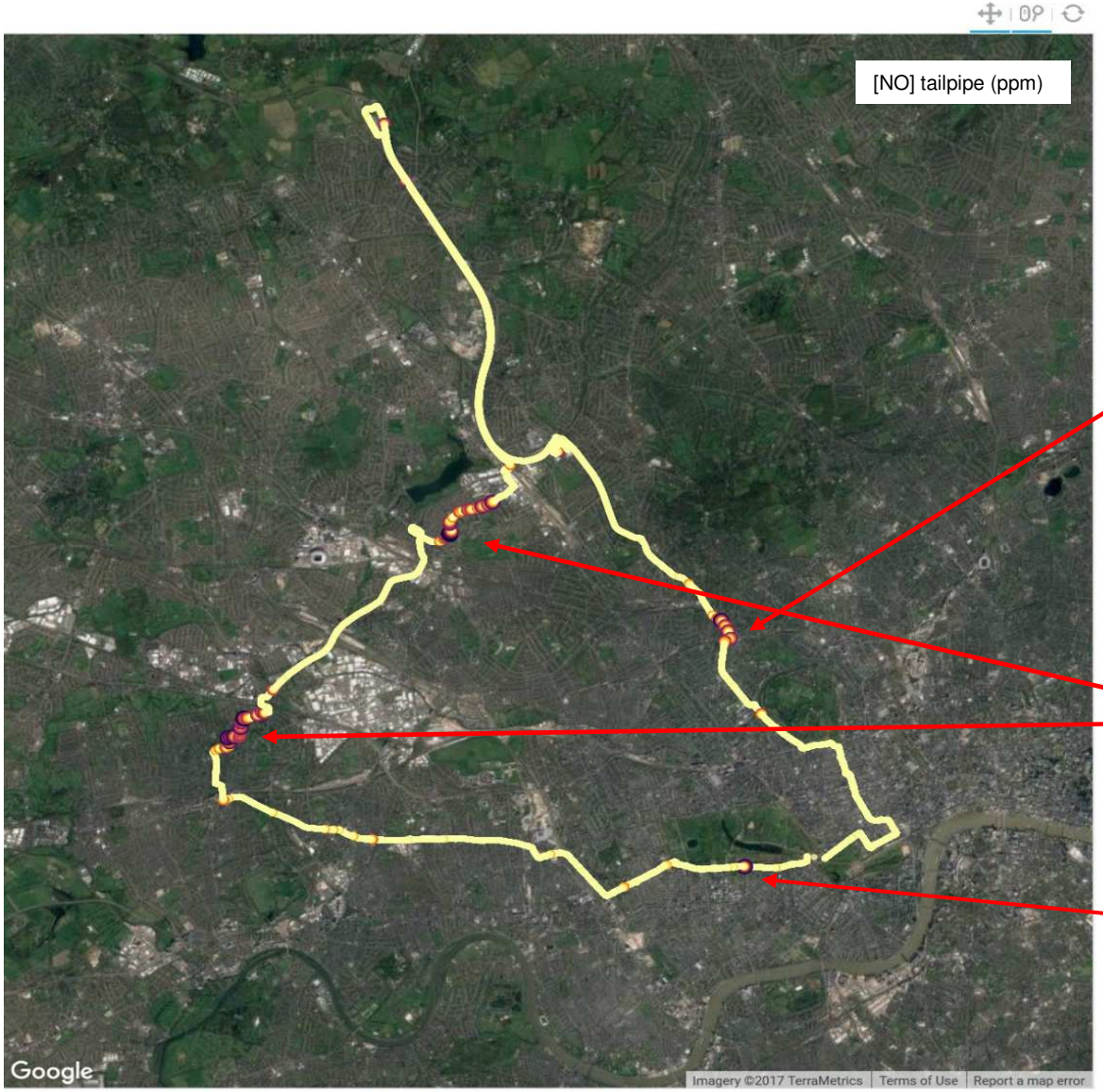
Speed bump – Euro 4 gasoline

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

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

