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IAQM meeting, ARUP, Fitzroy, London

Better accounting for NO_x/ NO₂ emissions in air quality action planning



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EVIDENCE

- Remote sensing vehicle emissions
- NO_x/ NO₂ emission factor uncertainties
- Challenges for diesel emission controls in urban driving

A DETAILED TRAFFIC-EMISSION MODELLING APPROACH

- Coupled micro-scopical traffic and instantaneous emission modelling
- York Case Study: Fulford AQMA
- Local vehicle fleet specification
- Comparison with remote sensing measurements

PRELIMINARY RESULTS

- Source apportionment

FUTURE WORK

- Case Study: Air Quality Action Plans for the Fulford Main Street AQMA
- City of York Low Emission Strategy

REMOTE SENSING VEHICLE EMISSIONS

Surveying the vehicle fleet on the road



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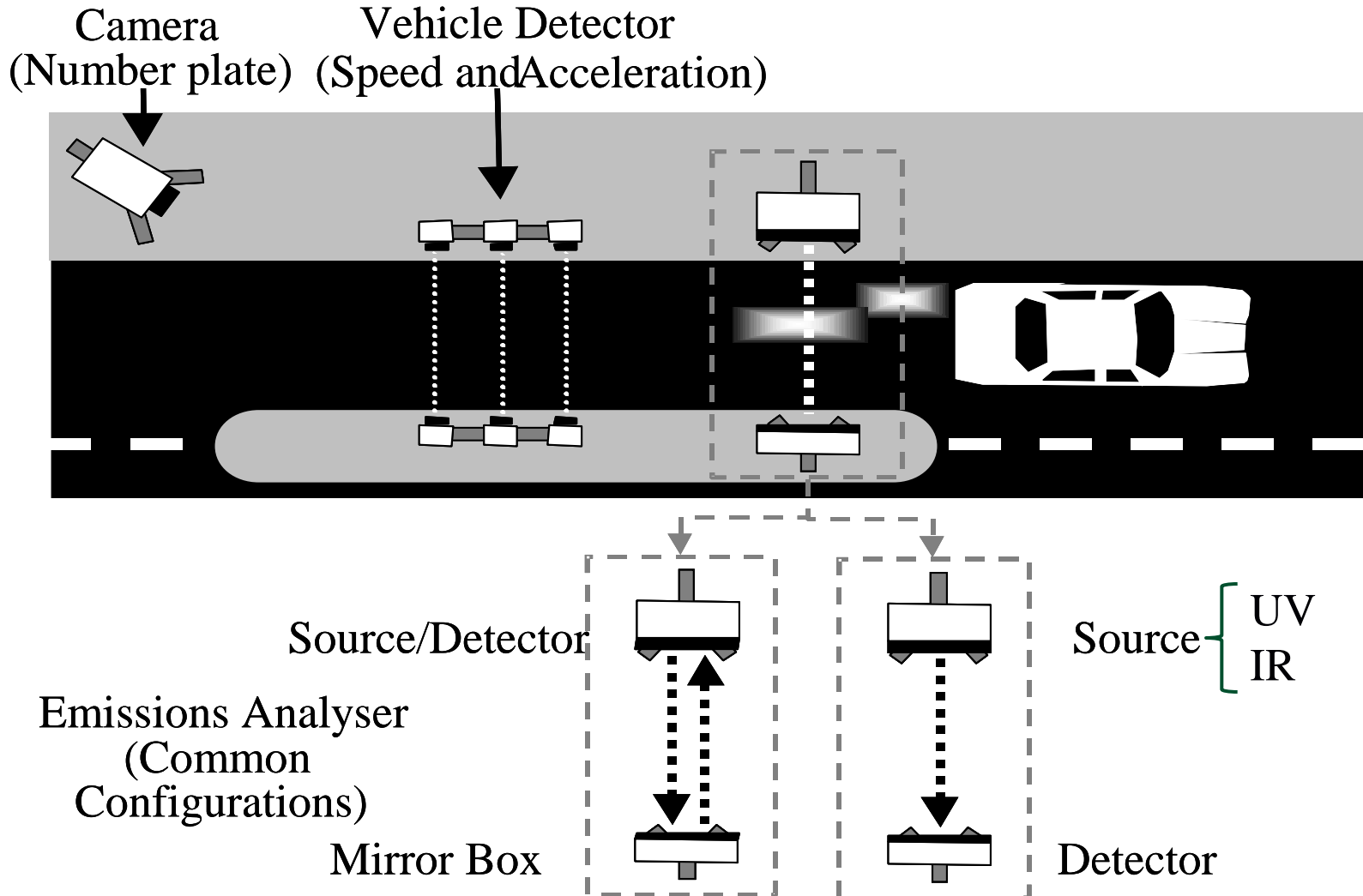
Halifax, Calderdale MBC, October 2009

REMOTE SENSING VEHICLE EMISSIONS

Surveying the vehicle fleet on the road

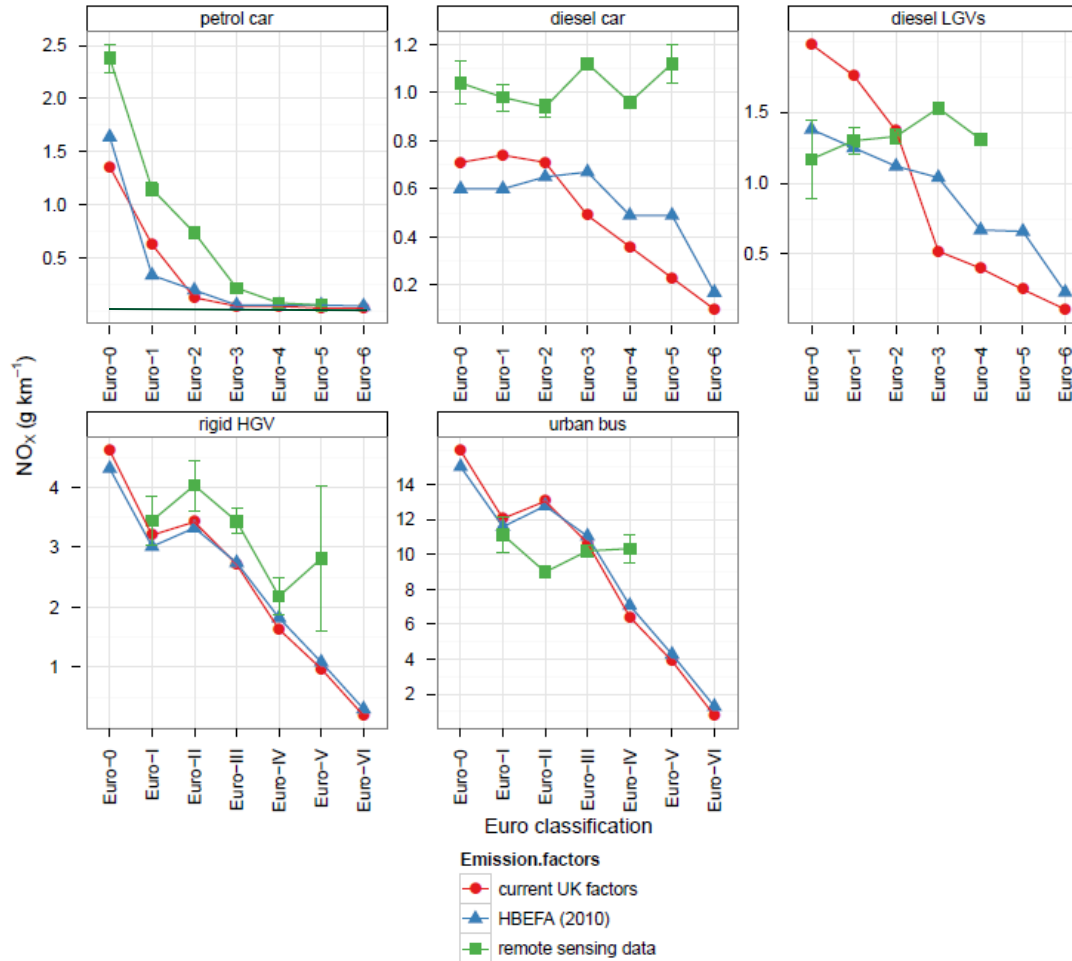


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ESP RSD-4600 instrument (www.esp-global.com)

NO_x/NO₂ EMISSION FACTOR UNCERTAINTIES



Carslaw, D., Beevers, S. Westmoreland, E. Williams, M. Tate, J. Murrells, T. Stedman, J. Li, Y., Grice, S., Kent, A., Tsagatakis, I. (2011). Trends in NO_x and NO₂ emissions and ambient measurements in the UK. Version 3, March 2011.

