Association for Emissions Control by Catalyst AISBL

Technical Seminar on Real-Driving Emissions

Real Driving Emissions - Experiences of a Technical Service with PEMS

Martin Kleinebrahm

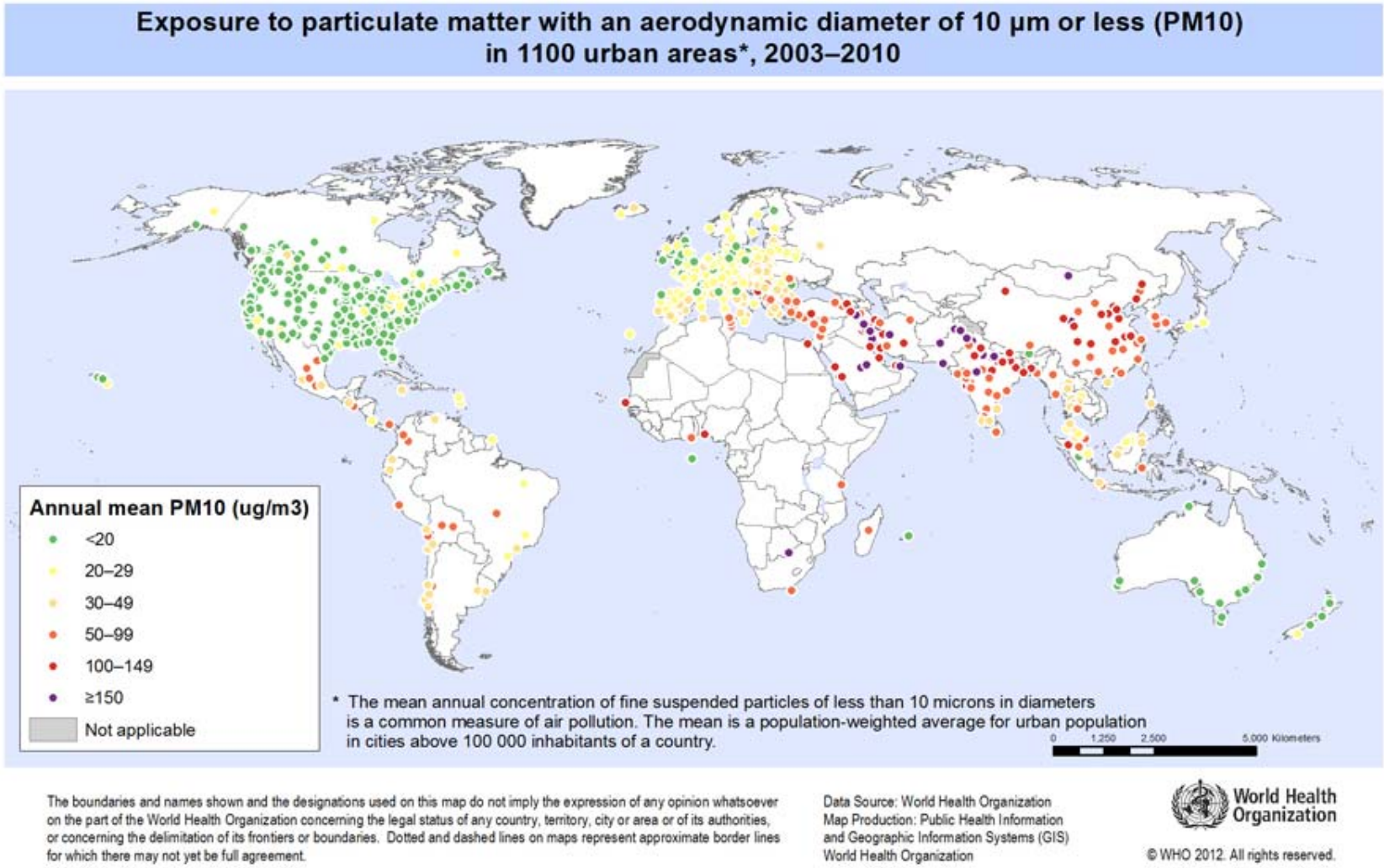
2015/04/29

TÜV NORD Mobilität

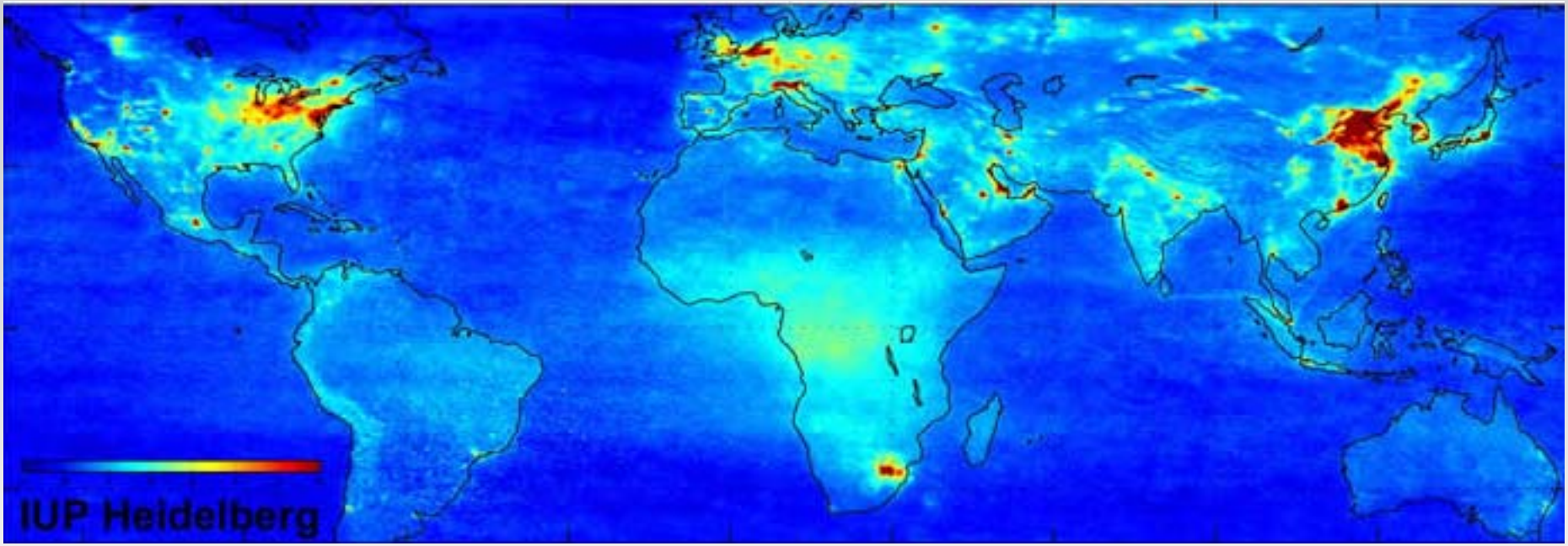
Agenda

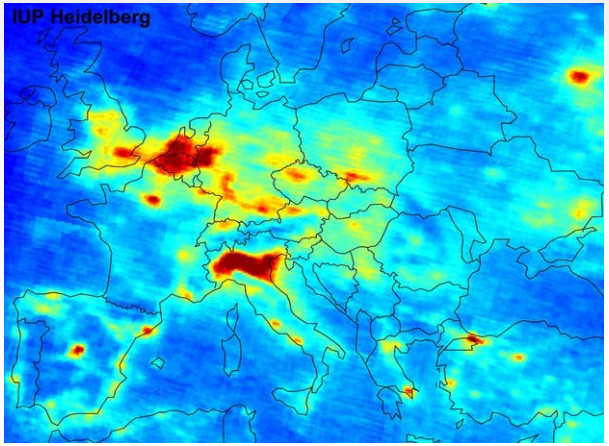
- Motivation
- PEMS history of TÜV NORD
- Motivation for LDV RDE
- Steps of LDV PEMS
- Boundary conditions and evaluation
- Spotlights on some results of Stuttgart / Munich LDV measurements

Air quality issues: PM10 (WHO)



Air quality issues: NO_2 (IUP)



