

A map of London showing a dense network of transport routes. The River Thames is highlighted in light blue, winding through the center of the city. Overlaid on the map are numerous colored lines representing different transport modes: red for major roads, blue for bus routes, green for cycling paths, and purple for other transit lines. The central urban area is shaded in a light tan color.

Developing ‘real-world’ emissions functions

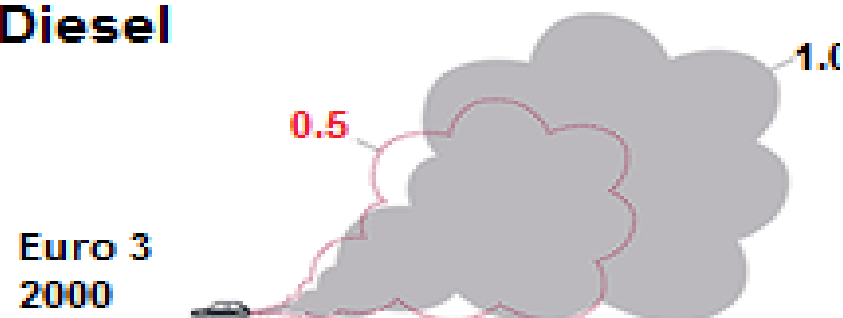
The problem with Euro Standards

NO_x Emissions for Type Approval and Real-World Driving (g/km)