ASSESSMENT OF VEHICLE EMISSIONS

Laboratory testing



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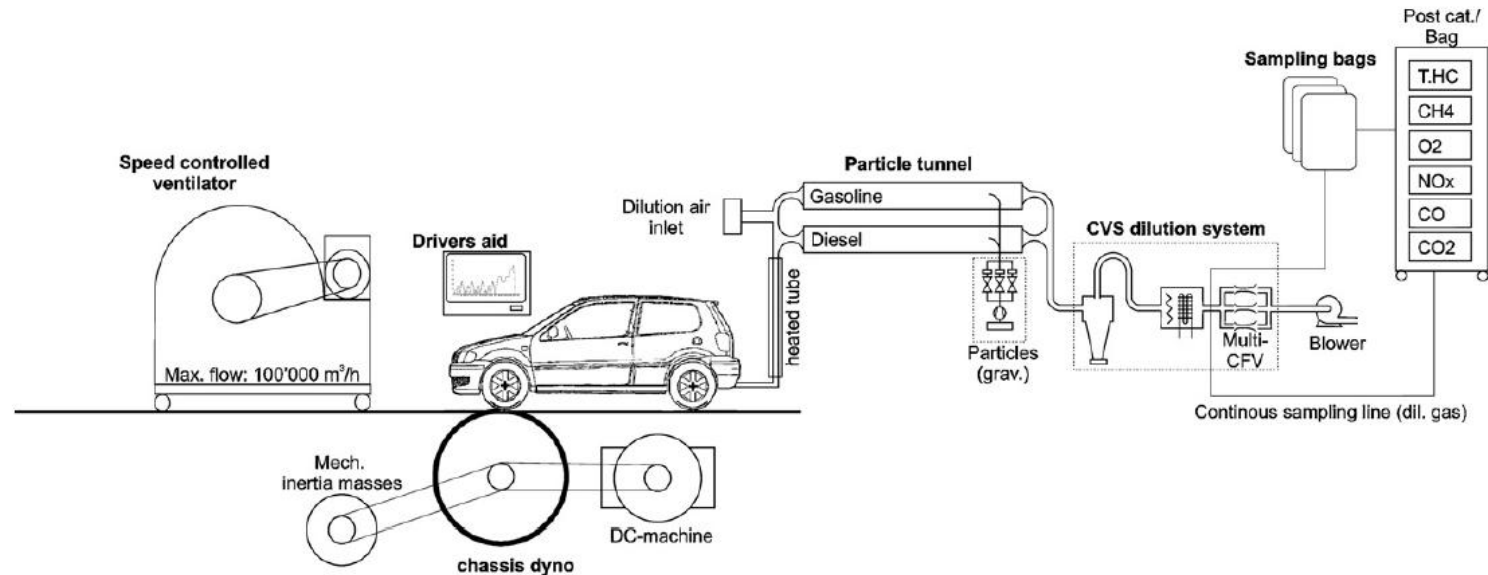


Fig. Chassis dynamometer and exhaust analysing equipment

Technical University of Graz (Austria):

- Light-duty
 - Heavy-duty
- Engine & Chassis dynos.



ASSESSMENT OF VEHICLE EMISSIONS

Vehicle operation



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Fig. Speed profile used for type approval purposes (New EU Drive-Cycle)

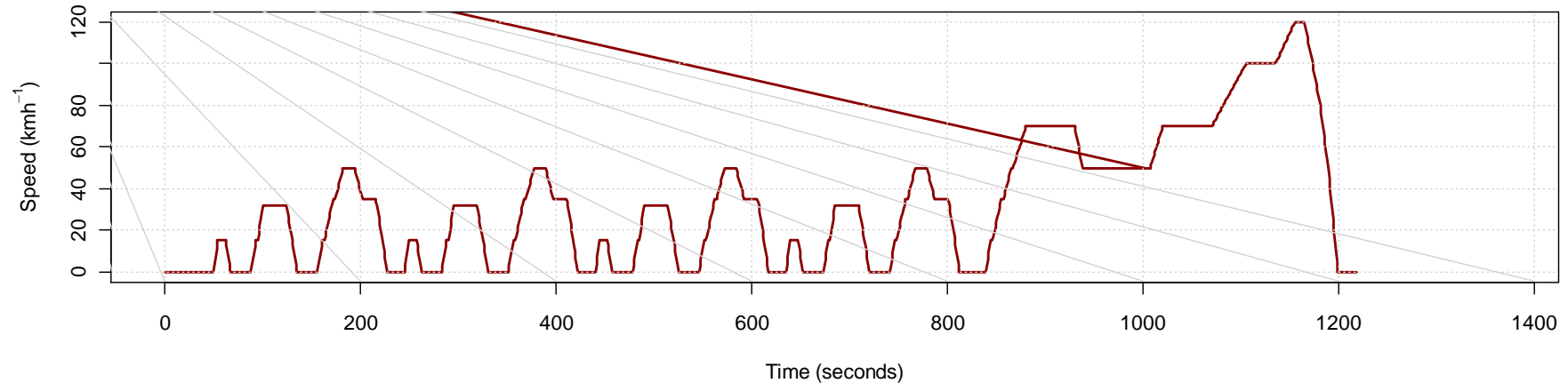
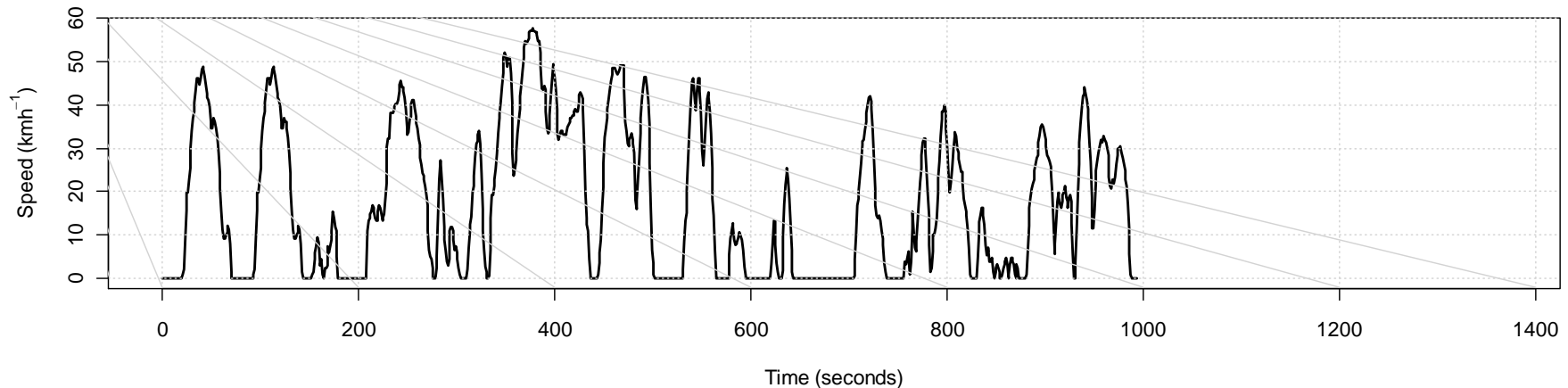
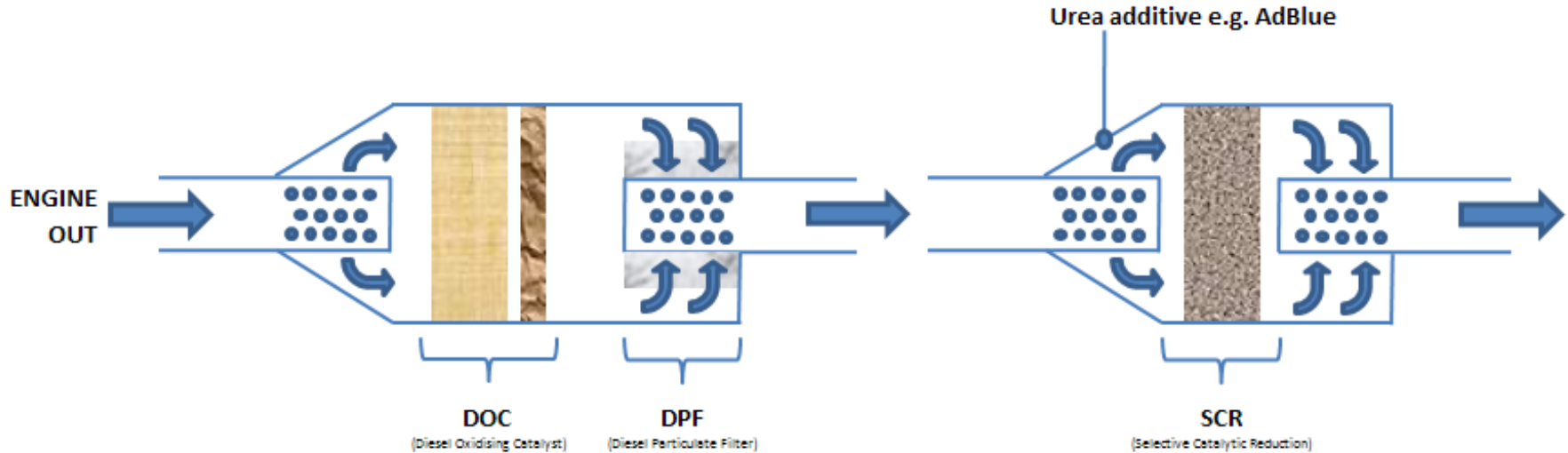