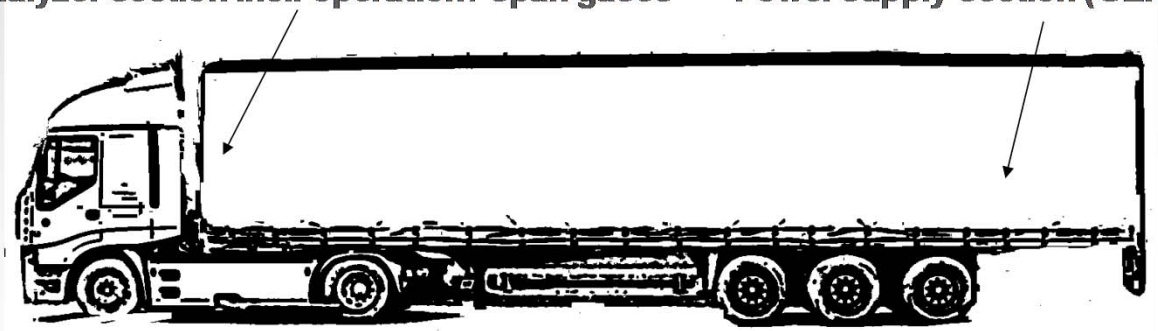


RDE – On-road PEMS measurement by TÜV NORD

History

Analyzer section incl. operation / span gases

Power supply section (GENSET)



Wireless communication to data aquisition in cab

Concrete block section for load simulation

PEMS – mobile emission measurement

2004

From its inception, TÜV NORD has been involved in the development of PEMS. EURO III, the first PEMS project commissioned by the German Federal Highway Research Institute, examined various commercial vehicles.

RDE – On-road PEMS measurement by TÜV NORD

History

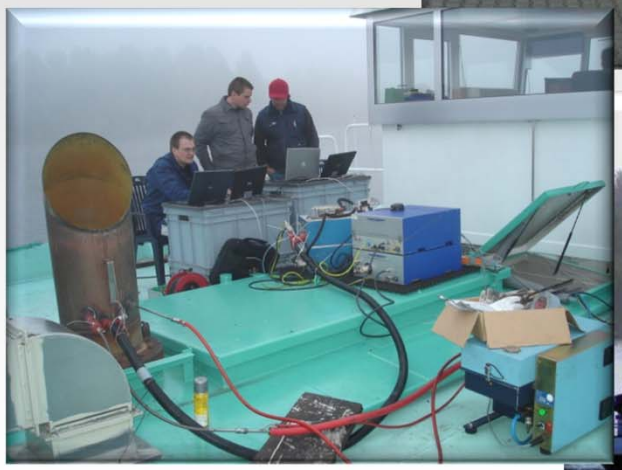
PEMS – mobile emission measurement

2005 - 2008

Co-operation commenced with
LANUV NRW: “City bus emissions”, diesel and natural gas drive (EURO III to EEV).

RDE – On-road PEMS measurement by TÜV NORD

History



PEMS – mobile emission measurement

2006 - 2007

In association with the Federal Environment Agency: Measurement of several commercial vehicles with PEMS.

2008 - 2010

Collaboration with the Federal Ministry for Transport, Building and Urban Affairs: retrofitting of inland waterway vessels with particle filters.

RDE – On-road PEMS measurement by TÜV NORD

History

PEMS – mobile emission measurement

2010 - 2011

PEMS-Project in Stuttgart for
LUBW Baden-Württemberg: Measurement of exhaust emission for passenger cars

Project with the Federal Ministry for Transport, Building and Urban Affairs: hybrid buses compared with conventional buses in the VRR. Measurement of emissions and energy flows.

2012

Retrofitting of exhaust filters on the Rhine passenger vessel “Jan von Werth“.

RDE – On-road PEMS measurement by TÜV NORD

History

PEMS – mobile emission measurement

2014

PEMS-Project in Stuttgart and München for LUBW Baden-Württemberg and LUA Bayern
Measurement of exhaust emissions of Euro 6 passenger cars with different NOx-reduction strategies

Regulation (EC) No 715/2007

Exhaust emissions of passenger cars and light duty trucks in Europe are measured by using the NEDC under well defined ambient conditions in a laboratory. The NEDC represents only a small part of all driving conditions in real traffic.
„Revisions may be necessary to ensure that real world emissions correspond to those measured at type approval. The use of portable emission measurement systems and the introduction of the ‘not-to exceed’ regulatory concept should also be considered.“

Real Driving Emissions

Real-Driving-Emissions (RDE) (1)

- In Europe it is discussed how to measure exhaust emissions in real traffic (Real Driving Emissions = RDE).
- Due to European air qualitiy regulations NOx emissions are the main issue of RDE.
- European Commission is also interested in particle measurement.
- Emissions can be measured by using Portable Emission Measurement Systems (PEMS) in real traffic.
- TÜV NORD is carrying out research programs on behalf of the German government within the RDE process.

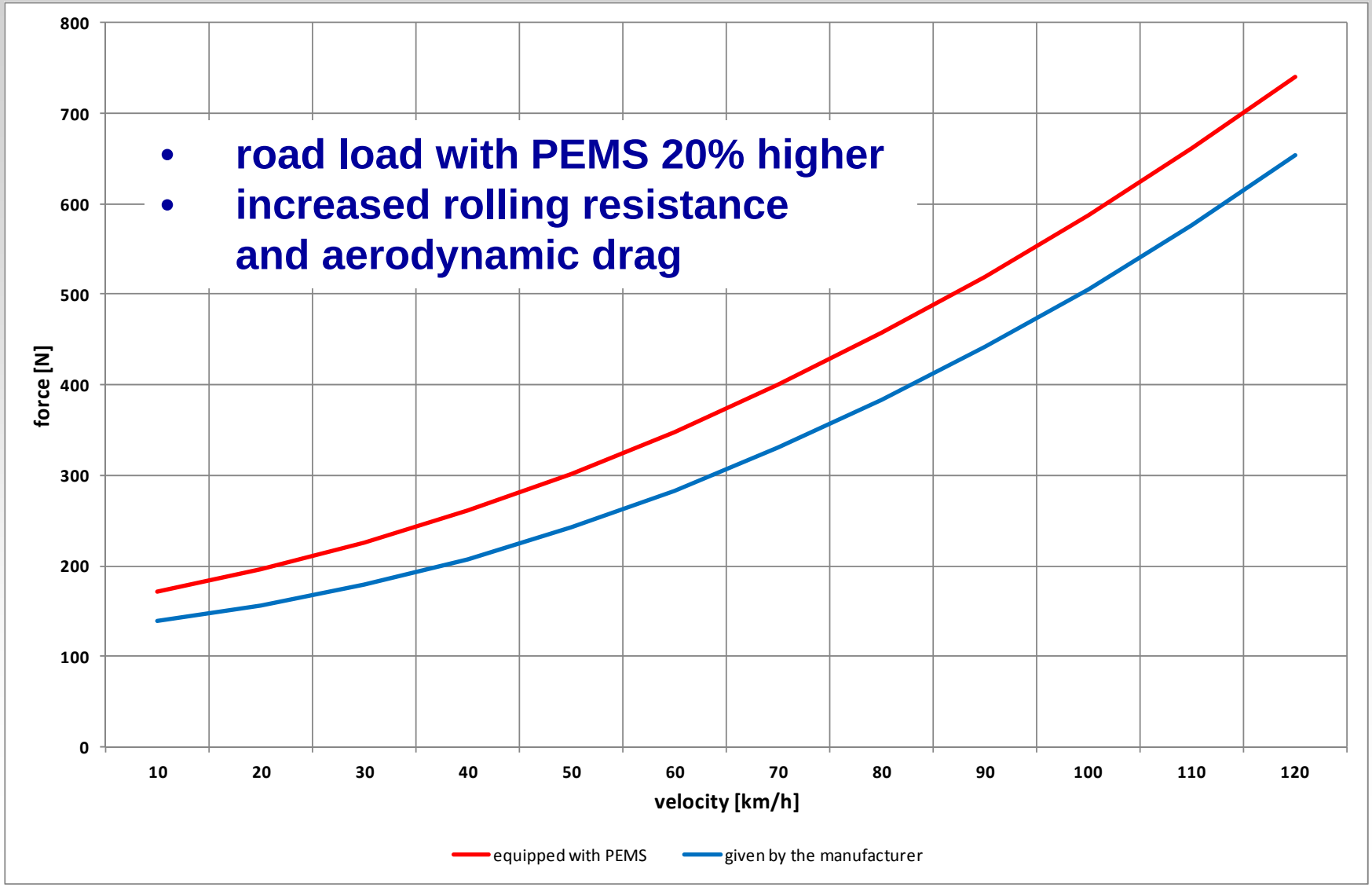
Heavy Duty System on Light Duty vehicles (1)