Gasoline



Diesel

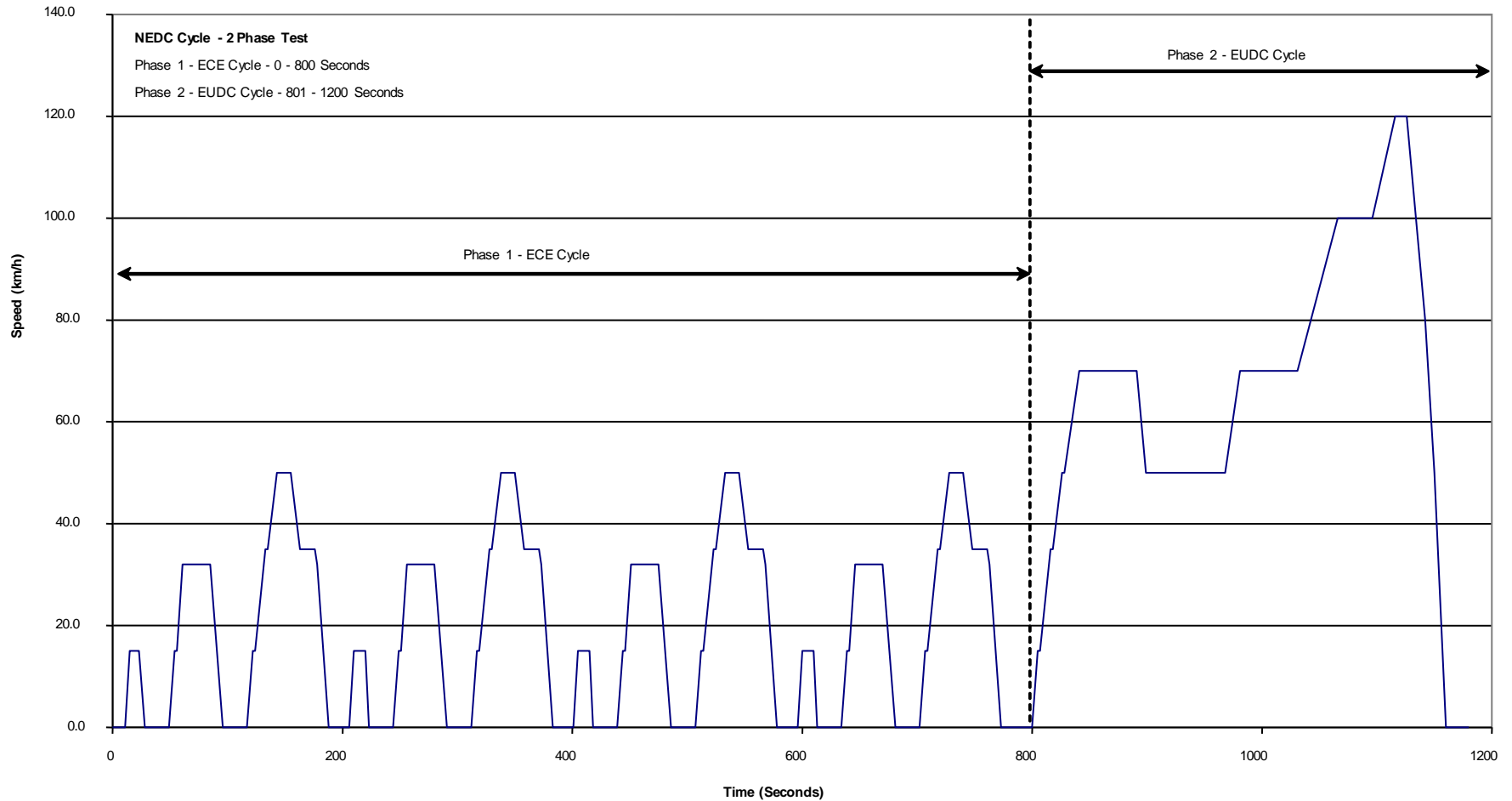


what are duty cycles?

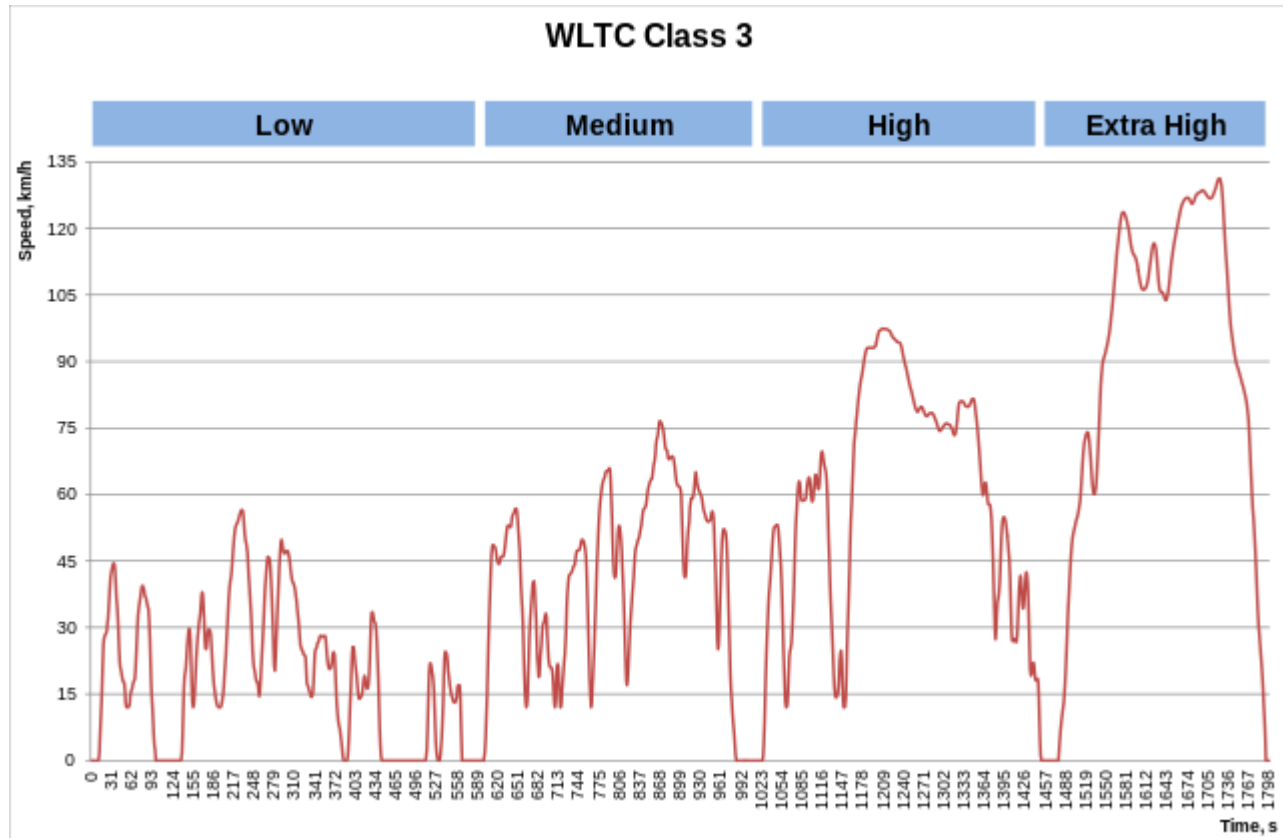
- The laboratory test procedure that simulates vehicle on-road driving using a chassis dynamometer or portable monitoring equipment.
- Some are more representative than others.
- TfL has developed a set for all types of vehicle and all traffic conditions, bespoke for London streets.
- London Passenger Car cycle, Millbrook London Transport Bus cycle, PCO-CENEX Taxi cycle
- Other duty cycles are available!