Bus lane convergence

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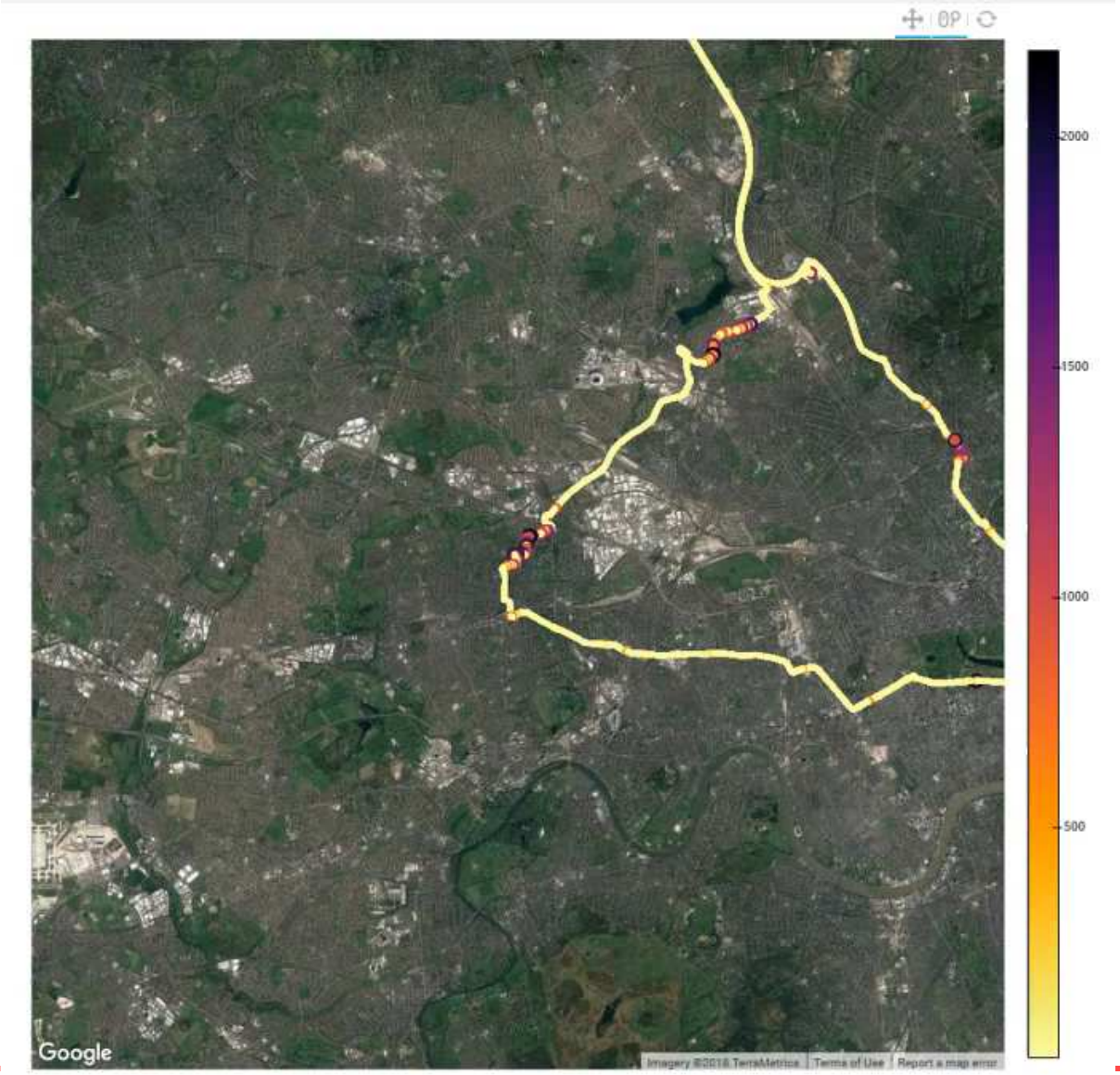
Map of Montpelier Park NOx pollution hot spots