Fig. Real-world driving: The Common ARTEMIS Drive Cycle (Andre, 2004).



MODERN DIESEL EMISSION CONTROLS

DOC, DPF + SCR



DPF

- Passive re-generation (in high power/ temperature operation e.g. motorway)
- Active re-generation

SCR

- To be effective the current technology also need high temp exhaust gases

Challenges in Urban driving

- Stop / start driving – intermittent & low engine power demand
- Idling - relatively cool exhaust gases

DETAILED TRAFFIC-EMISSION MODELLING

Coupled micro-sscopic traffic & instantaneous emission model



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Vehicle types:

- Car, Van, Bus, Coach, Artic & Rigid HGVs

Age:

- Euro 0, 1, 2, 3, 4, 5, 6

Fuel type:

- Petrol, diesel, *hybrid*

Model:

- Transient engine maps
- Gear change (sub) model

TRAFFIC MICROSIMULATION

S-Paramics, Version 2010.0

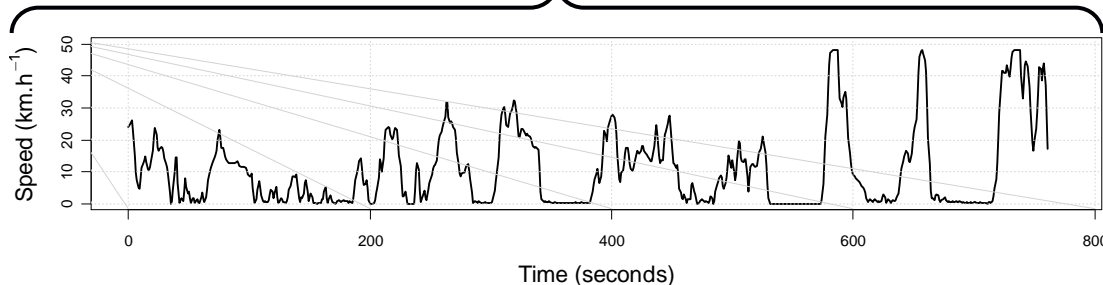
1Hz vehicle trajectory (speed profile) data

VEHICLE EMISSIONS

PHEM (Passenger car & Heavy-duty Emission Model), Version 10.4.2.

RESULTS

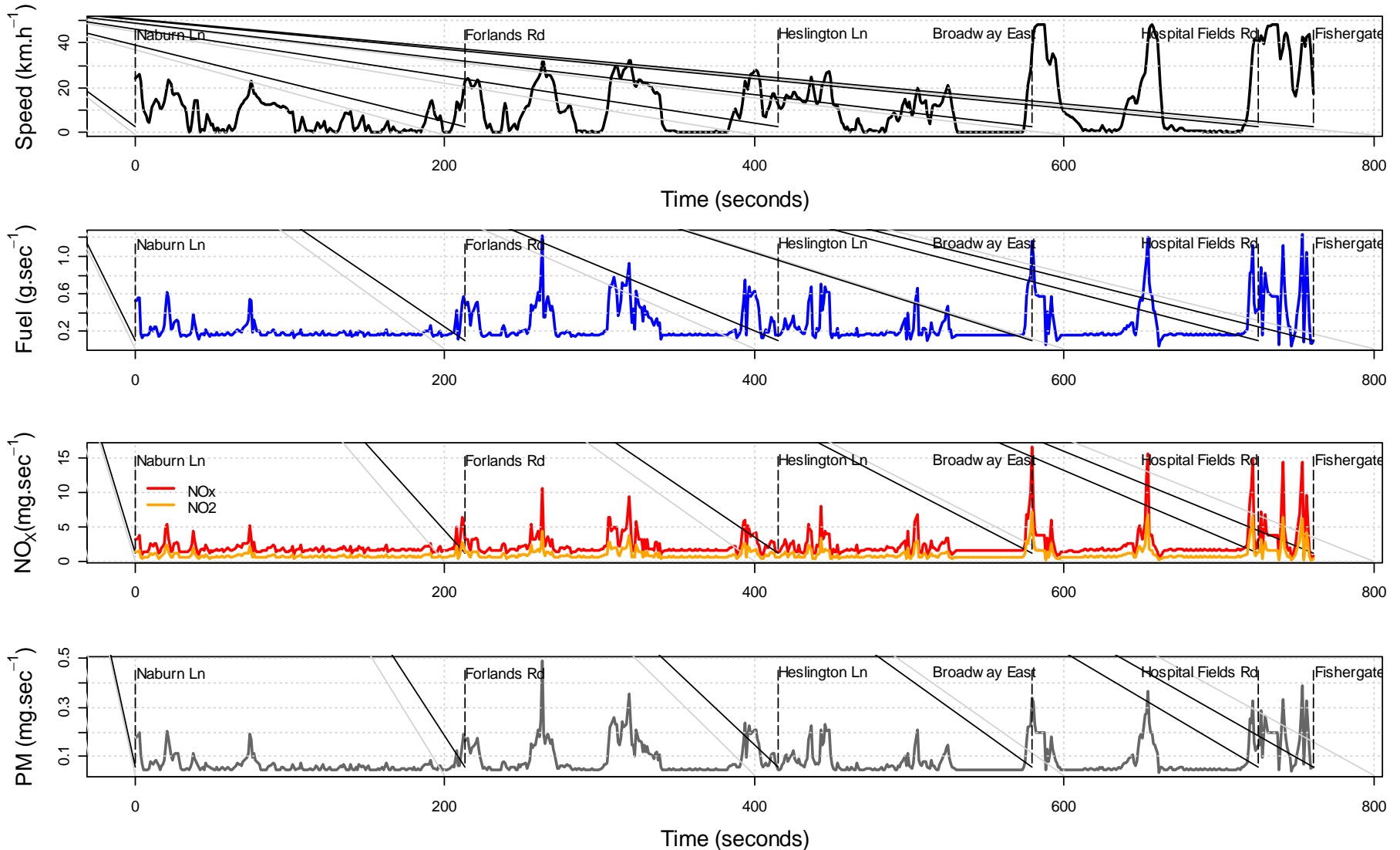
Broken down by area, road section, time-of-day, vehicle & fuel type, etc.