Portable Emission Measurement System (PEMS):

- PEMS is installed in the vehicle, emissions are measured in real traffic.
- PEMS is already used for heavy duty vehicles (ECE R49)

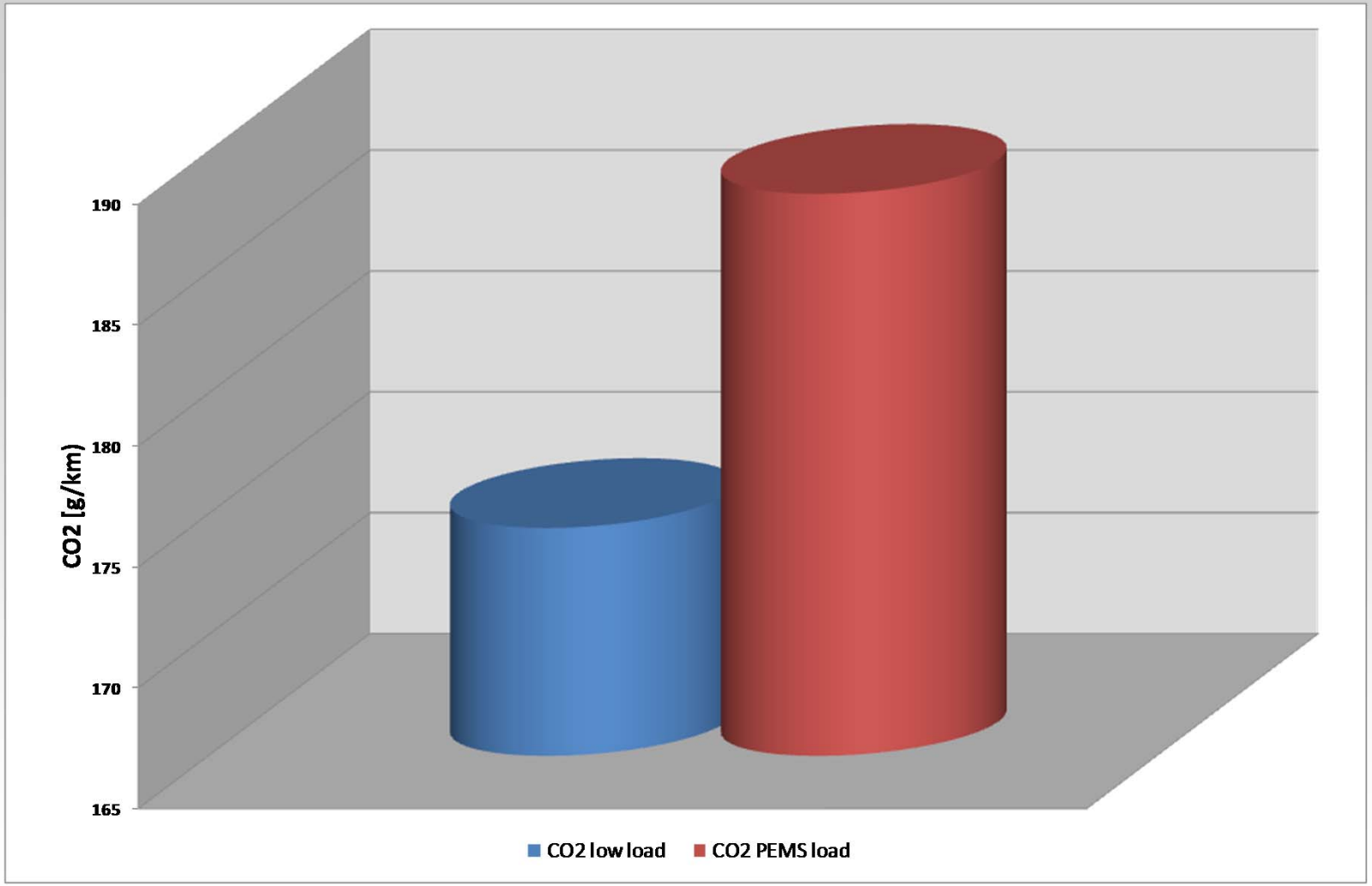
Heavy Duty System on Light Duty vehicles (2)

Coast Down with PEMS / Values given by the manufacturer



- road load with PEMS 20% higher
- increased rolling resistance and aerodynamic drag

NEDC CO_2 values



-> CO_2 Emissions 8% higher with PEMS road load

Resulting needs:

- **Weight reduction**
- **Reduction of the aerodynamic influence**
- **Flexible design of the system**
- **No generator for power supply**
- **Shorter set-up times**
- **Clarification of safety aspects**

  (burnable gas (FID) in the interior, exhaust gases in the interior, accident prevention regulations)

PEMS for passenger cars 1st generation

Light Duty PEMS:

- Exhaust Flow Meter
- NDIR: CO, CO_2,
- O_2 - Sensor
- NDUV: NO + NO_2 = NO_x
- FID: THC

PEMS for passenger cars 1st generation (2)

PEMS for passenger cars 1st generation (3)

Battery

Manufacturer: Voltavision

Li-Fe-Battery

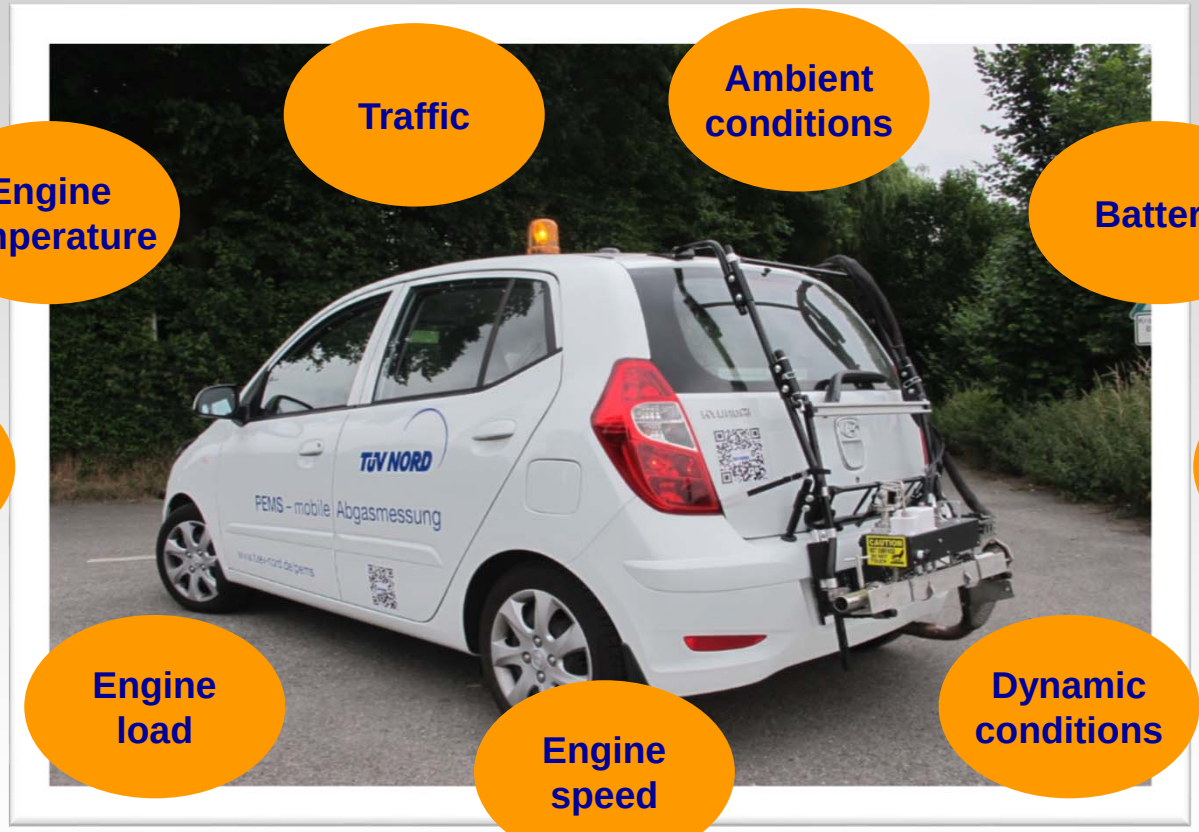
Measurement time: about 4h

Capacity: 200Ah

PEMS for passenger cars currently used

- No HC Measurement
  ⇨ no FID
  ⇨ no gas bottles inside the vehicle
- PEMS outside the car
  ⇨ no exhaust gases inside the car
- Optional use of OBD data for exhaust flow calculation
  ⇨ no EFM