Type Approval Cycle for Passenger Cars in Europe

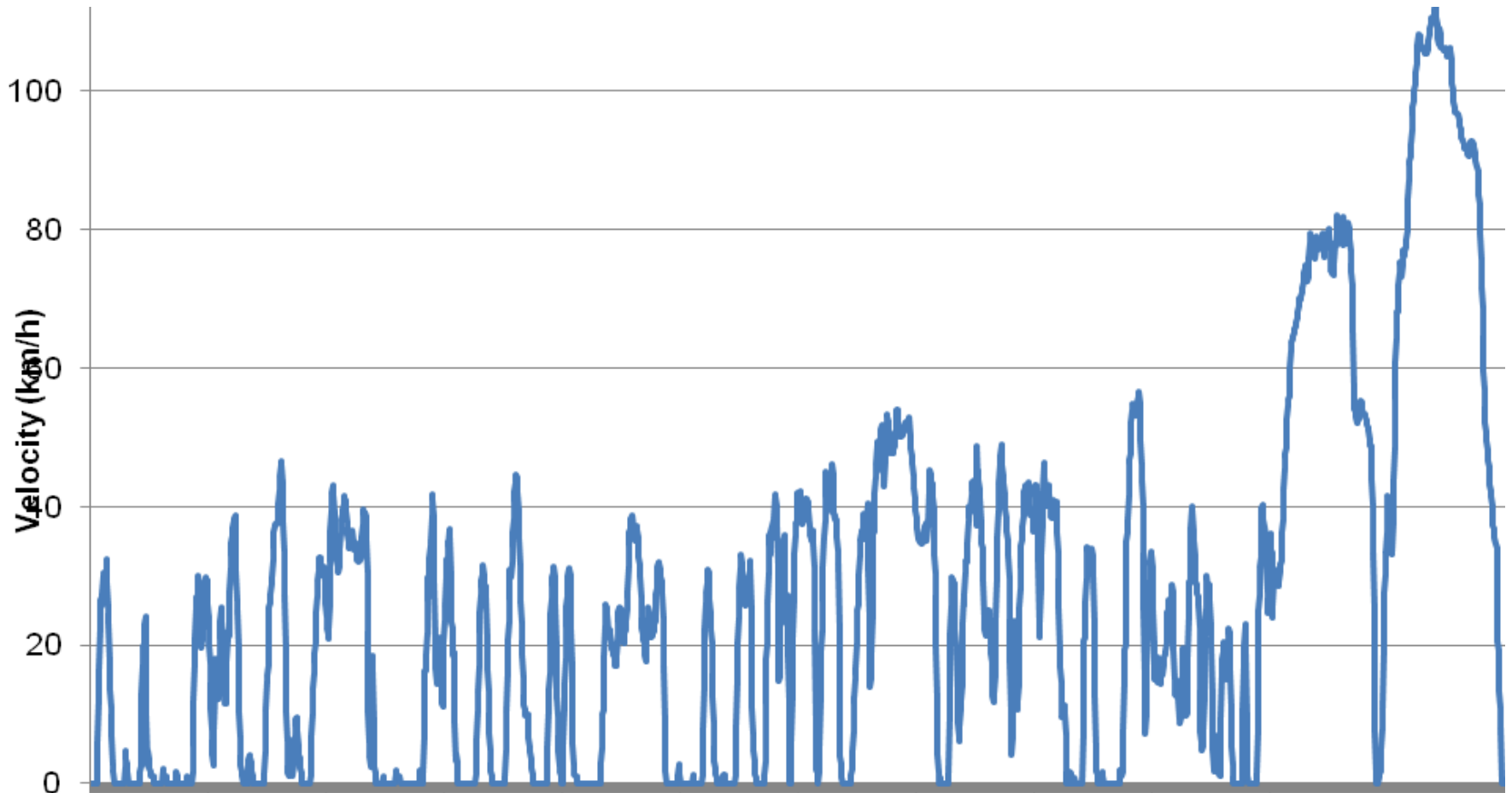
NEDC Drive Cycle



The World-harmonised Light-duty Test Cycle.