DETAILED TRAFFIC-EMISSION MODELLING

Coupled micro-scopic traffic & instantaneous emission model

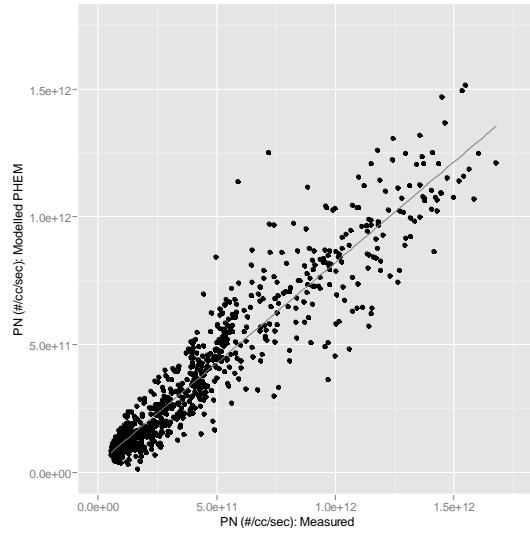
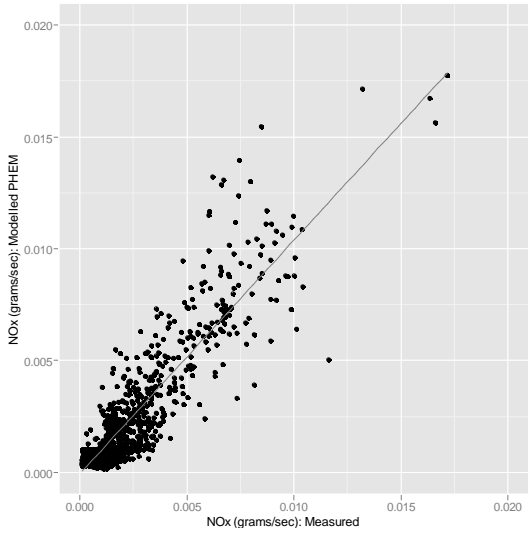
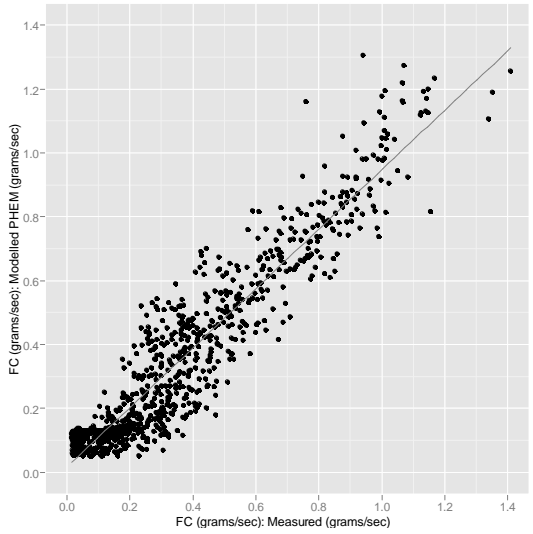
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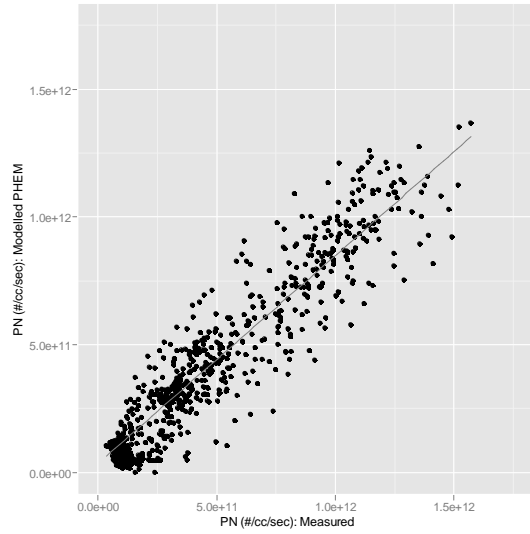
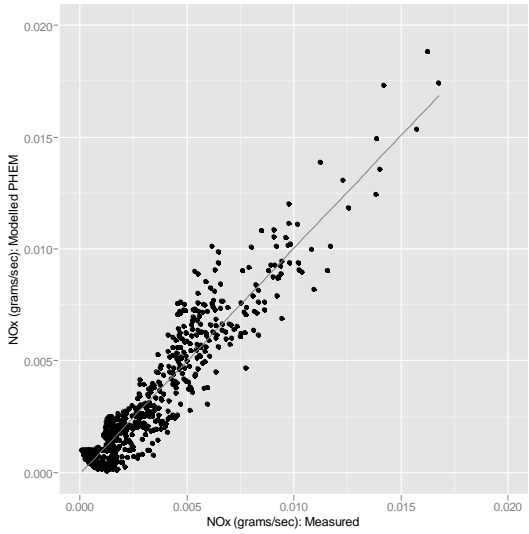
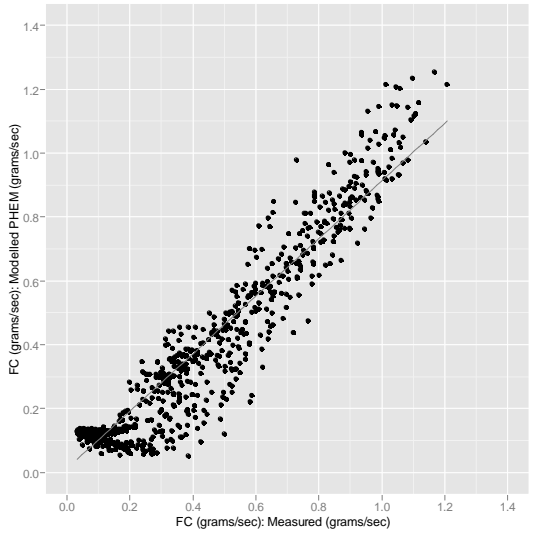
VALIDATING THE TRAFFIC-EMISSION MODEL