Driving conditions in real traffic



Traffic

Ambient conditions

Engine temperature

Battery

Driver

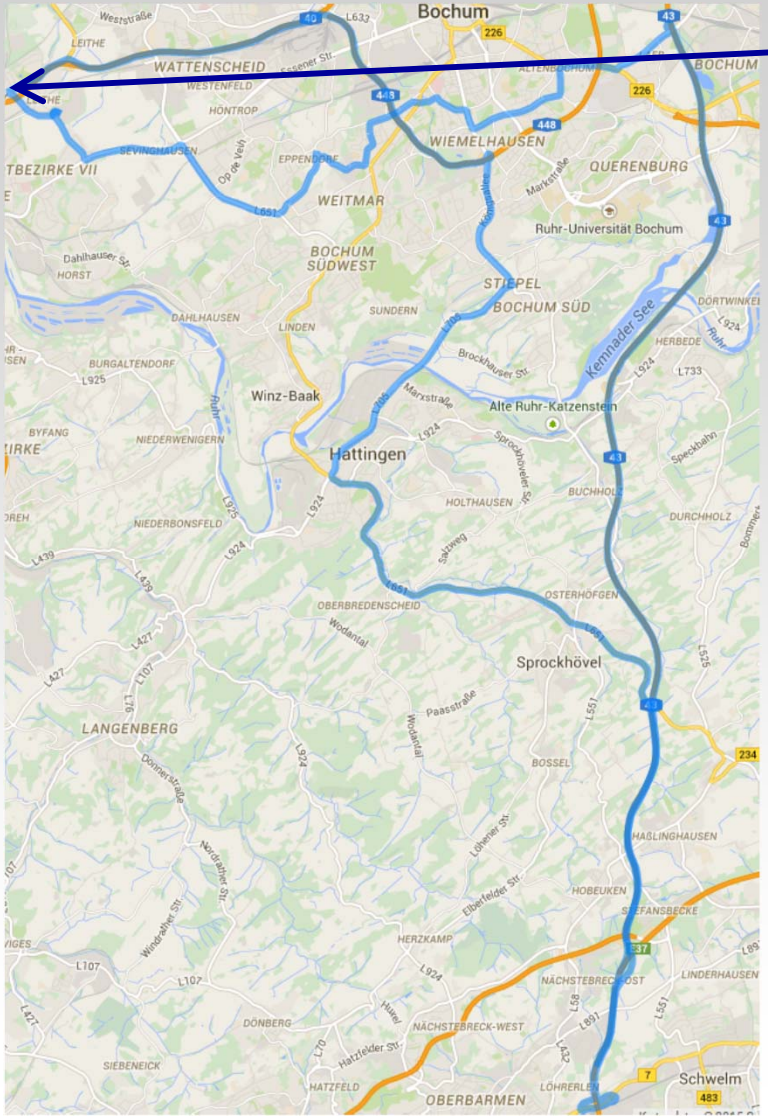
Route composition

Engine load

Engine speed

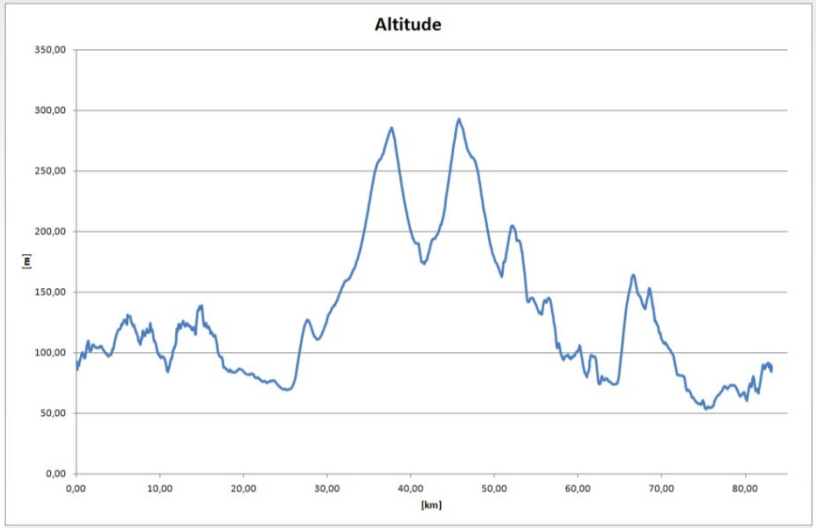
Dynamic conditions

TÜV NORD PEMS-Route



TÜV NORD IFM

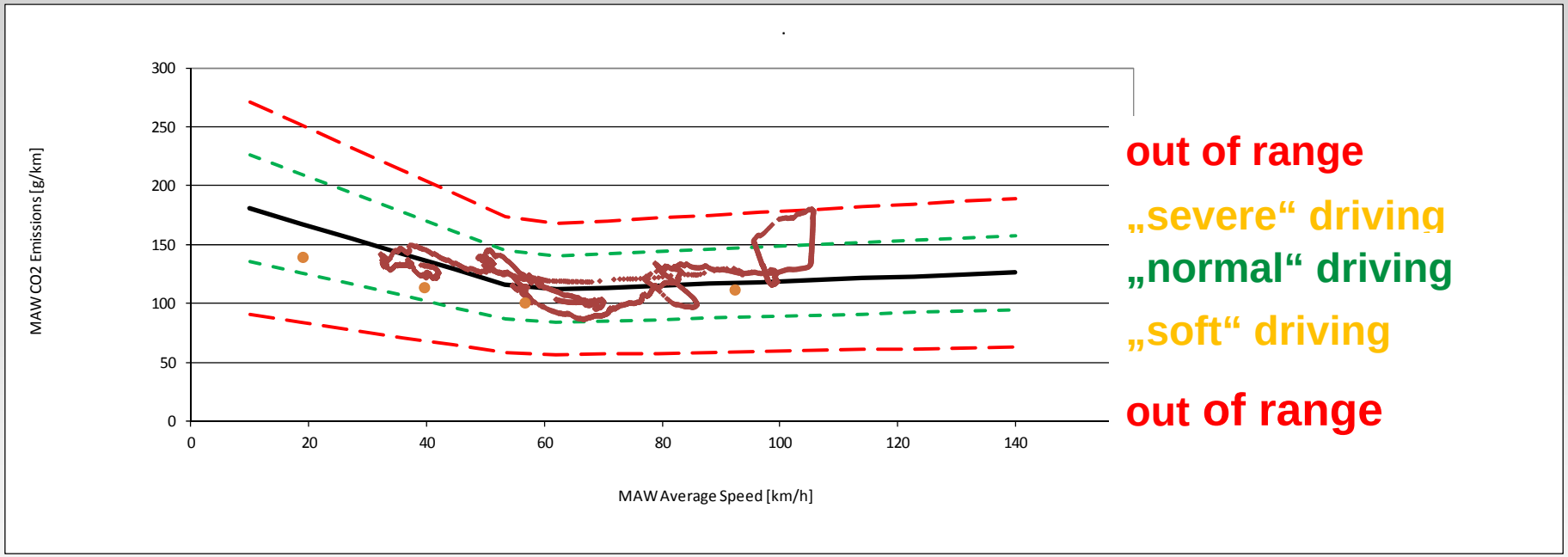
- Distance: 83 km
- Duration: about 105 minutes
- Urban Driving: about 34%
- Extra Urban Driving: about 33%
- Motorway Driving: about 33% (related to driven distance)
- Cumulated pos. altitude difference: 846 m/100km



