

Naturalistic driving  
Relevance to reducing  
environmental impacts of traffic

Marika Hoedemaeker &  
Richard Smokers

**TNO** | Kennis voor zaken



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# Driver has large influence on vehicle emissions and fuel consumption

- Emissions and fuel consumption of vehicles are determined by:

- **technical aspects of the vehicle**

- engine technology and exhaust gas aftertreatment
- mass and aerodynamics

- **traffic conditions**

- road type
- maximum speed
- level of congestion

- **driver behaviour**

- driving style
- use of accessories

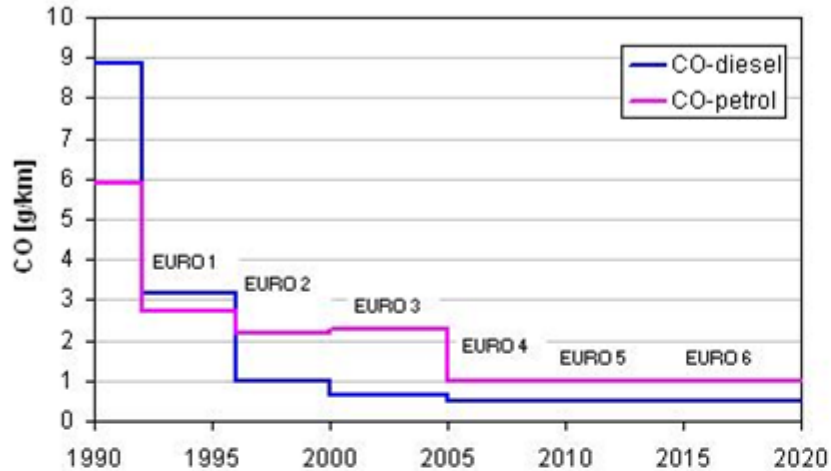
} Euro-standards

} traffic management

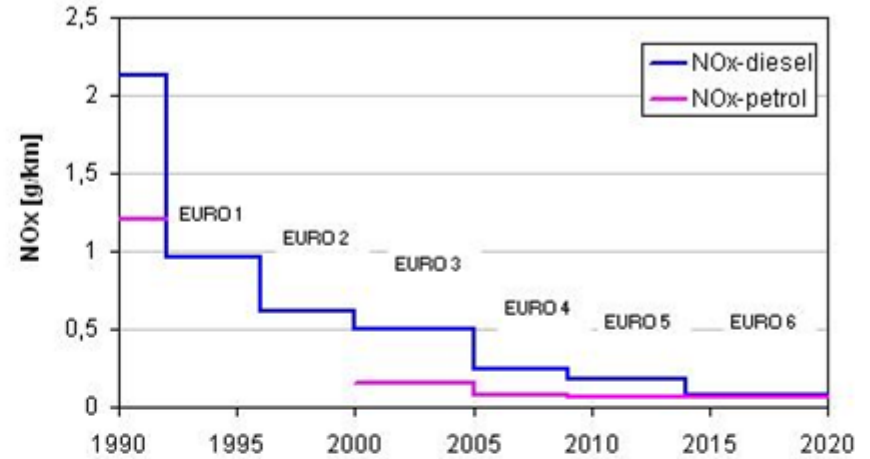
} eco-driving

# Cars become cleaner all the time... on the TA test

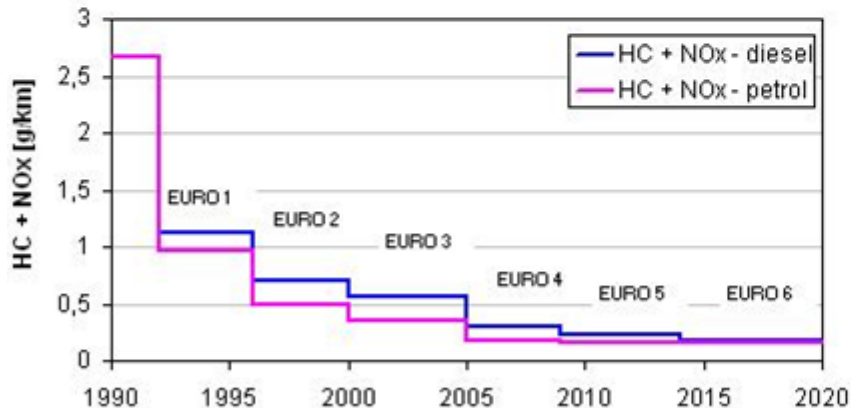
Emission limits 1990 - 2020



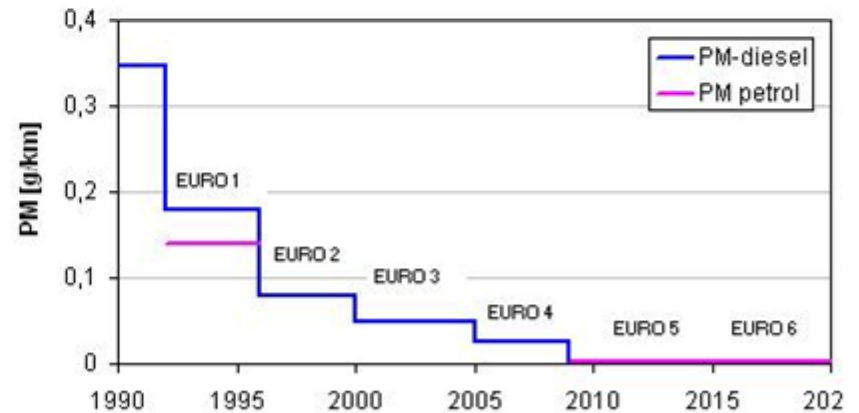