Euro4 diesel passenger car: *OBSERVED* and *MODELLED* 5-second moving average

'ON-ROAD'
drive cycles



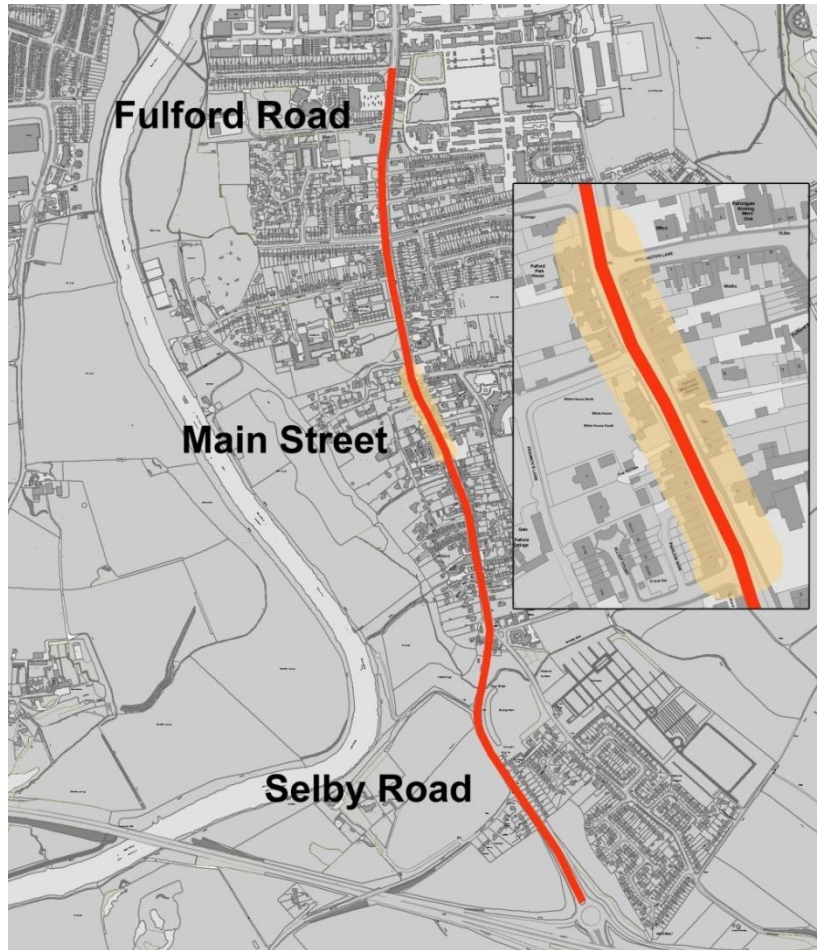
'MICRO-SIMULATED'
drive cycles



YORK - FULFORD AQMA

Coupled micro-sscopic traffic & instantaneous emission model

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SIMULATIONS

Stage 1 (Further Assessment, April 2011)

www.jorair.co.uk

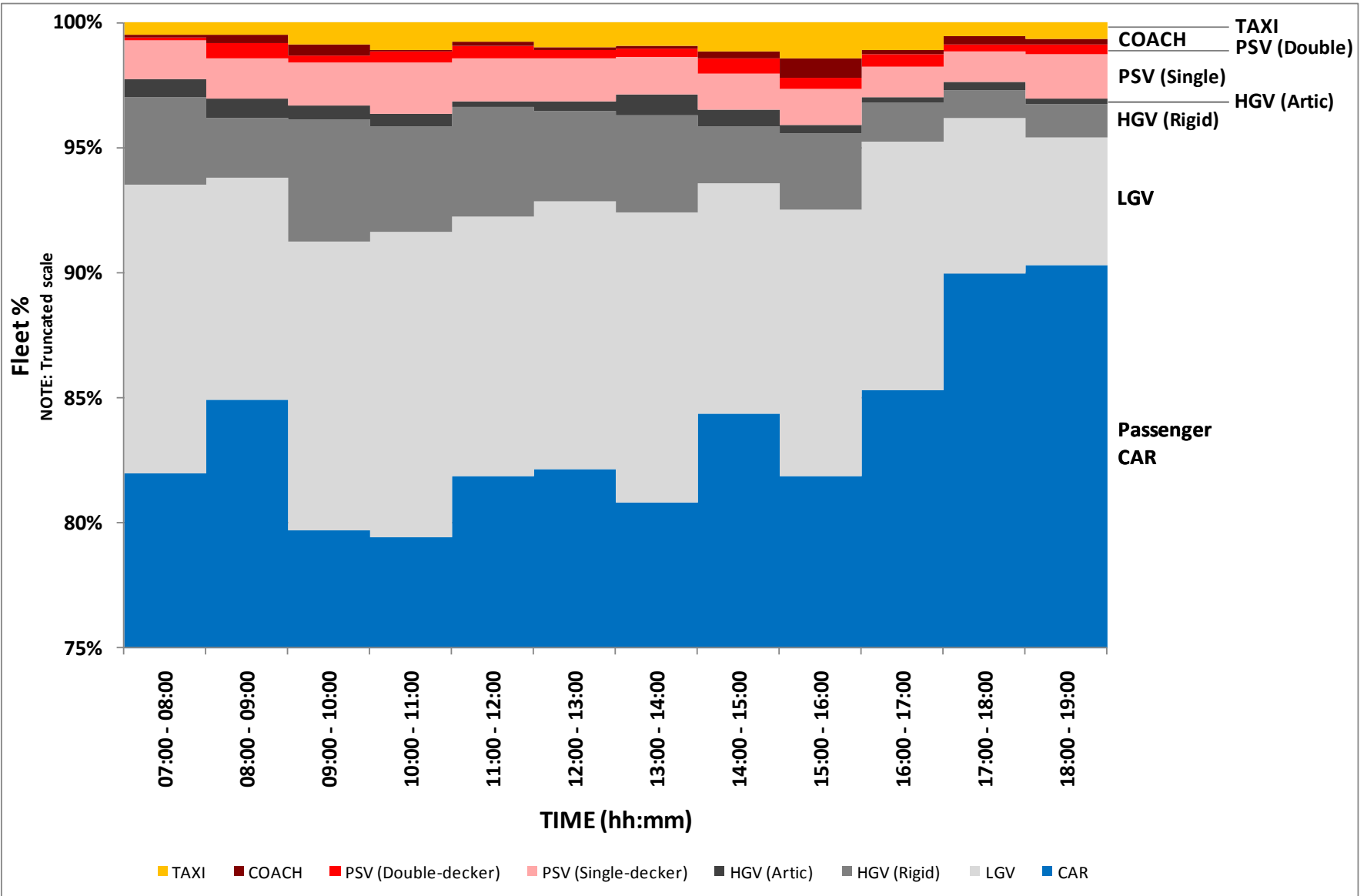
- 4 time periods (am, midday, pm, night)
- VEHICLE FLEET – number plate surveys, 1 day in July 2010 → UK Vehicle registration database
- TRAFFIC – selected average from 6 simulations [Trajectory files ~ ½ Gb, ~ 5000 trips]
- EMISSIONS – 1hz resolution, files ~ ½ Gb

Stage 2 (Action Plan, October 2011)

- 5 time periods (am, midday, pm, + evening, night)
- VEHICLE FLEET – number plate surveys, 1 day in May 2011 → UK Vehicle registration database [*Higher specification*]
- TRAFFIC – multiple (x10) simulations each period [*Better calibrated traffic demand, Bus services*]
- EMISSIONS – multiple (x10) simulations [*Better specified vehicle fleet, York P&R Bus*]