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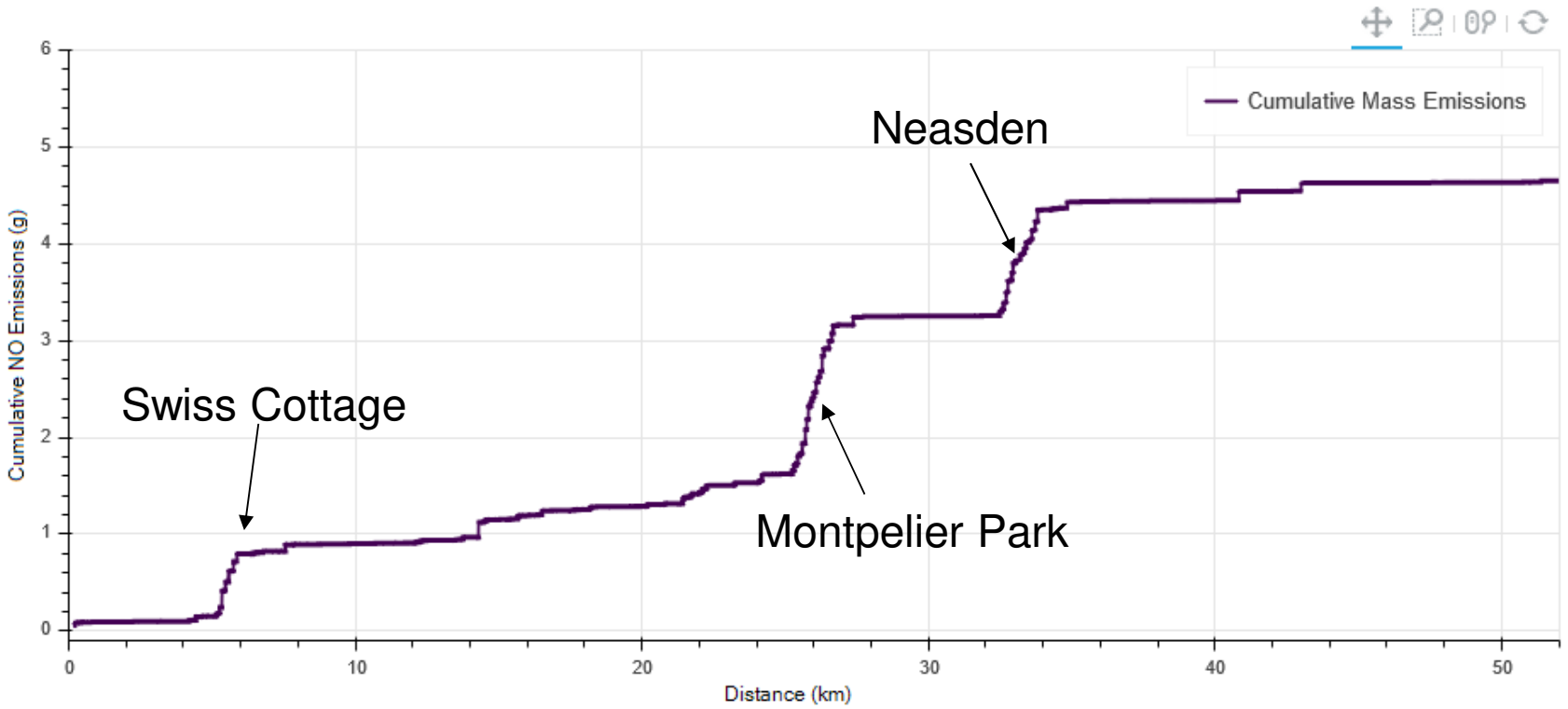
Main emissions contributors