Real-Driving-Emissions (RDE)

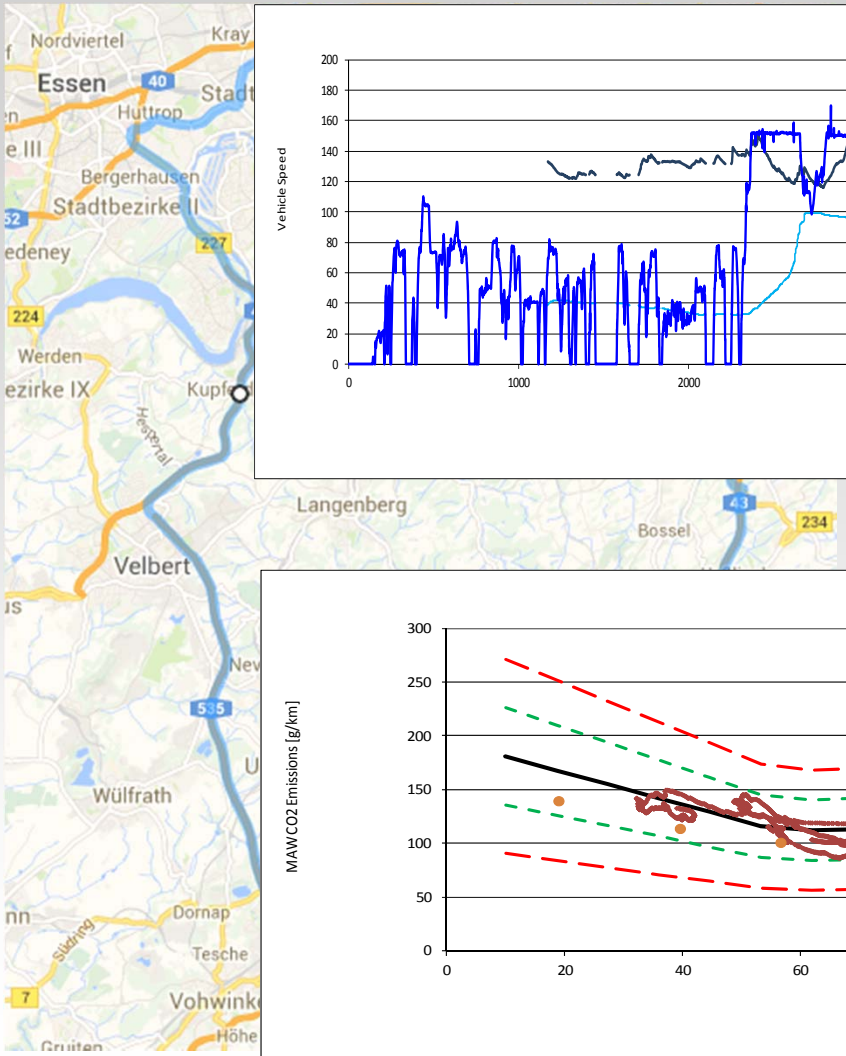
- There are 2 different data evaluation tools in discussion, the SPF tool (Standardized Power Frequency distribution) and the MAW tool (Moving Averaging Window). Both tools shall ensure emission results of „normal driving“.
- Ambient conditions (ambient temperature, altitude, humidity…) and driving conditions are discussed within the working group.
- Not to exceed factors need to be defined in dependence of driving conditions and ambient conditions.
- Current proposal: Both evaluation methods shall be used for monitoring (both values to be recorded). With a revision clause to be introduced the final decision which tool becomes mandatory can be postponed to a later point in time where more detailed data is available.