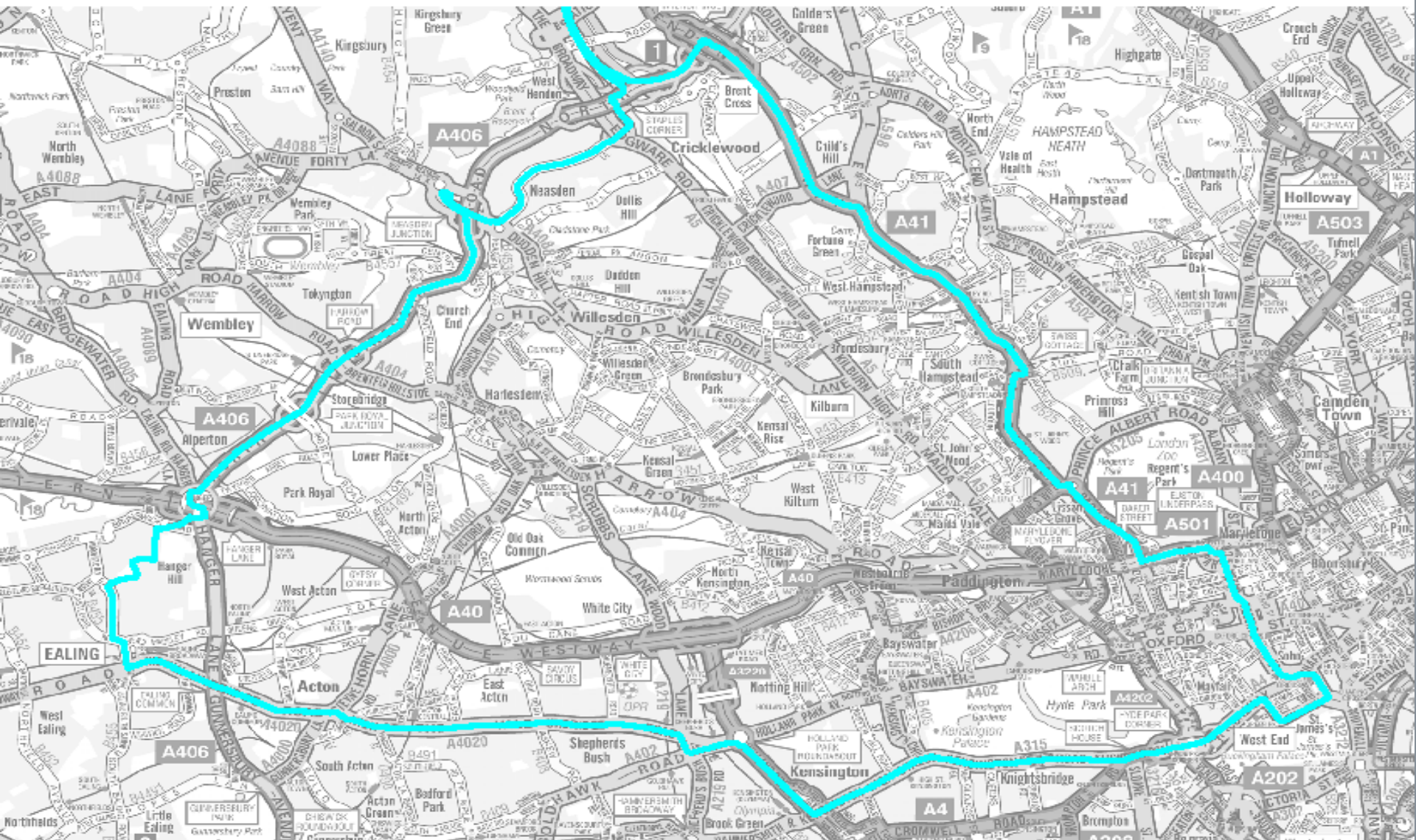


The London Passenger Car Drive Cycle

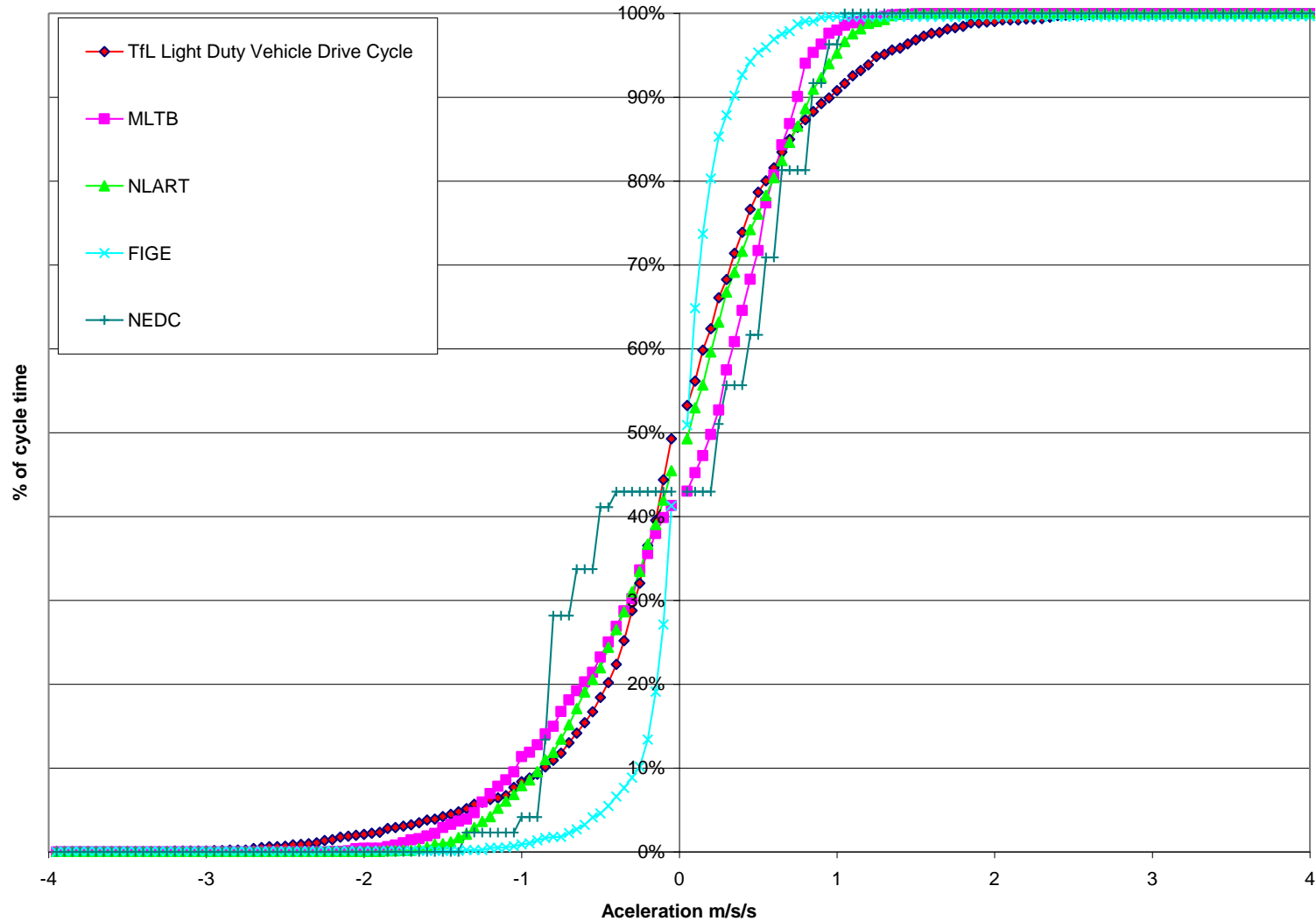


| Cycle Phase | Description | Time (secs) | Distance (km) | Avg Spd (km/h) |
|-------------|-------------|-------------|---------------|----------------|
| Phase 1 | Urban | 1656 | 8.38 | 18.20 |
| Phase 2 | Suburban | 528 | 4.69 | 32.00 |
| Phase 3 | Motorway | 216 | 4.48 | 74.80 |
| Total | - | 2400 | 17.56 | 26.34 |

The route for drive cycle development



Cycle Comparison – cumulative acceleration



An emissions test in progress



Classifying the vehicle fleet

A broad range from compact cars to 40 tonne articulated HGVs.

Passenger cars:-

- Compact
- Supermini
- Small family
- Hybrid Saloon - Gasoline
- Hybrid Saloon – Range-extended Electric Vehicle
- Family saloon/MPV
- Prestige saloon/sports
- SUV/4X4

Goods vehicles:-

- Light commercial vehicle - N1 class III - Diesel - 3500 kg GVW
- Heavy Goods Vehicle – N2 - 2 axle rigid - Diesel - 7500 kg GVW
- Heavy Goods Vehicle – N3 - 2 axle rigid - Diesel - 18000 kg GVW
- Heavy Goods Vehicle – N3 - 6 axle artic - Diesel - 40,000 kg GVW

Analysing the emissions

- Passenger cars were tested over all nine TfL sub-cycles.
- Goods vehicles were tested over two sub-cycles, but in both unladen and fully laden condition.
- Emissions were measured at one second intervals allowing detailed analysis.
- NOx emissions are speciated to reveal *inter alia*, primary NO₂.