Emission limits 1990 - 2020



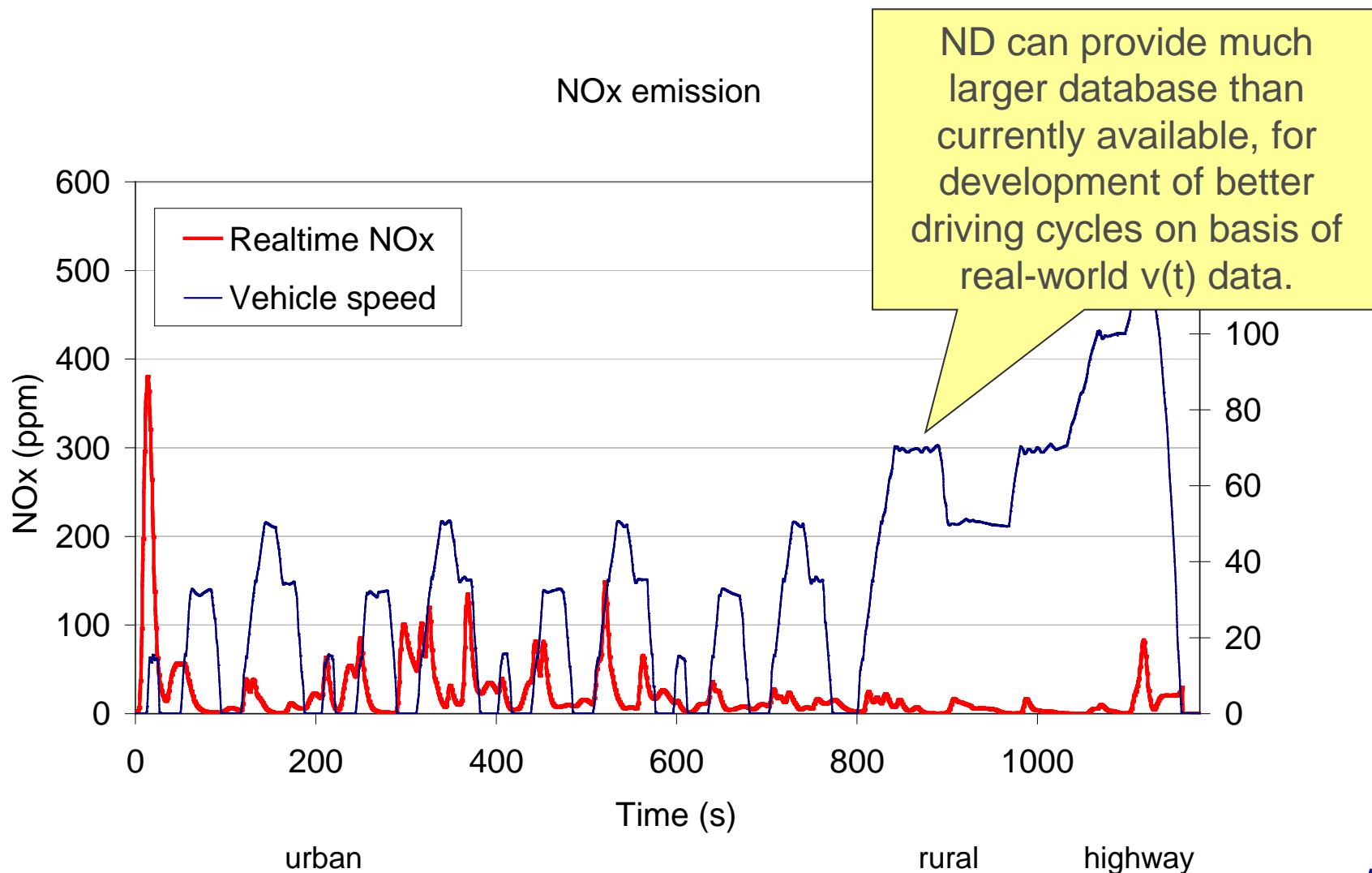
Emission limits 1990 - 2020



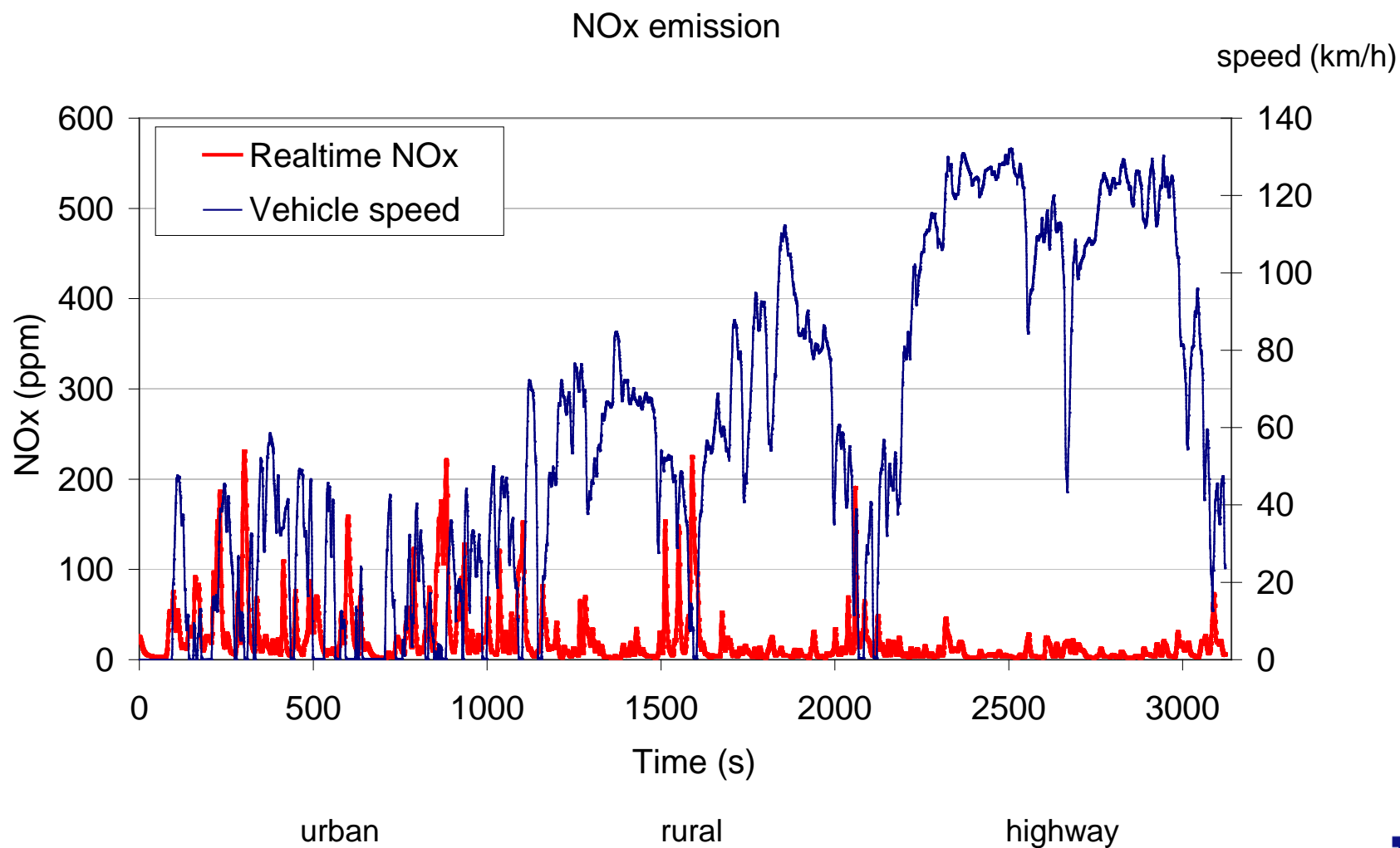
Emission limits 1990 - 2020



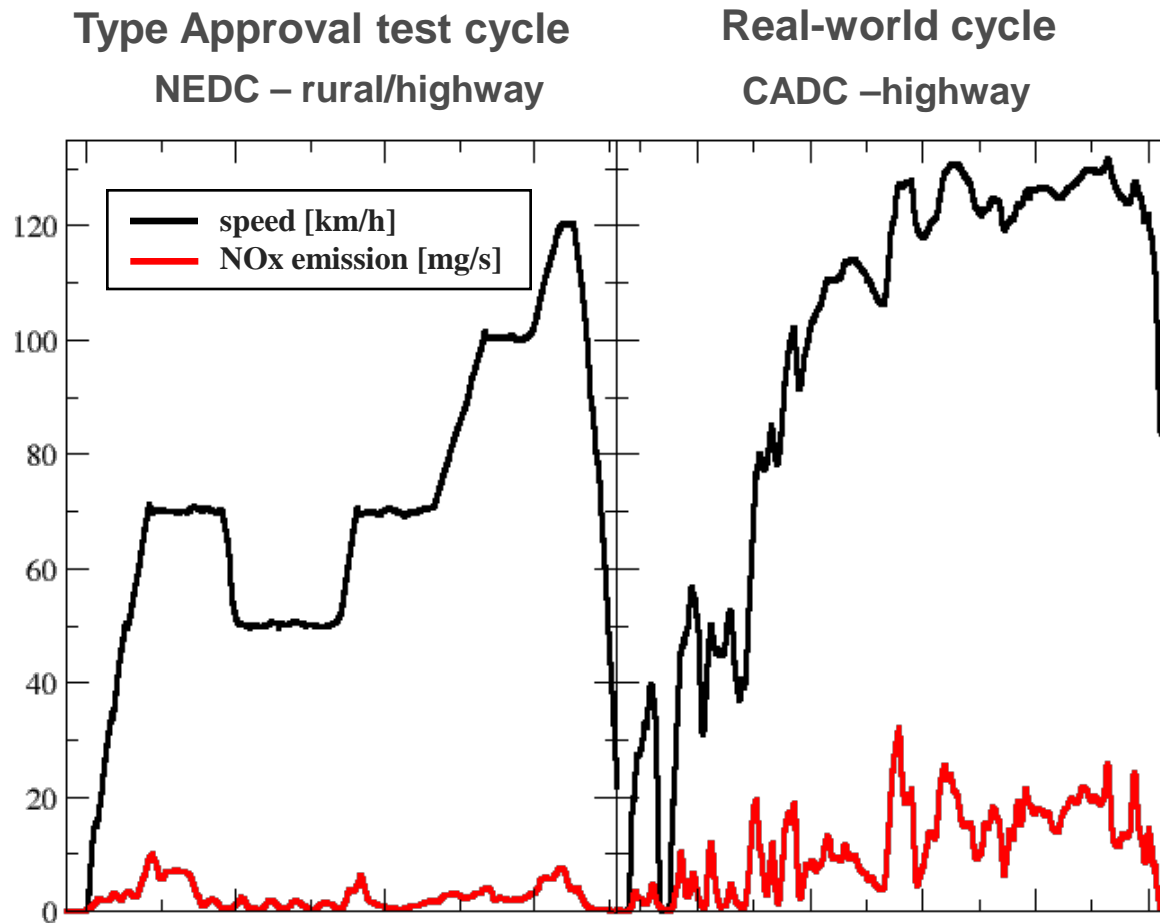
# On type approval test (NEDC-cycle) the $\text{NO}_x$ emissions of petrol cars are determined by cold start and transient “spikes”



Real-world cycle (CADC with hot start) is more dynamic and thus leads to more NO<sub>x</sub> “spikes”