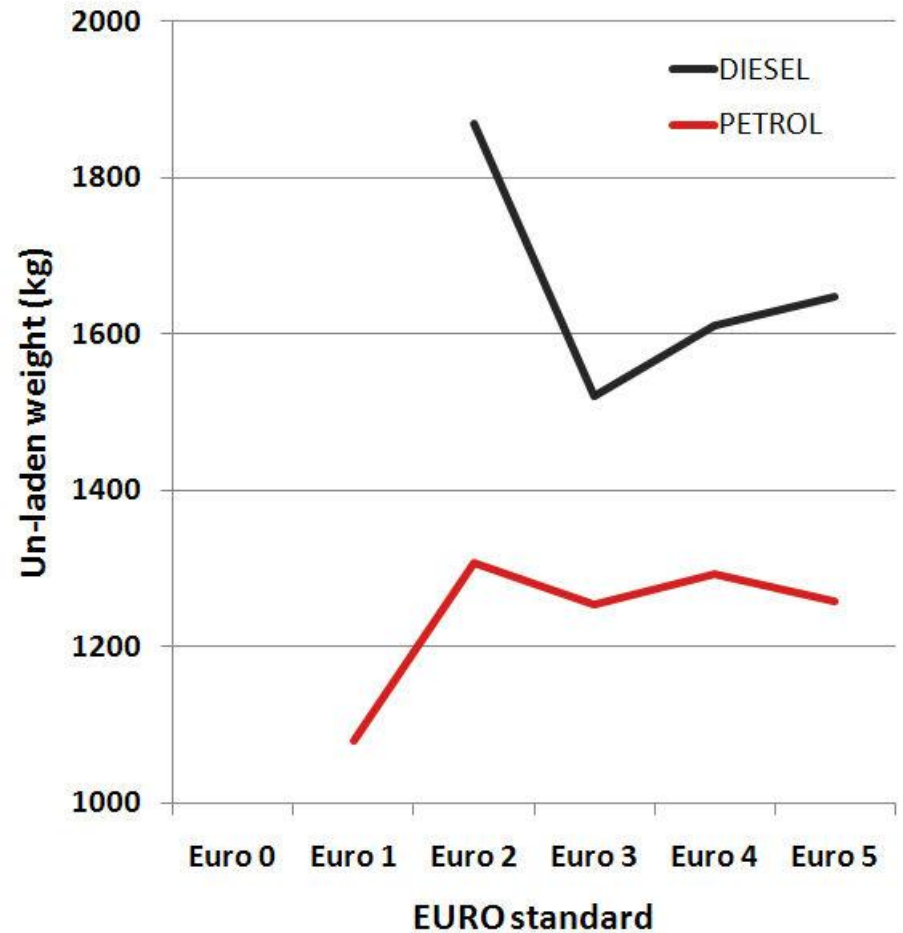
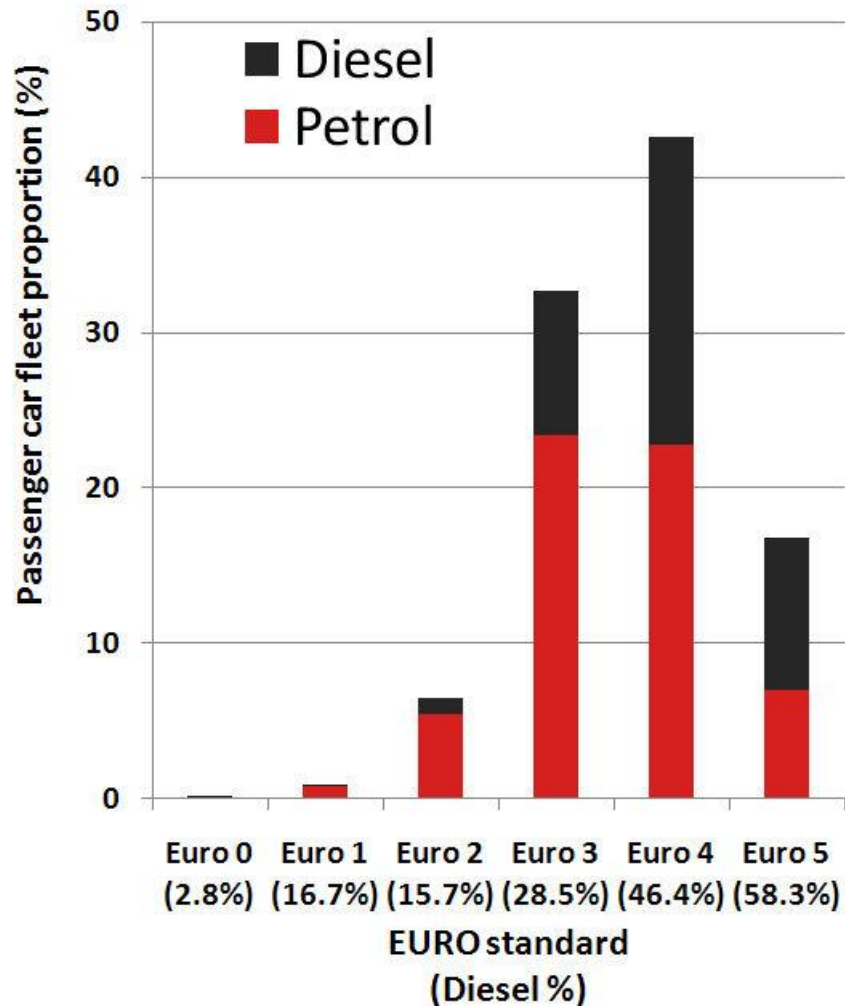
VEHICLE FLEET IN THE FULFORD AQMA

Detailed UK Vehicle Registration Information (May 2011)



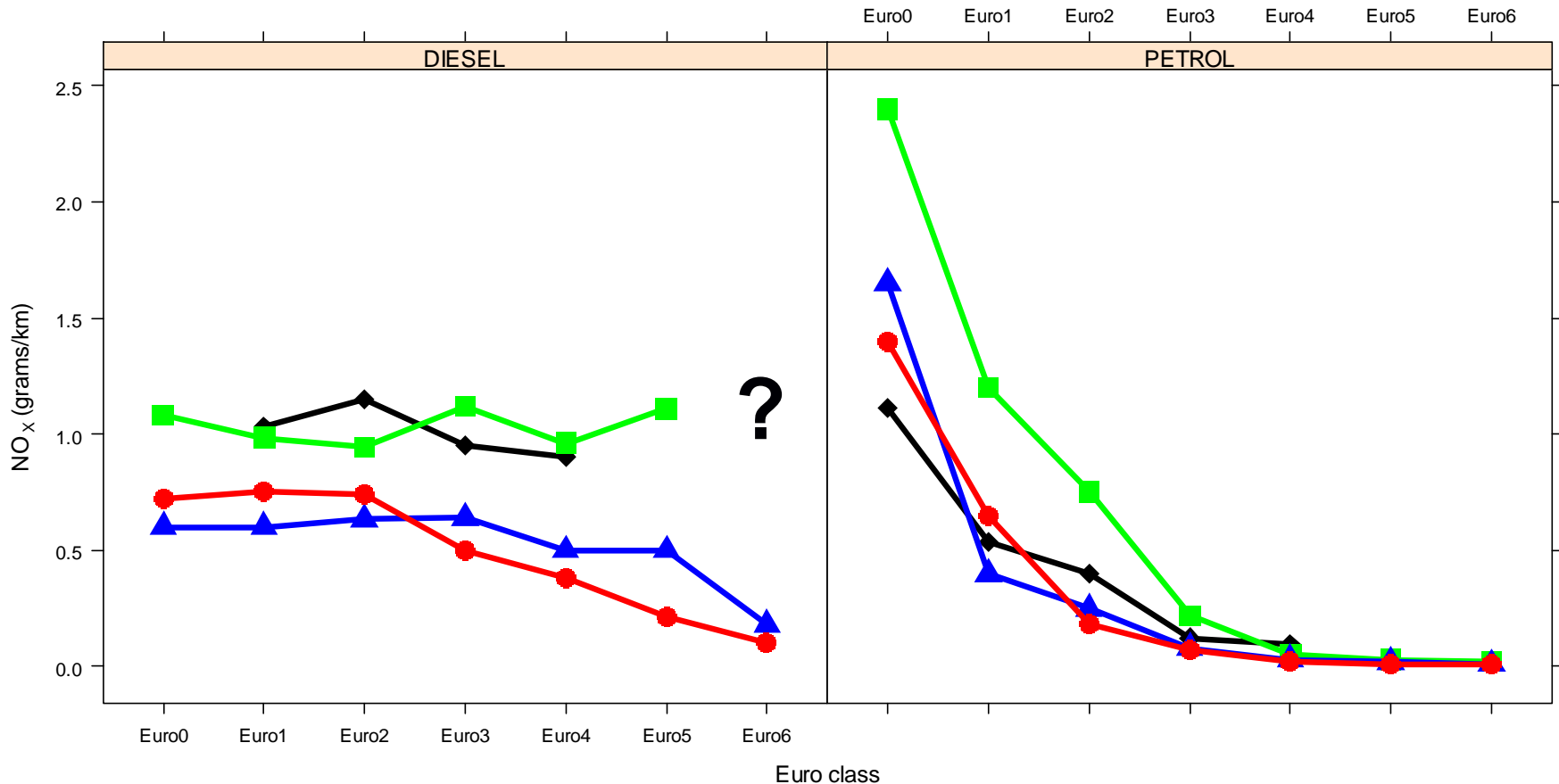
VEHICLE FLEET IN THE FULFORD AQMA

Detailed UK Vehicle Registration Information (May 2011)