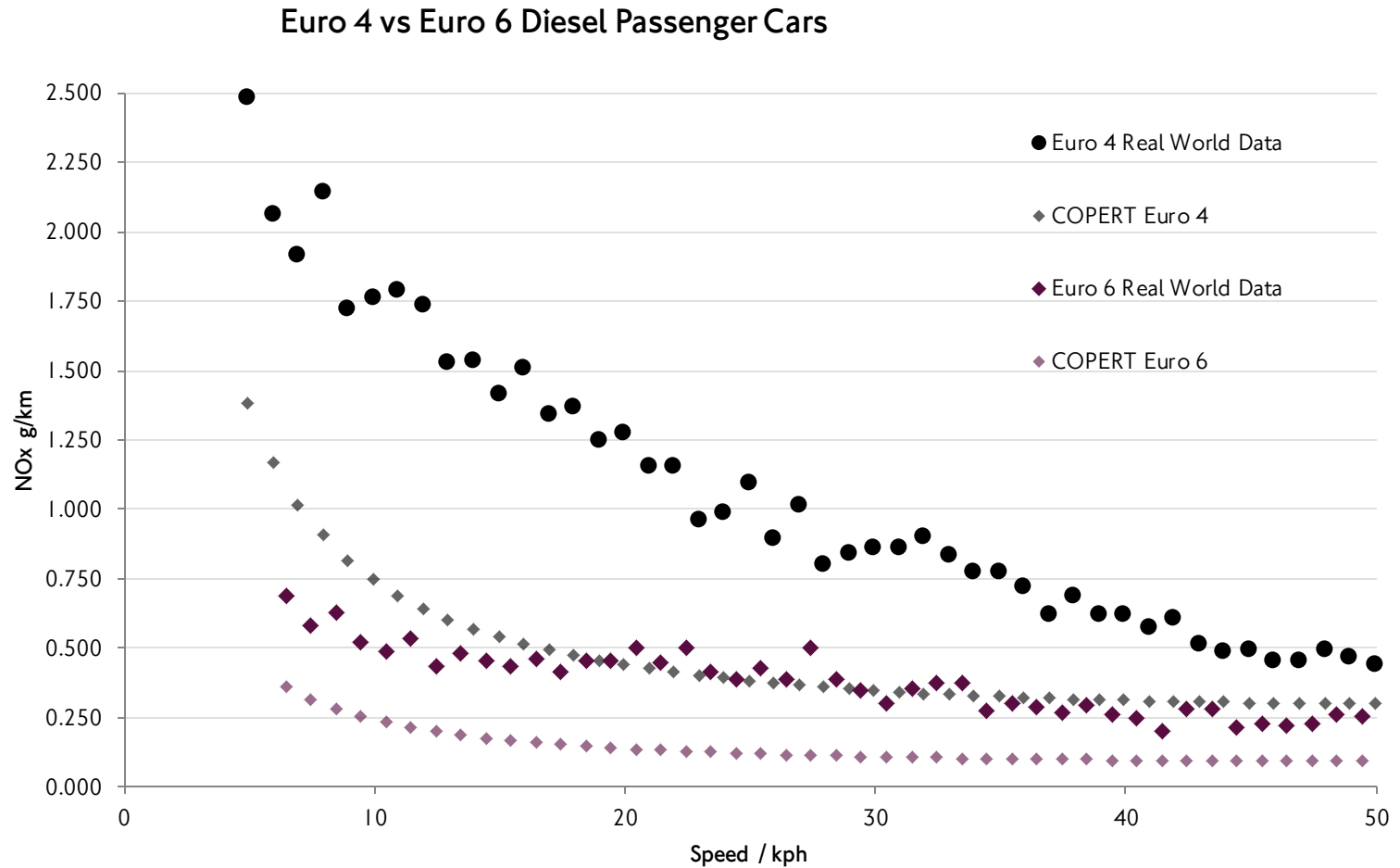
| The nine TfL London drive cycle key metrics | | | | |
|---|-----------|---------------|----------|-------------|
| Cycle | Sub-cycle | Distance (km) | Time (S) | Speed (kmh) |
| Urban | Freeflow | 8.921 | 1201 | 26.74 |
| | AM Peak | 8.921 | 2048 | 15.68 |
| | Interpeak | 8.921 | 2311 | 13.90 |
| Suburban | Freeflow | 13.327 | 1036 | 46.31 |
| | AM Peak | 13.327 | 1894 | 25.33 |
| | Interpeak | 13.327 | 1591 | 30.16 |
| Motorway | Freeflow | 24.609 | 1015 | 87.28 |
| | AM Peak | 24.609 | 1884 | 47.02 |
| | Interpeak | 24.609 | 1030 | 86.01 |