Euro 6 NEDC limit is 0.06g/km of NOx

TfL route yielded 0.09g/km, 70% of which was caused by these 3 sites

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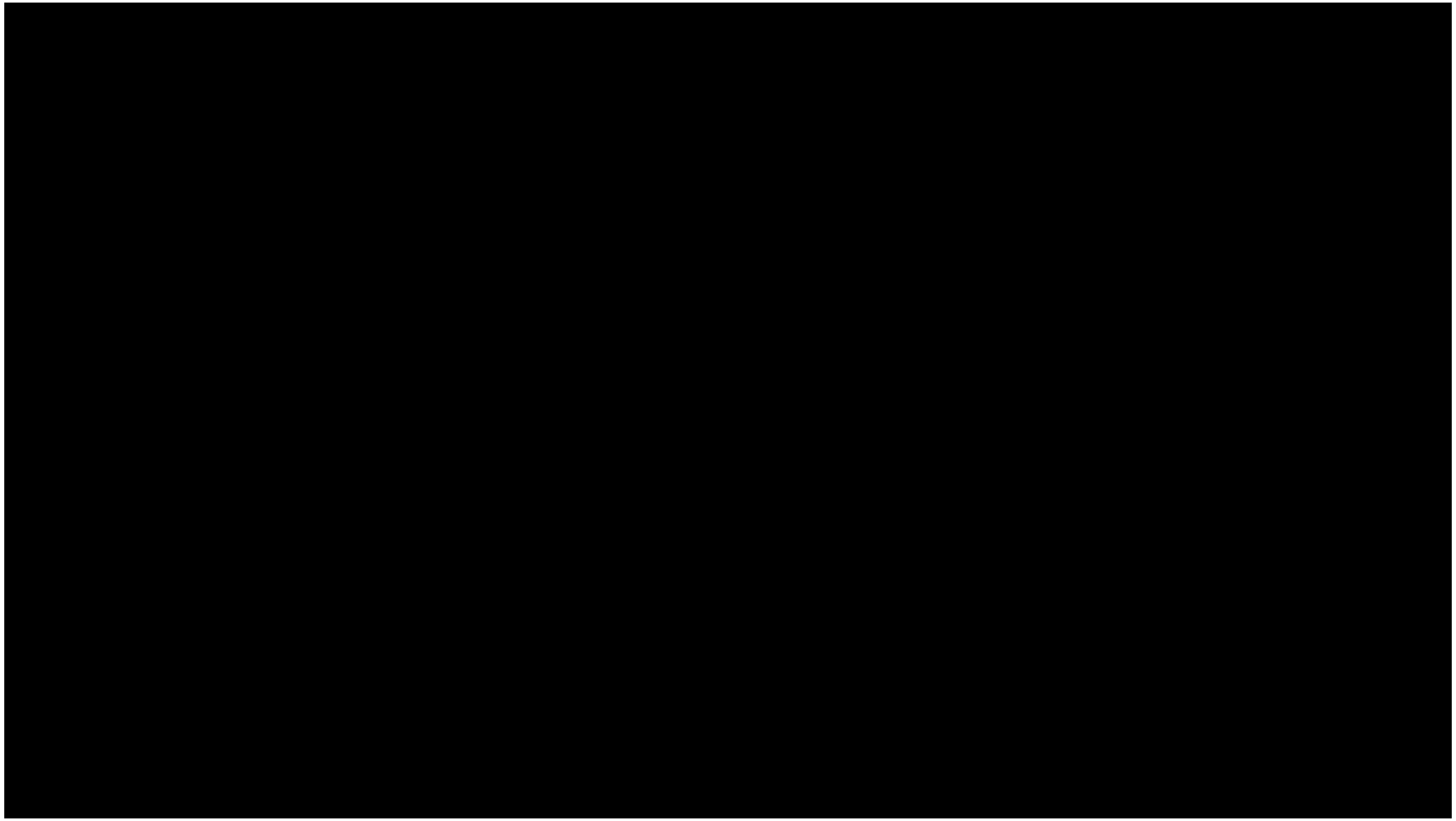
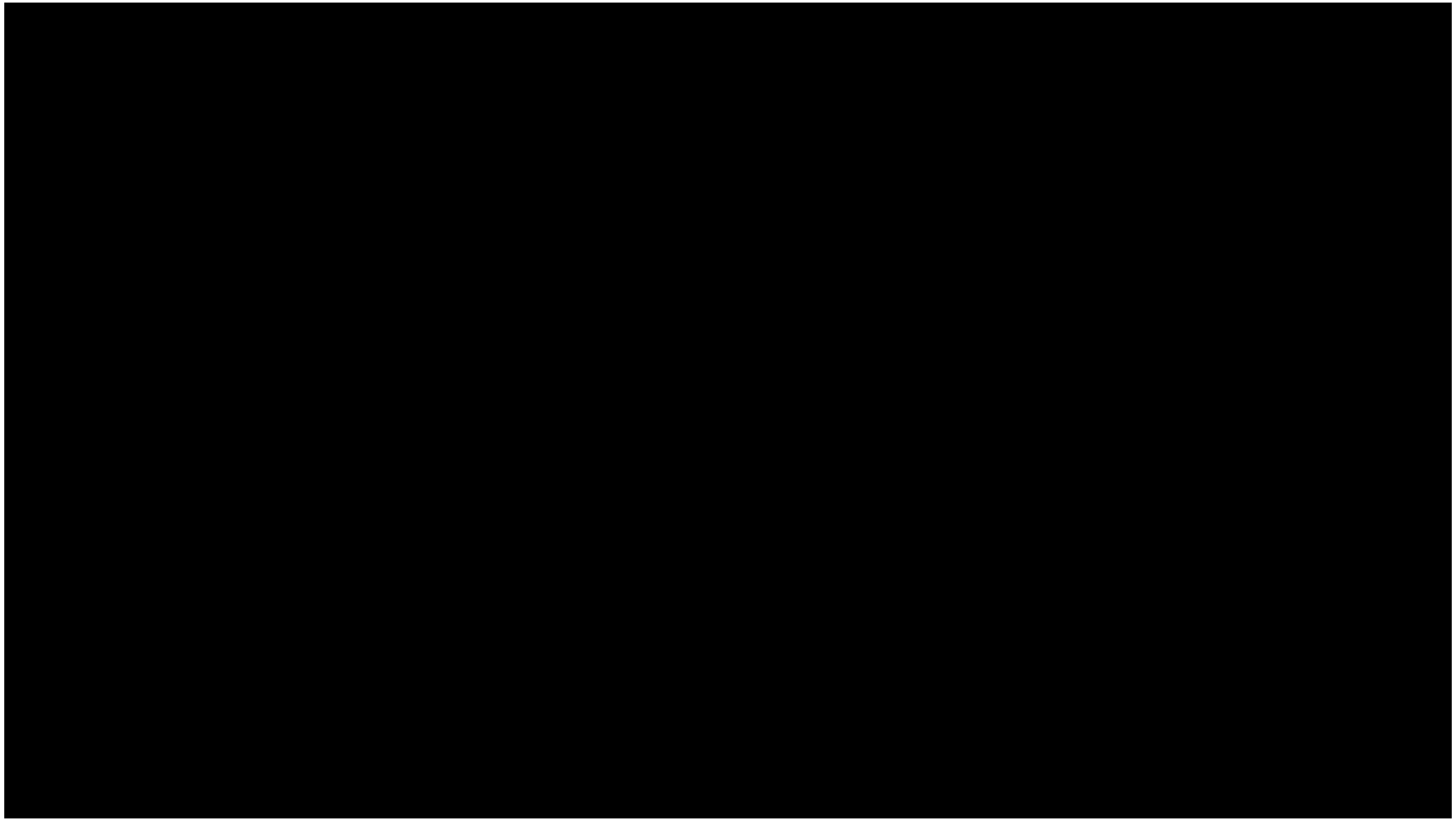
Swiss Cottage