PRELIMINARY RESULTS (Stage 1)

Comparison with Remote Sensing Measurements



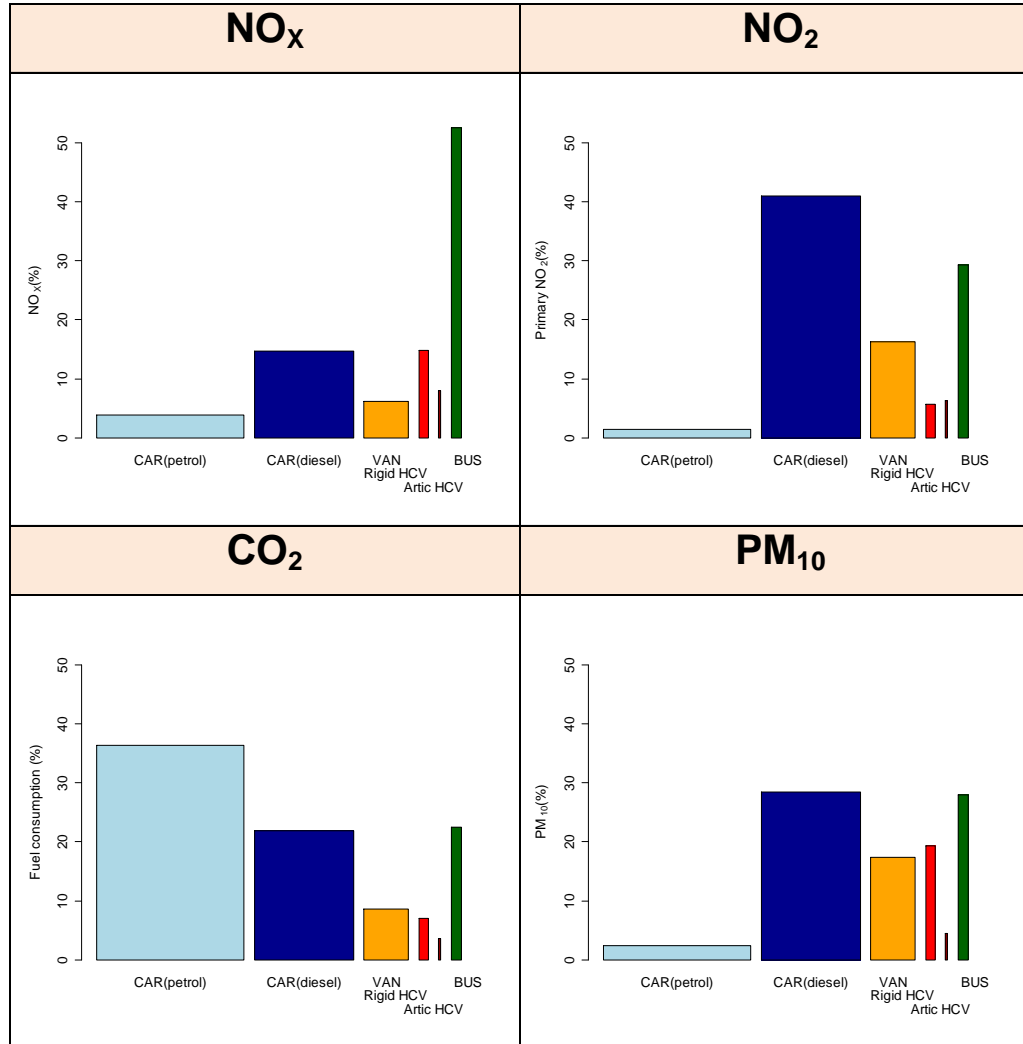
Carlaw, D. et al. 2011. Trends in NO_x and NO₂ emissions and ambient measurements in the UK. March 2011.

- ◆— PHEM
- RSD
- ▲— HBEFA
- UK emission factors

PRELIMINARY RESULTS (Stage 1)

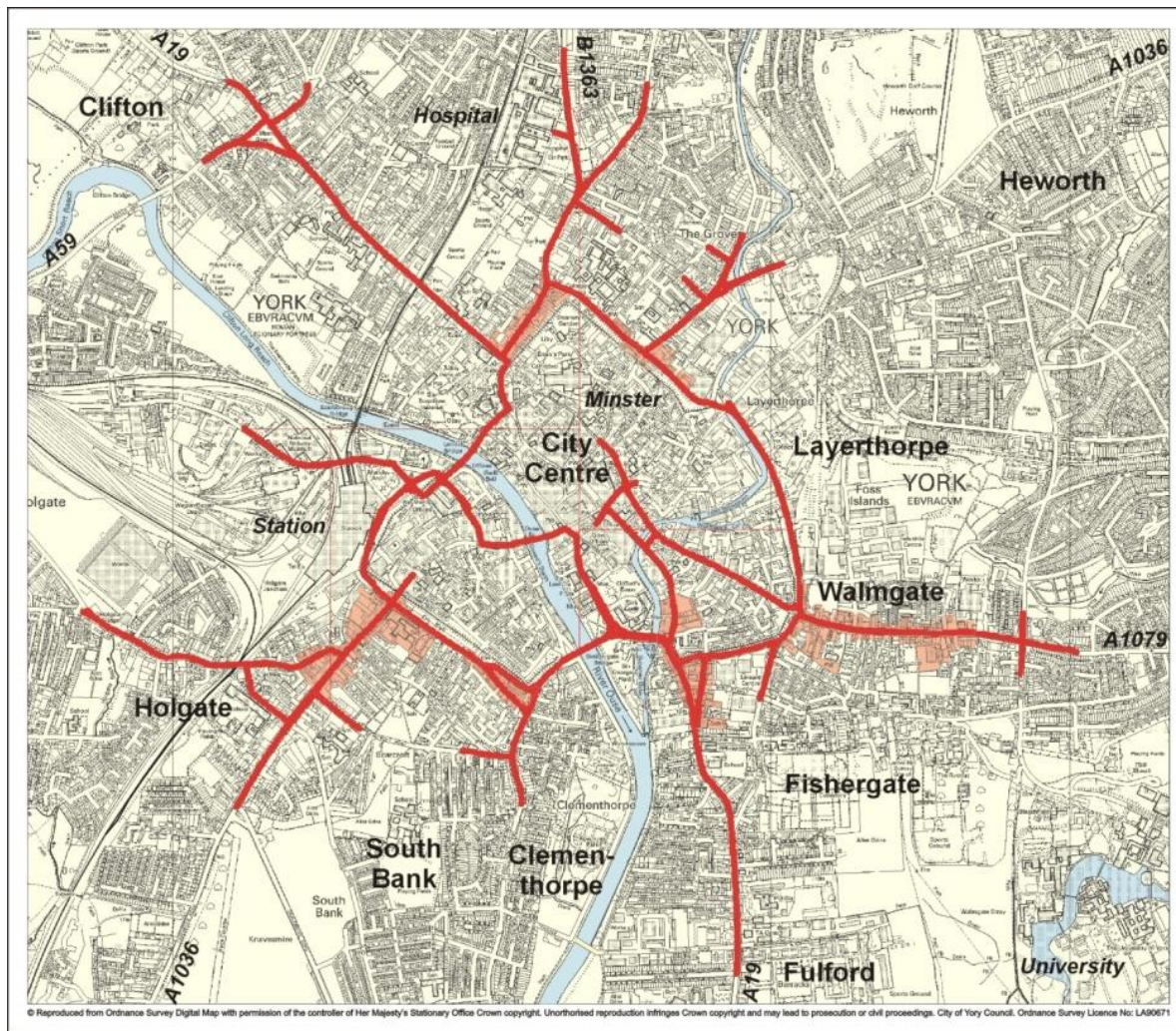
Source apportionment

DAILY EMISSION CONTRIBUTION (%)



HOW CAN THIS APPROACH ASSIST LOCAL AUTHORITIES?