Analysing the data

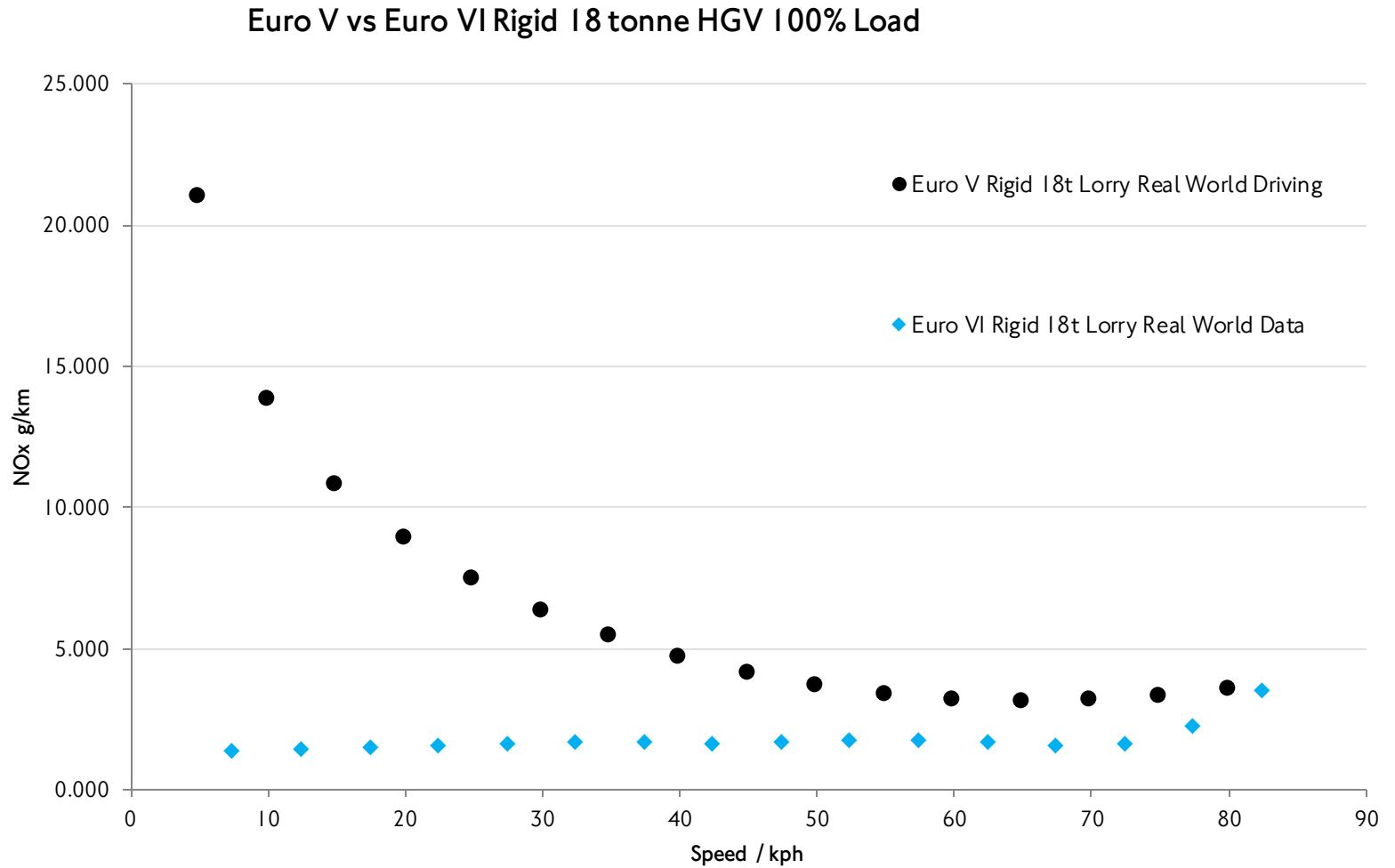
Creating emissions factors

- Average emissions are calculated using a “speed binning” approach. These emissions factors are plotted to allow comparison with other modelling factors such as COPERT 4.
- To allow predictions of emission factors from the TfL vehicle test data at any speed over the range commonly encountered in the real world (i.e. 0 km/h to 120 km/h) polynomial emission-speed curves are fitted to the data using least squares regression.
- Passenger car emissions were compared against COPERT 4 functions.
- HGV emissions are measured in g/km (*cf* g/kwh), so comparison was made to similar vehicles at Euro V.

Comparing emissions factors – diesel cars



Comparing emissions factors – rigid HGV 18,000kg



Developing new emissions functions

- The PHEM instantaneous emissions model has been validated using TfL laboratory data, additional data logging of vehicle behaviour and ibus data.
- There is very good correlation of CO₂ and NO_x emissions from diesels in particular.
- Data logging analysed to identify 'micro-trips'. (must exceed 5km/h and 20 metres distance).
- This is combined with 1 hz average speed and resultant average emissions.
- This method is innovative in balancing the effects of acceleration and deceleration to give a more representative picture of emissions outputs.
- A paper will be published on the work later in the year.

Thank you for listening

Adam Moody

<https://tfl.gov.uk/cdn/static/cms/documents/in-service-emissions-performance-of-euro-6vi-vehicles.pdf>