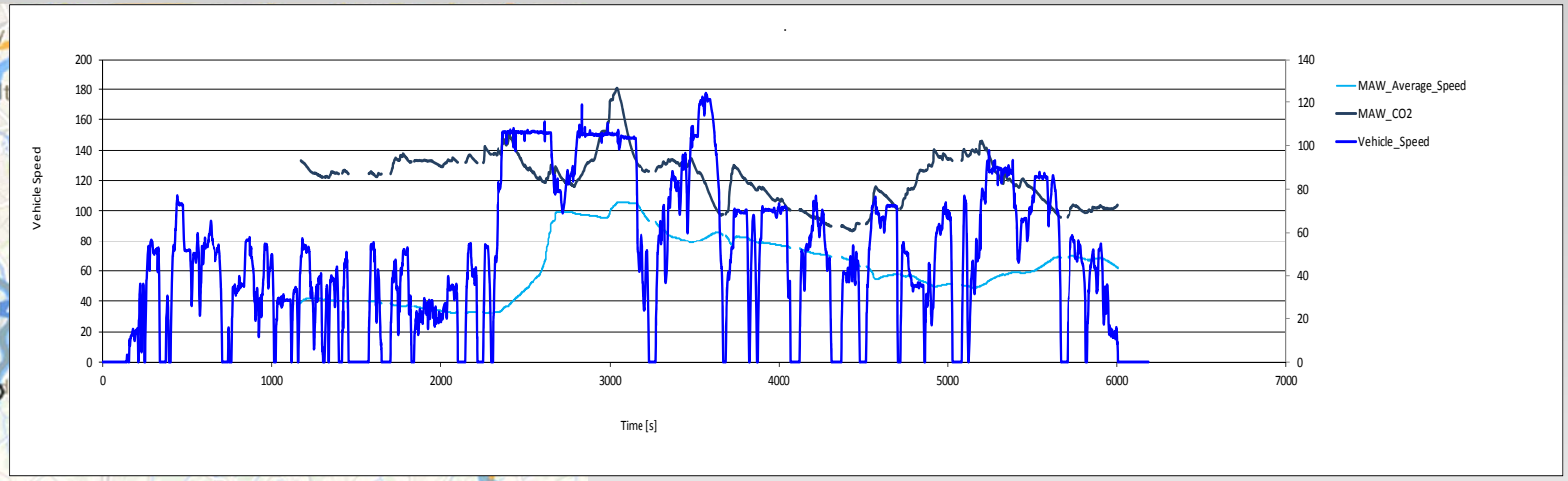
Example of a MAW evaluation

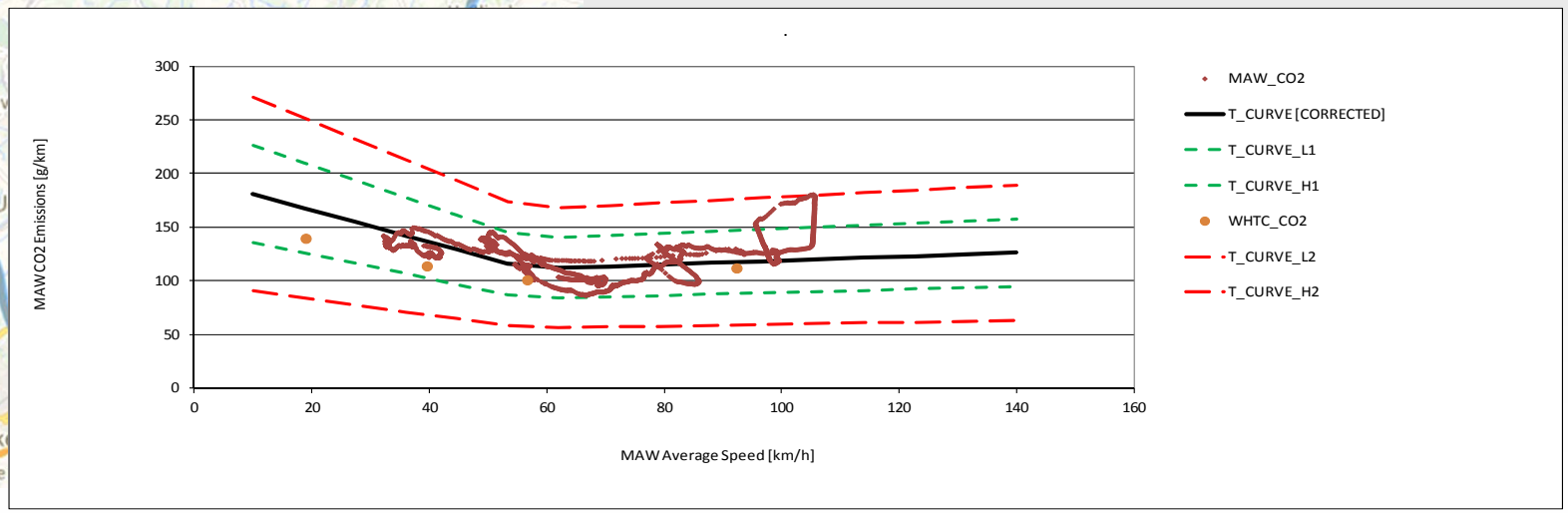


Severity Category >		MAIN RESULTS					NORMAL R-T1<W<R+T1					NORMAL [+] R+T1<W<R+T2					NORMAL [-] R-T2<W<R-T1					ALL WINDOWS				
		URBAN	RURAL	MOT.	CORRECTED LWR/M	ALL	URBAN	RURAL	MOT.			URBAN	RURAL	MOT.			URBAN	RURAL	MOT.							
NUMBER OF WINDOWS							995	2126	905		4026	0	0	157		157	0	0	0		0	995	2126	1073		4194
% (WITHIN THE CATEGORY)							25	53	22			0	0	100								24	51	26		
% (W / ALL WINDOWS)							100	100	84			0	0	15			0	0	0							
SEVERITY INDICES		-5,84	-1,19	6,17			-5,84	-1,19	6,17					36,96								-5,84	-1,19	11,12		
CO_EMISSIONS	**g/km**	**0,14**	**0,19**	**0,11**	**0,15**	**0,15**	**0,14**	**0,19**	**0,11**					**0,10**								**0,14**	**0,19**	**0,11**		
NOx_EMISSIONS	**g/km**	**0,30**	**0,28**	**0,42**	**0,33**	**0,33**	**0,30**	**0,28**	**0,41**					**0,49**								**0,30**	**0,28**	**0,41**		

CO_2 based Data Evaluation (MAW)







Comparison of SPF and MAW evaluation

SPF Results						
	Weighted			Averrage		
	CO2 [g/km]	NOx [g/km]	CO [g/km]	CO2 [g/km]	NOx [g/km]	CO [g/km]
Total	190,91	0,79	0,22	125,93	0,32	0,16
Urban	217,23	0,42	0,63	152,22	0,32	0,16

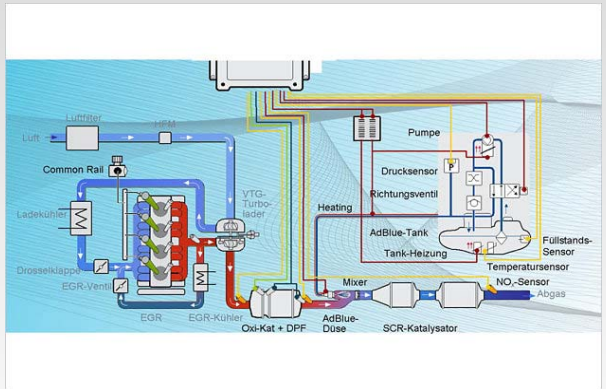
Severity Category >		MAIN RESULTS					NORMAL R-T1<W<R+T1					NORMAL [+] R+T1<W<R+T2					NORMAL [-] R-T2<W<R-T1					ALL WINDOWS				
		URBAN	RURAL	MOT.	CORRECTED URBM	ALL	URBAN	RURAL	MOT.			URBAN	RURAL	MOT.			URBAN	RURAL	MOT.							
NUMBER OF WINDOWS							995	2126	905		4026	0	0	157		157	0	0	0		0	995	2126	1073		4194
% (WITHIN THE CATEGORY)							25	53	22			0	0	100								24	51	26		
% (W / ALL WINDOWS)							100	100	84			0	0	15			0	0	0							
SEVERITY INDICES		-5,84	-1,19	6,17			-5,84	-1,19	6,17					36,96								-5,84	-1,19	11,12		
CO_EMISSIONS	**g/km**	**0,14**	**0,19**	**0,11**	**0,15**	**0,15**	**0,14**	**0,19**	**0,11**					**0,10**								**0,14**	**0,19**	**0,11**		
NOx_EMISSIONS	**g/km**	**0,30**	**0,28**	**0,42**	**0,33**	**0,33**	**0,30**	**0,28**	**0,41**					**0,49**								**0,30**	**0,28**	**0,41**		

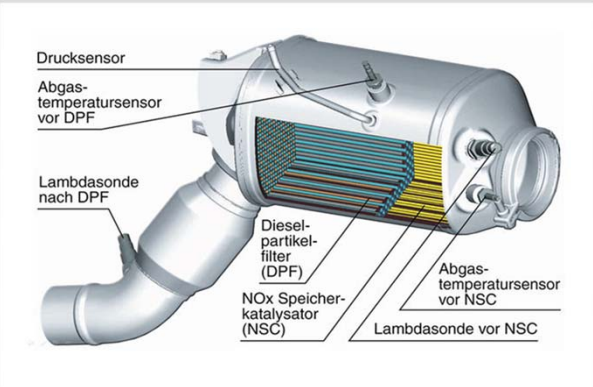
Preliminary observations to TÜV NORD experiences

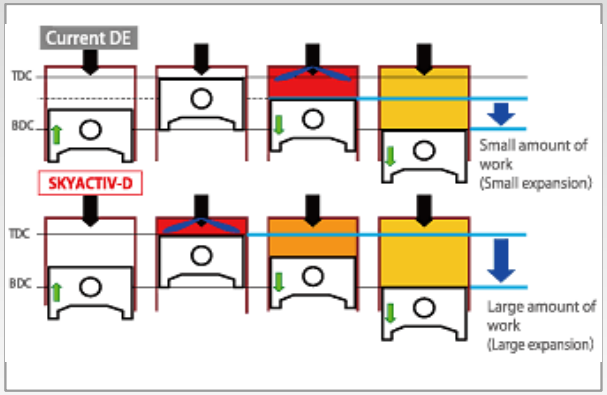
- CO2 is not the favorite parameter to analyse driving dynamics
- Calculation of emission results with standardized power bins leads to large varities in the results
- Parameters reflecting the dynamic driving pattern are more sufficient for the evaluation of „normal driving“
- Calculation of emission results by an averaging approach (e.g. MAW method)

Results of PEMS tests with Euro 6 vehicles

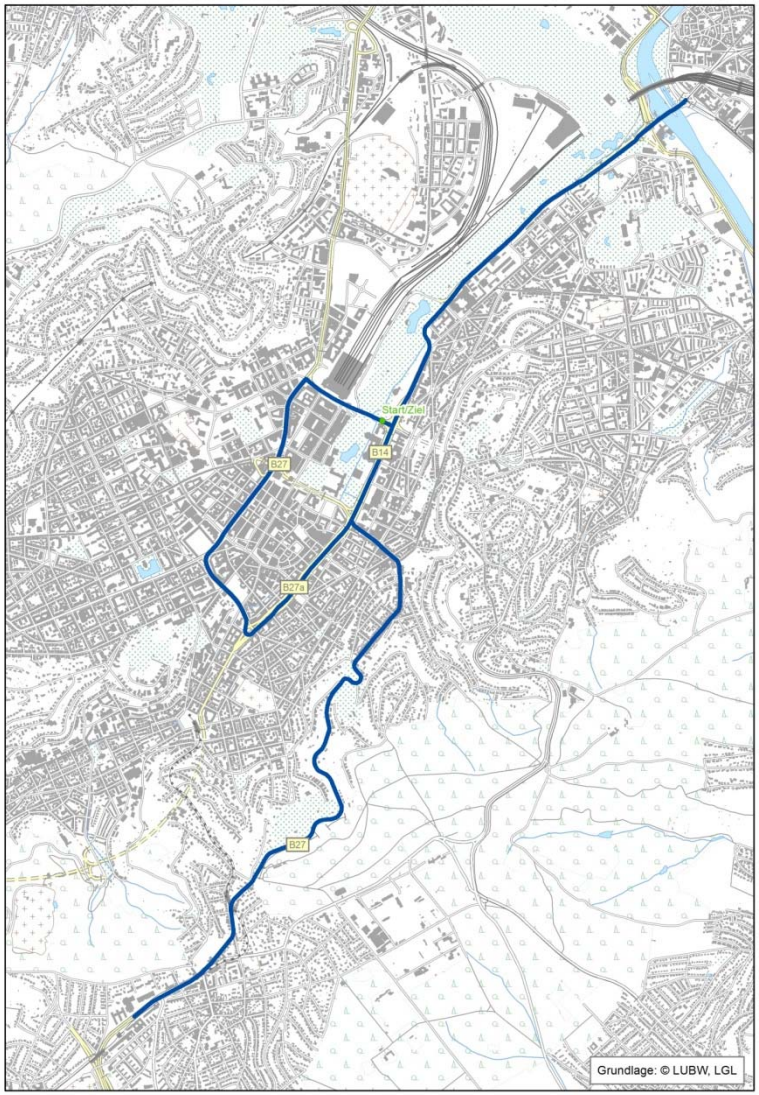
DPF + SCR Catalyst	NSC + DPF	Engine setup and calibration + DPF