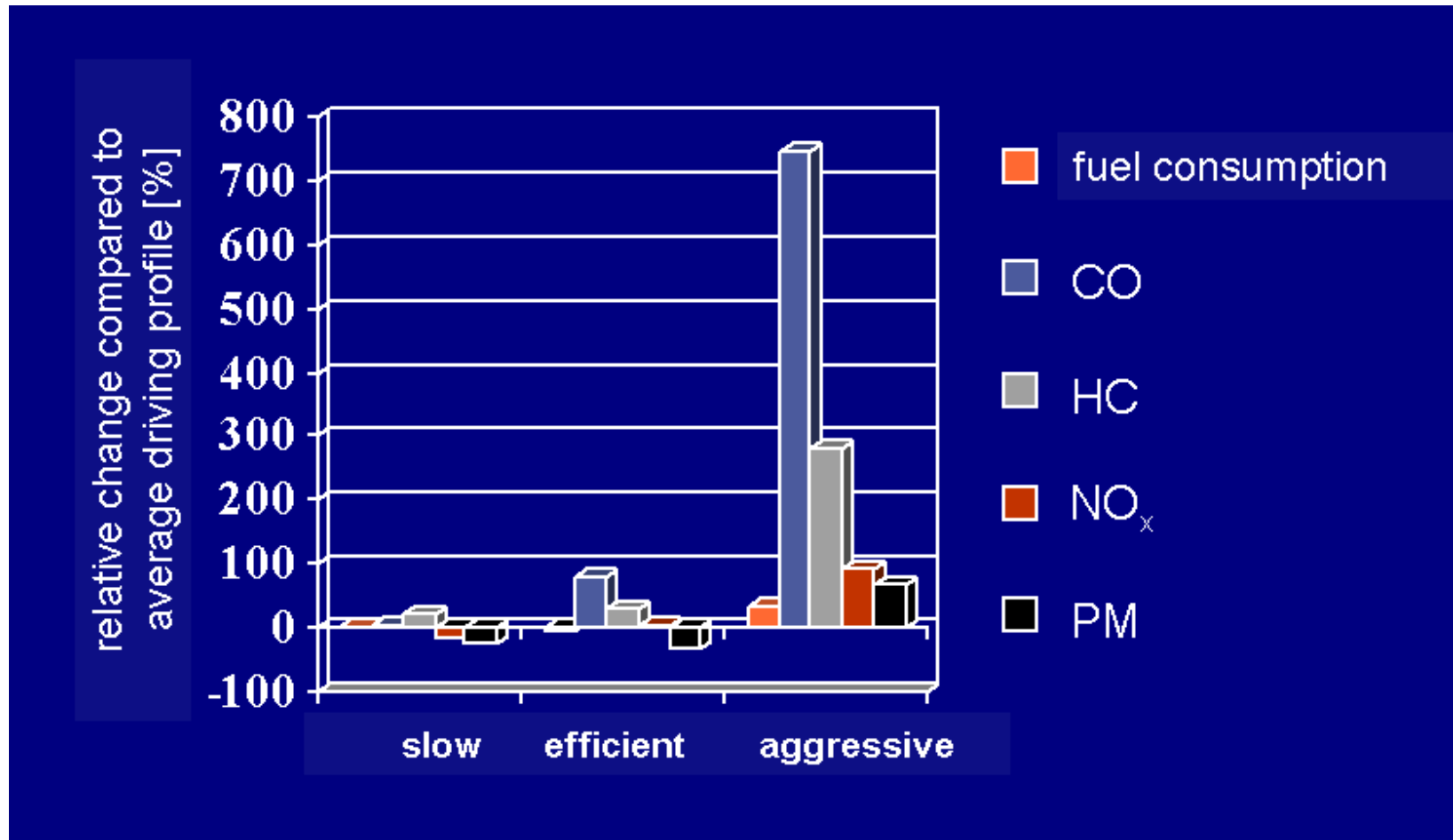


# Diesel vehicles show more spikes but also a higher background level in real world emissions

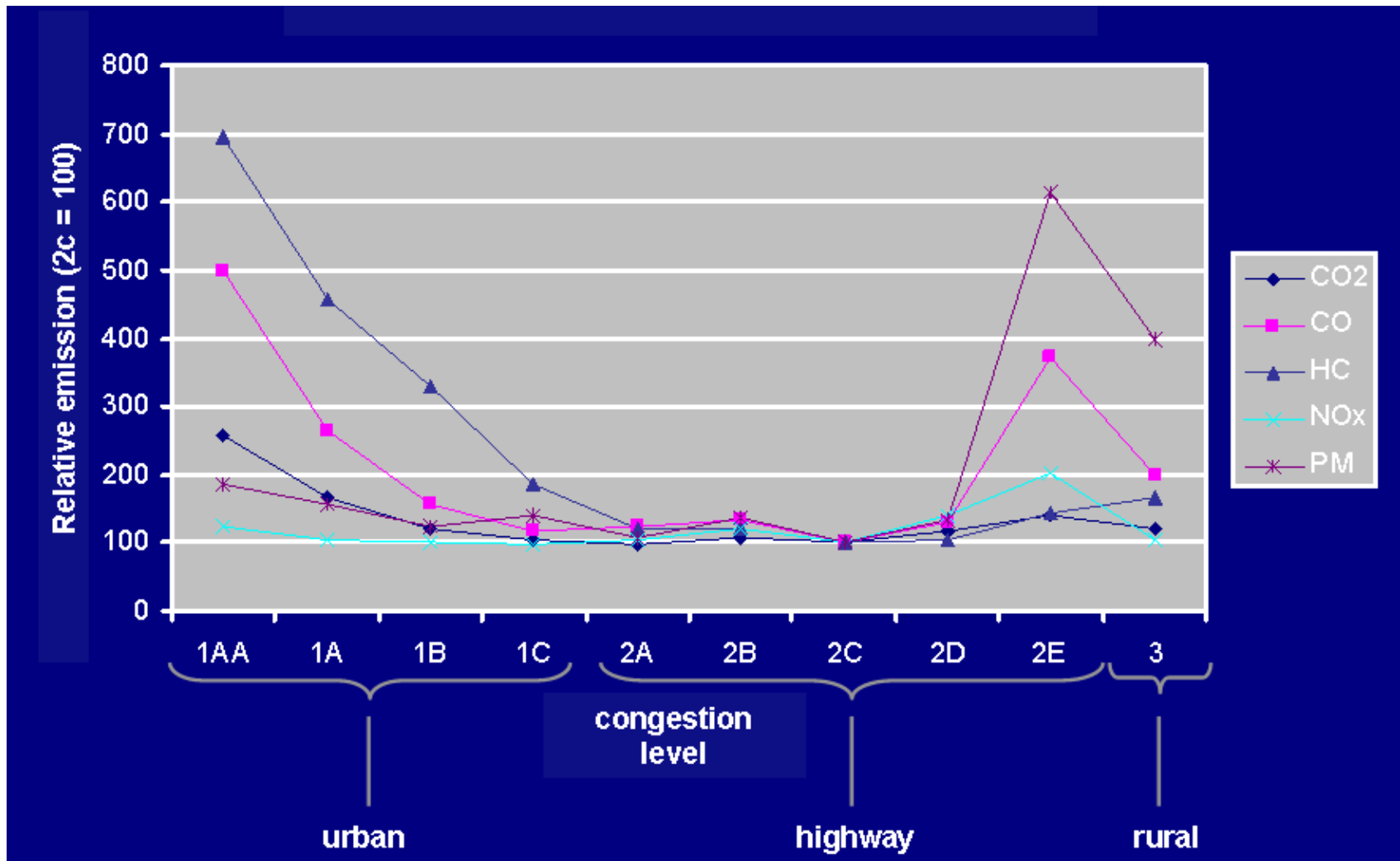


Example: Euro-4 diesel

# Driving style has strong influence on fuel consumption and even stronger influence on emissions

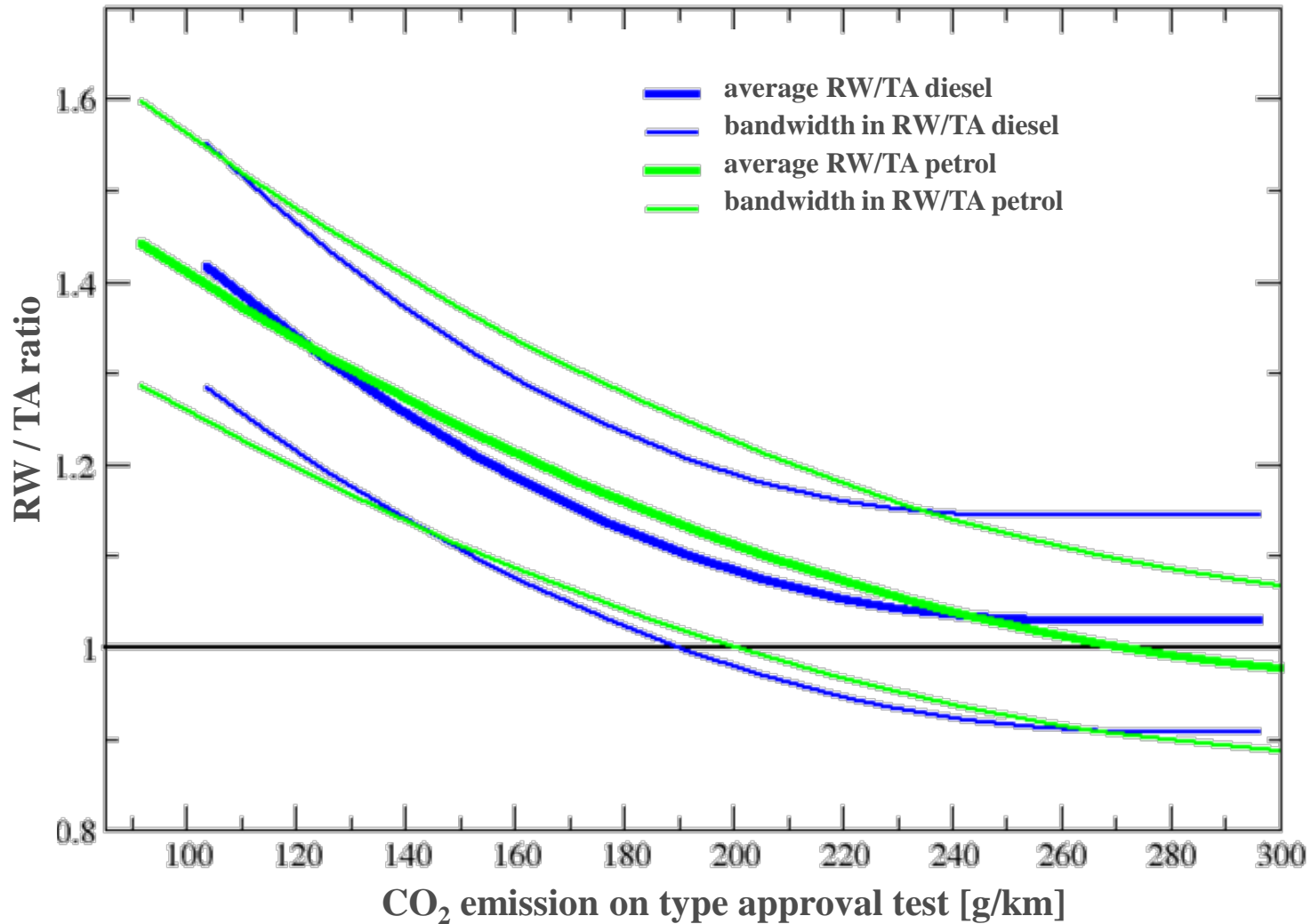