West London residential speed bumps



Guildford City Centre NOx pollution hot spots

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Vehicle motion

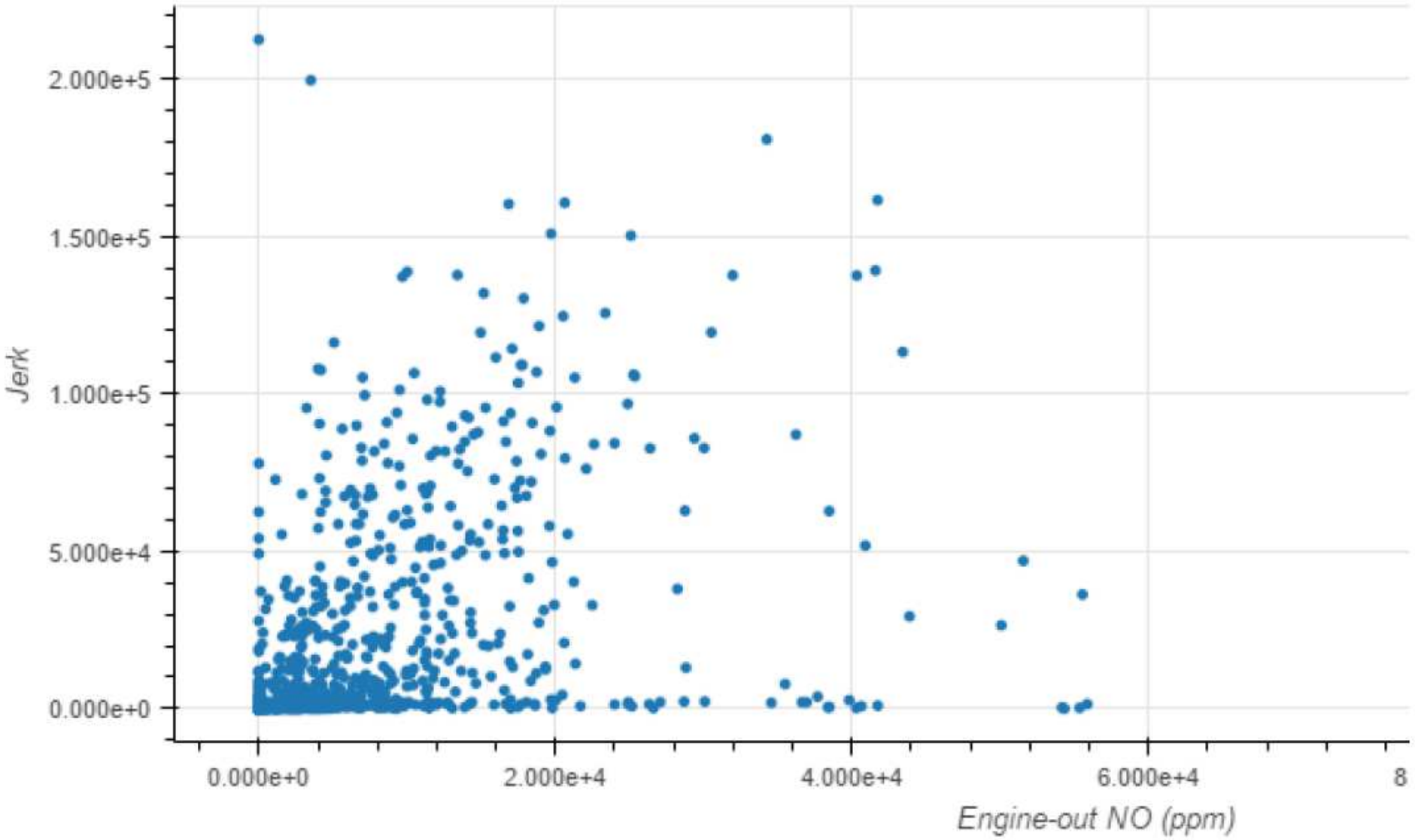
$$x = distance$$

$$\frac{dx}{dt} = velocity$$

$$\frac{d^2x}{dt^2} = acceleration$$

$$\frac{d^3x}{dt^3} = jerk$$

[NO] vs jerk



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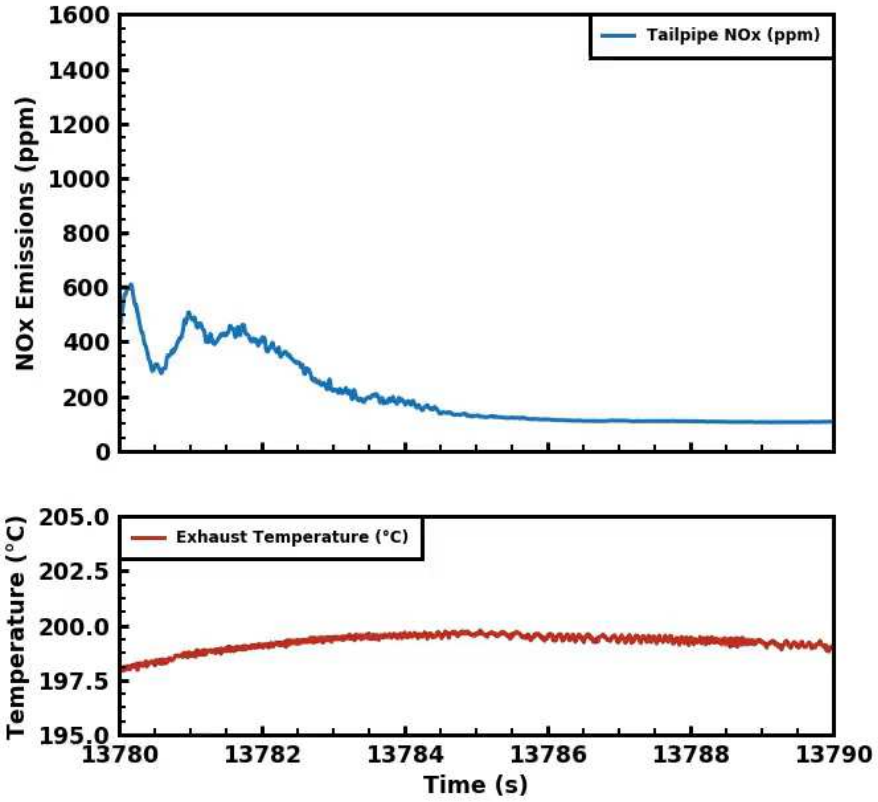
Euro 6 bus real time NOx emissions - roundabout