Understanding the problem



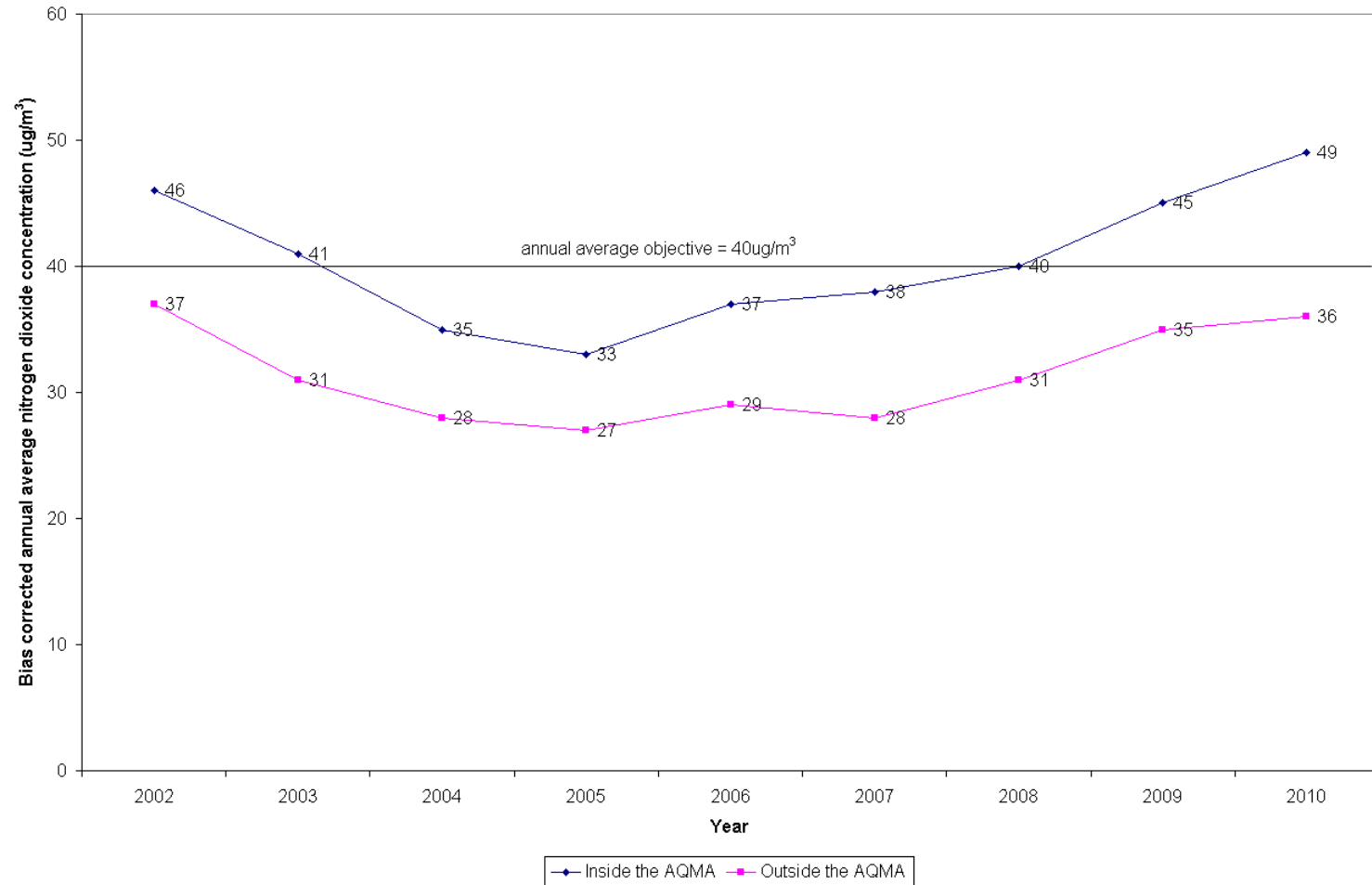
The Council of the City of York
Air Quality Management Area
Order No 1

Boundary of the Air Quality
Management Area

- Roads
- Properties



Mean of annual average NO₂ concentrations around York IRR (40 fixed sites) – 2002 to 2010



Deteriorating AQ in York – the reasons

- Larger proportion of diesel vehicles in the fleet than originally predicted (particularly new diesel cars)
- Newer diesel cars emit a greater proportion of primary NO_2
- The proportion of NO_x emitted by buses is higher than originally identified (and we now have more buses than ever!)
- NO_x emissions from diesel engines haven't significantly improved between Euro III and Euro V (upgrading beyond Euro III is unlikely to have helped much)



Deteriorating AQ in York – the reasons

- Increased cheaper parking on periphery of city centre coupled with increased bus fares, particularly on P&R
- Impact of new development also likely to be much higher than air quality impact assessments have suggested



Expectations for air quality improvement have to date been too high due to underestimates in NO_x / NO_2 emissions in both the air quality action planning and development control processes

THE WAY FORWARD

Use coupled micro-scopical traffic & instantaneous emission models to develop AQAP for Fulford

- Measures promoting further modal shift. e.g. LSTF delivers:
 - 5% reduction in passenger car trips
 - 10% reduction in passenger car trips
- Low Emissions Zones (LEZs)
 - Scenario testing: Bus, Heavy-duty, Heavy-duty + pre-Euro cars
- Hybrid Buses
- Car Clubs
- High occupancy Vehicle (HOV) Lanes
- Addressing emissions from HGVs through re-routing and alternative fuels
- Gating and 'green-wave' signal control policies

Wider Low Emission Strategy Development

- Further development of evidence base for ‘overarching’ low emission strategy – expand source apportionment to city centre AQMA
- Undertake low emission bus corridor feasibility study – 2011 /2012
- Assist with development of a low emission measures for taxis
- Undertake a feasibility study for a freight transshipment centre
- Provide evidence base and justification for measures in LES Supplementary Planning Document (SPD)

SUMMARY

- Current emission factors are unreliable when dealing with real life situations
- Increase in NO_x emissions from diesel vehicles can at least partially explain why current modal shift based approach to action planning and development control are not delivering air quality improvement for NO₂ in York
- Local authorities need to be confident that future measures they put in place will deliver real life NO_x reduction and be able to provide robust evidence bases to support this
- A new set of emission factors are needed in the longer term but coupled micro-simulation traffic and instantaneous emissions modelling can help local authorities make more informed decisions now

ACKNOWLEDGEMENTS

- Andrew Gillah – Principal Environmental Protection Officer CYC
- Institute for Internal Combustion Engines and Thermodynamics, Technical University of Graz (TUG), Austria.
- Low Emission Strategies Partnership and LCR Rgi

ITS Research Funding:

- EPSRC Platform and Renewal Grants: 2001 – 2009
- University of Leeds, Enterprise & Knowledge Transfer (EKT): September 2010 – October 2011
- DEFRA Air Quality Grants:
 - Leeds City Council (2010-2011)
 - Calderdale MBC (2010-2011)