# Average emissions on different road types depend on maximum speed and level of congestion



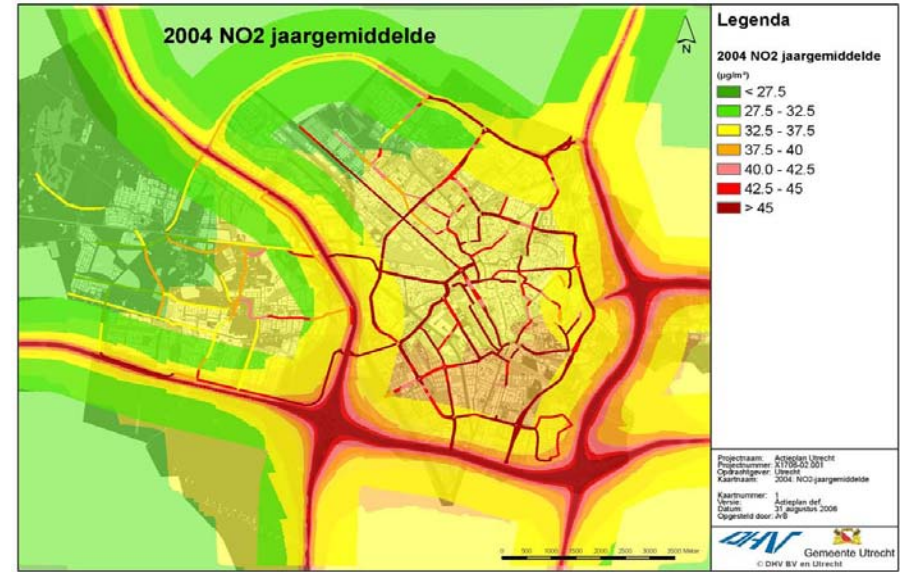
# Difference between RW and TA fuel consumption increases with decreasing fuel consumption on TA test

source: TNO 2010, based on analysis of TravelCard tankpass data



# Control of real-world emissions crucial for solving problems wrt air quality and CO<sub>2</sub>

- Important parameters:
  - speed
  - dynamics
  - energy consumption of accessories
    - e.g. airco
  - other:
    - use of ski-boxes and thelike, tyre pressure, ...
- There are many possibilities to influence these parameters
  - More insight in real-world driving necessary to assess effects and effectiveness of different measures