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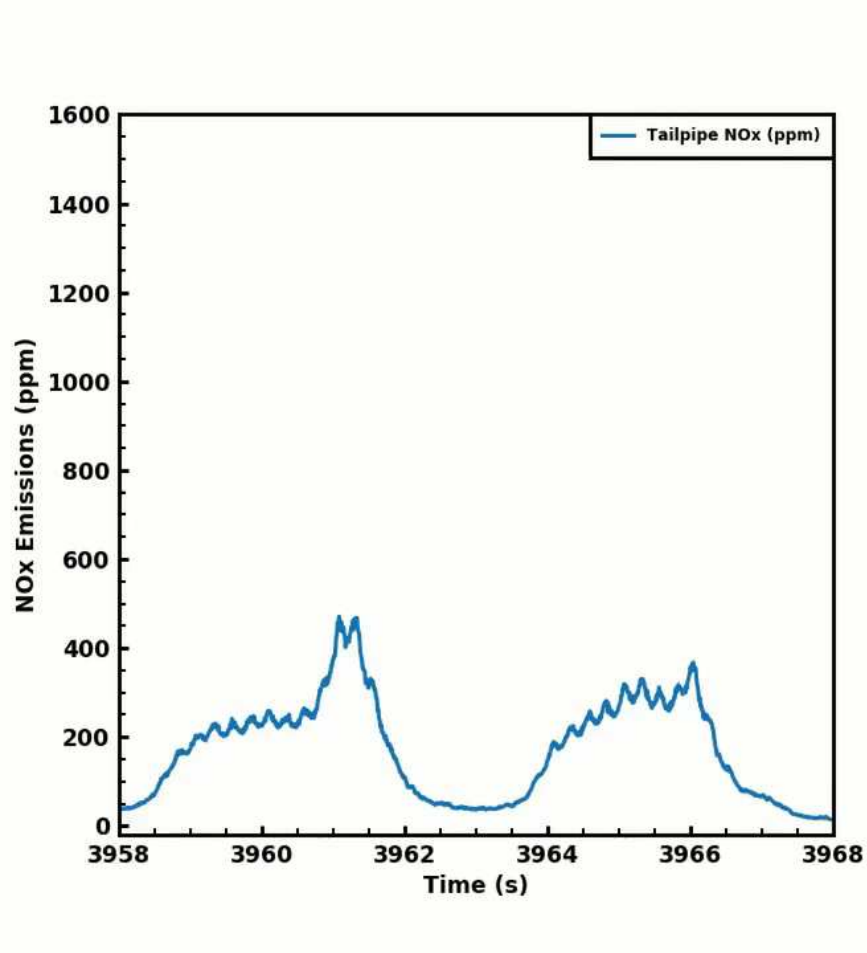
Euro 5 retrofit SCR bus – speed bumps



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Locomotive emissions…

SCR on new trains - GWR

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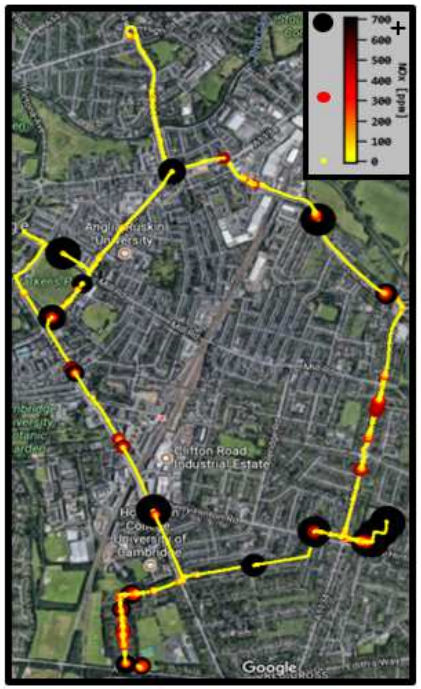
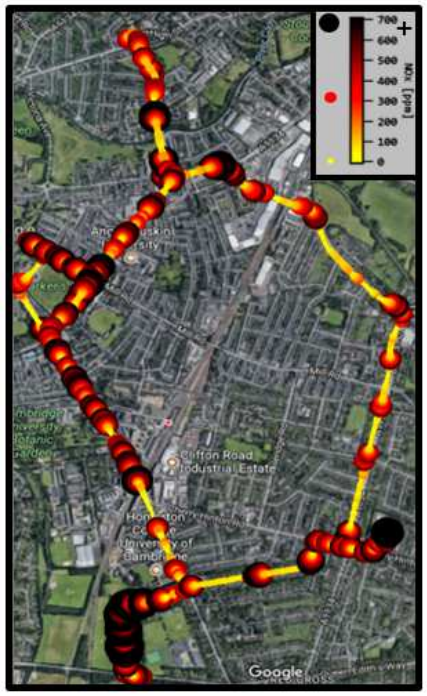
Are vehicle comparisons valid?

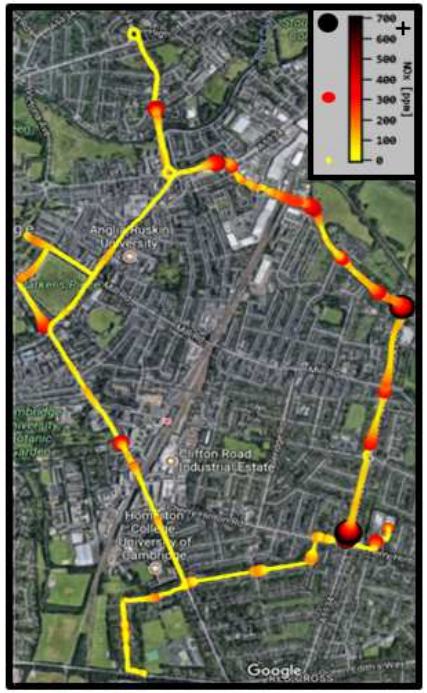
PETROL EURO4



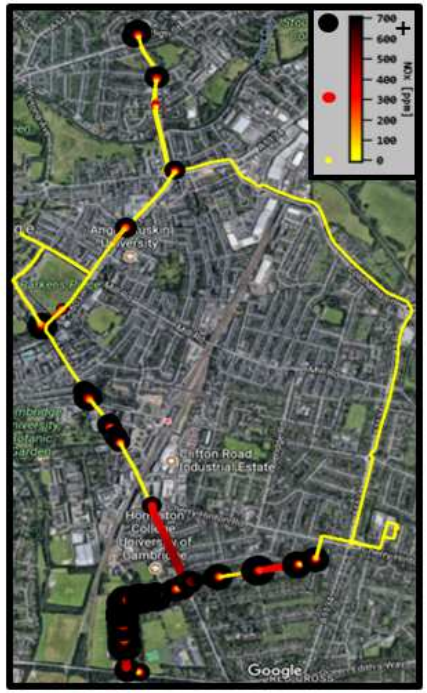
DIESEL EURO5



DIESEL EURO6



PHEV PETROL EURO6



Variations in climate, congestion, battery state of charge, *ppm* vs *mg/m* etc etc will greatly affect the above – treat comparisons with great care!

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In conclusion

- Engines & vehicles are generally getting cleaner, spurred-on by the new RDE legislation
- RDE presents unpredictable transients
- Very good spatial resolution of pollution “hot spots”
- Fast response analyzers can measure transient emissions and correlate these with other engine parameters
- Observed emissions issues are solvable using conventional means

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