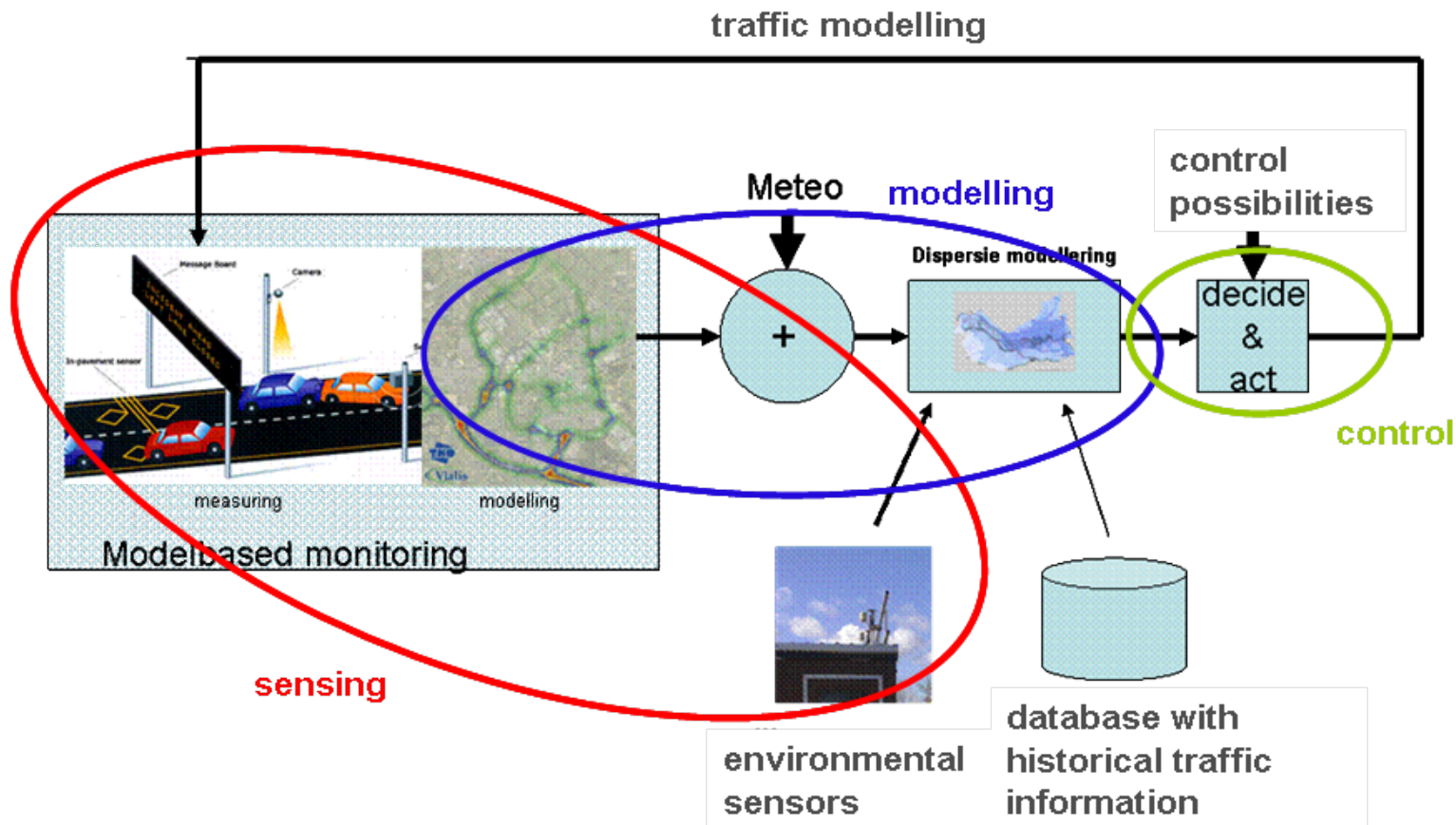


# Naturalistic driving can provide better insight in real-world driving and the effects of influencing behaviour

- Important research questions for naturalistic driving perspective from an environmental perspective:
  - driving style and gear shift behaviour of drivers
    - share of different driving styles / driver types in driver population
  - use of accessories
  - influence of various measures on behavioural aspects
    - speed measures
    - traffic management
    - ITS
    - eco-driving tips

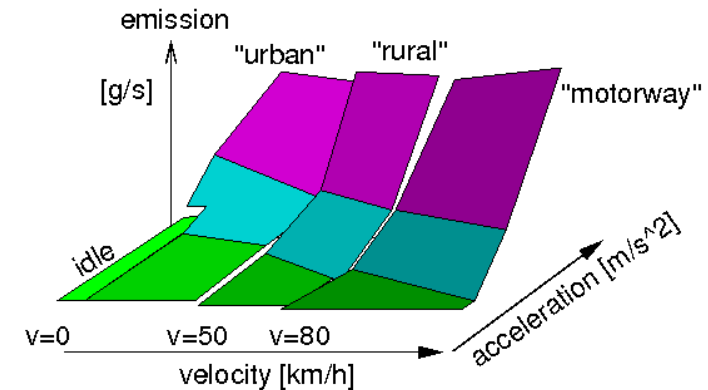
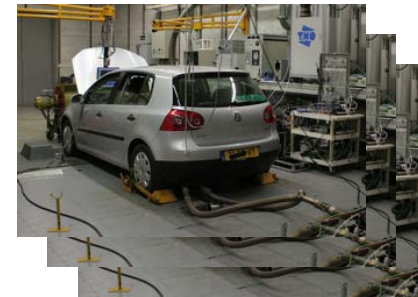
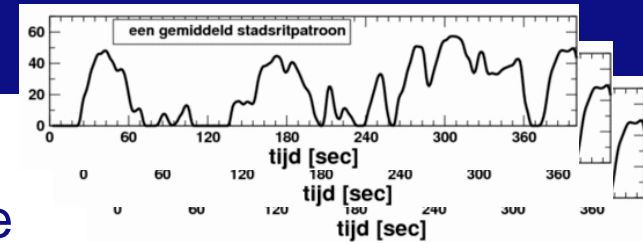
# ND can help to improve effectiveness of complex types of dynamic traffic management and ITS under development

- Effectiveness depends on the response of drivers wrt to control measures
  - ND can help to design effective intervention tools
- Strong interaction between effects on traffic flow and environment



# Results of ND experiments are useful input for improving emission factor modelling

- Emission factor models are used to calculate average emissions of different vehicle classes under different traffic conditions:
  - $\text{NO}_x$  en  $\text{NO}_2$ ,  $\text{PM}_{10}$ , HC, CO,  $\text{CO}_2$
- Real-world  $v(t)$  patterns as input for existing models
- Simultaneous time-resolved recording of speed and actual fuel consumption is input for developing improved models for RW  $\text{CO}_2$  emissions



# Implications of including environmental aspects into ND studies

- Including environmental aspects in large scale ND experiments with Naturalistic Driving requires :
  - recording of speed / time / location information
  - if possible also instantaneous fuel consumption (from CAN-bus)
- Actual vehicle emissions are difficult to measure in real-time.
  - can be estimated using advanced off-line emission factor modelling
- Changes in the recording of driver behaviour may relate to response of drivers to information provided from the road side or by in-car instruments
  - crucial for optimal design of measures such as in-car instruments, advanced traffic management and ITS intended to influence driving behaviour for the improvement of traffic flow and/or environmental impacts of traffic

# Contact

Marika Hoedemaeker

Tel. +31 88 866 58 53

E-mail [marika.hoedemaeker@tno.nl](mailto:marika.hoedemaeker@tno.nl)

Richard Smokers

Tel. +31 88 866 86 28

E-mail [richard.smokers@tno.nl](mailto:richard.smokers@tno.nl)

[www.tno.nl](http://www.tno.nl)