Results of PEMS tests with Euro 6 vehicles



Stuttgart

Citytrip:

- **Length about. 20 km**
- **Max. difference in altitude about. 250m**

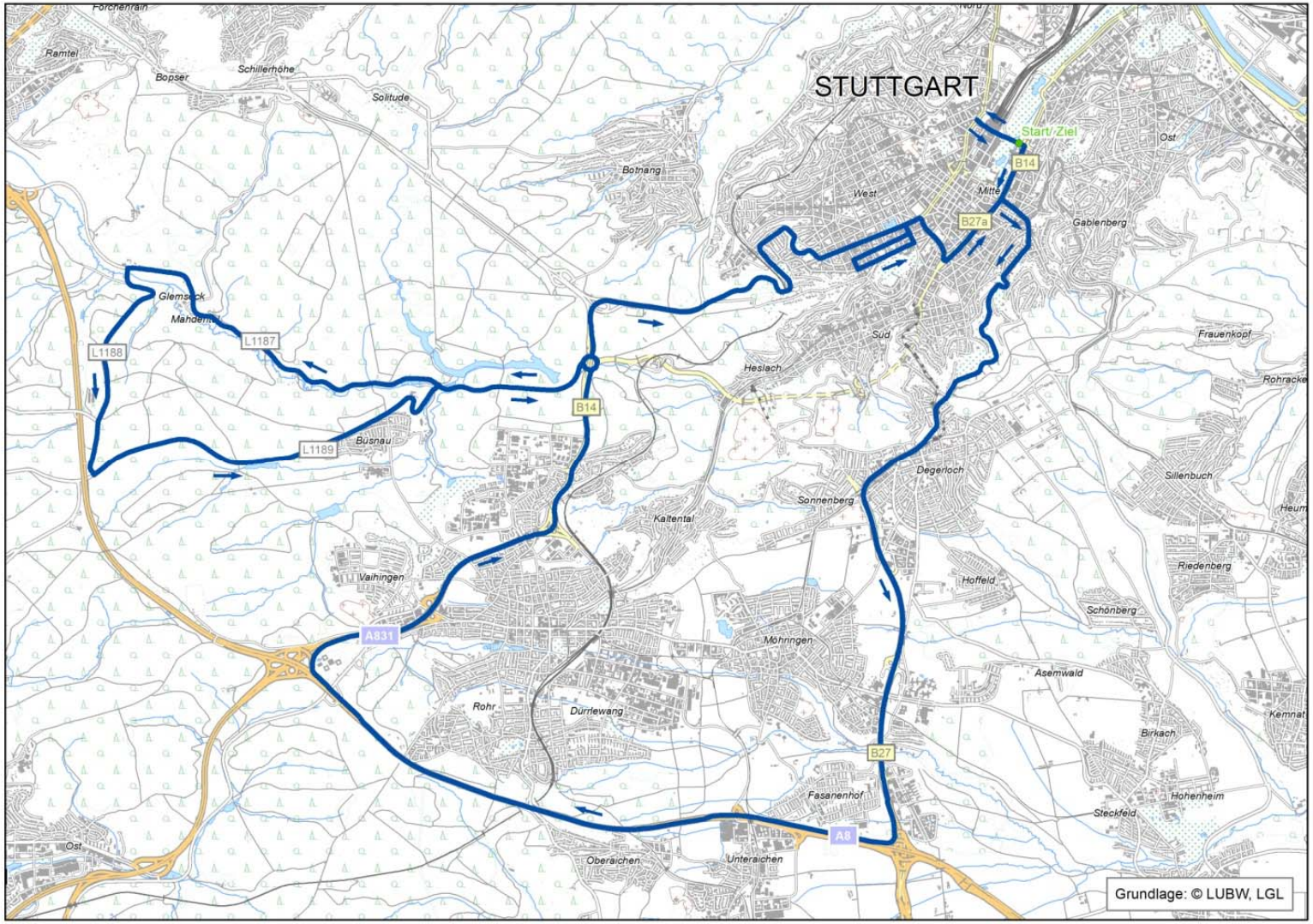
Starting at Start/End going lefthand along the City Ring, further along Neckartor, Cannstatter Str. to the river Neckar bridge. Turning around going back along B14 to Hohenheimer Str.
Uphill the Hohenheimer Str. along the Neue Weinsteige till Degerloch, turn back at Albplatz going down to Start/End.

Results of PEMS tests with Euro 6 vehicles

Stuttgart

Stuttgart, urban and rural:

- Length about 54,5 km
- Max. difference in altitude about 275 m



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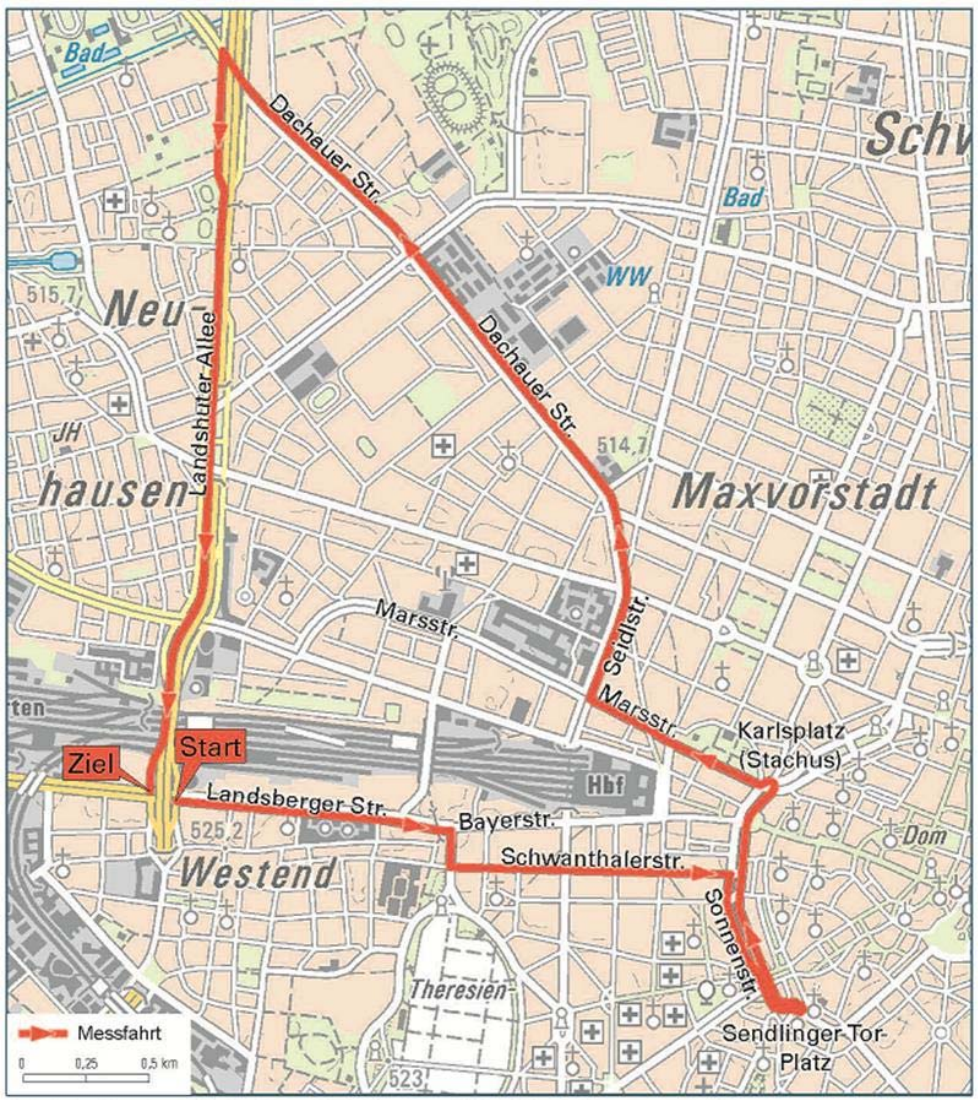
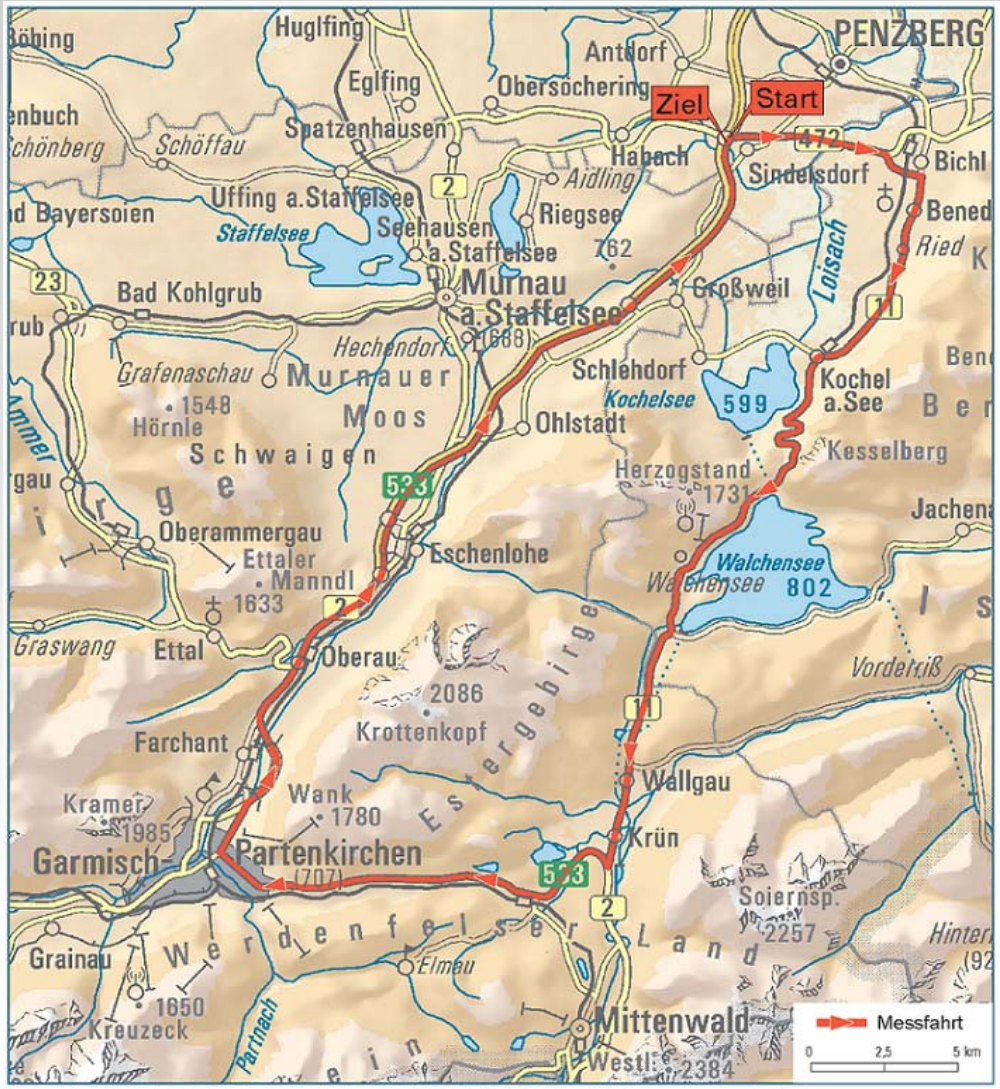


München

Citytrip:

- **Length about 10,9 km**
- **Max. difference in altitude about 15 m**

Results of PEMS tests with Euro 6 vehicles

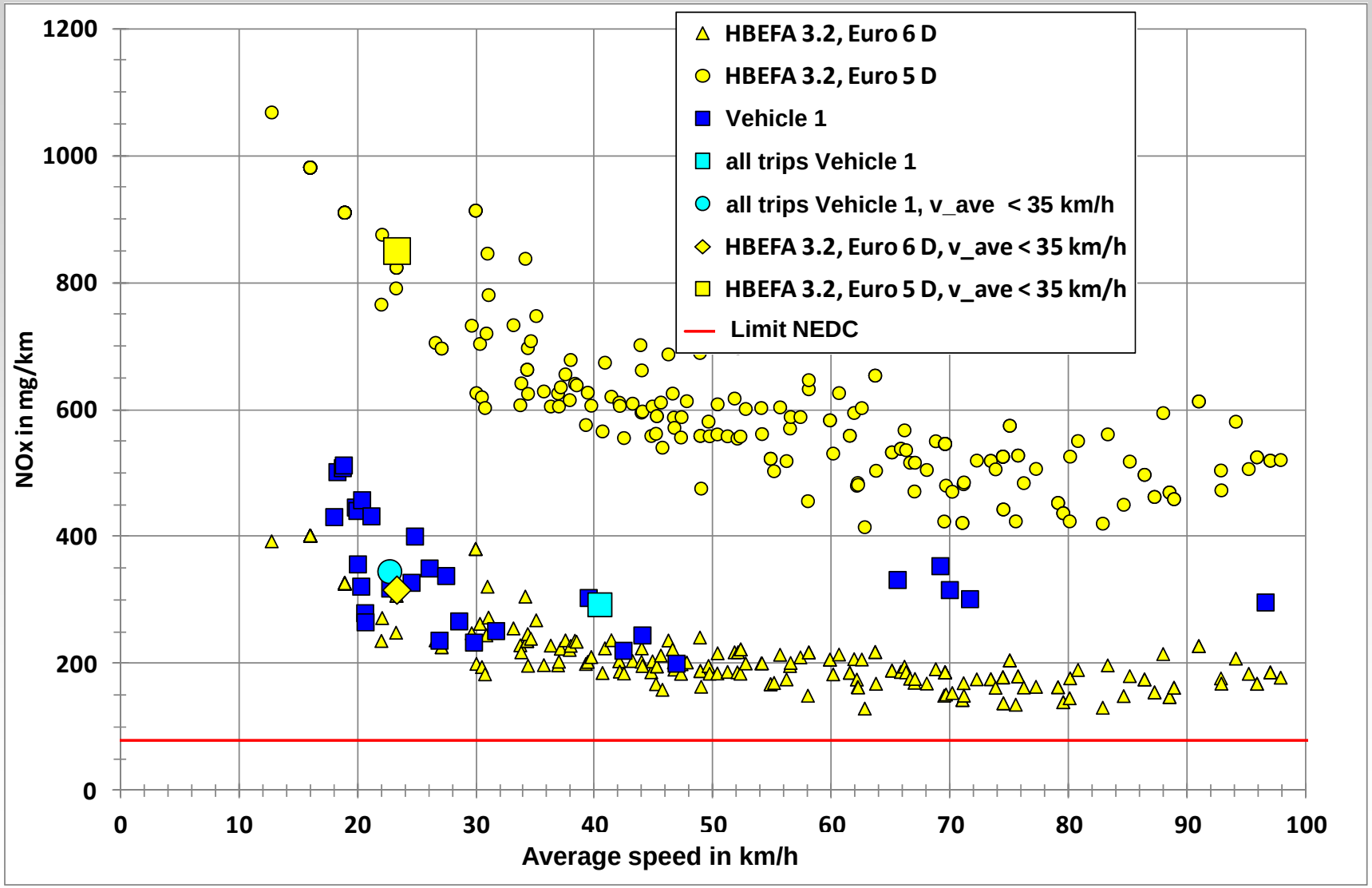


Garmisch

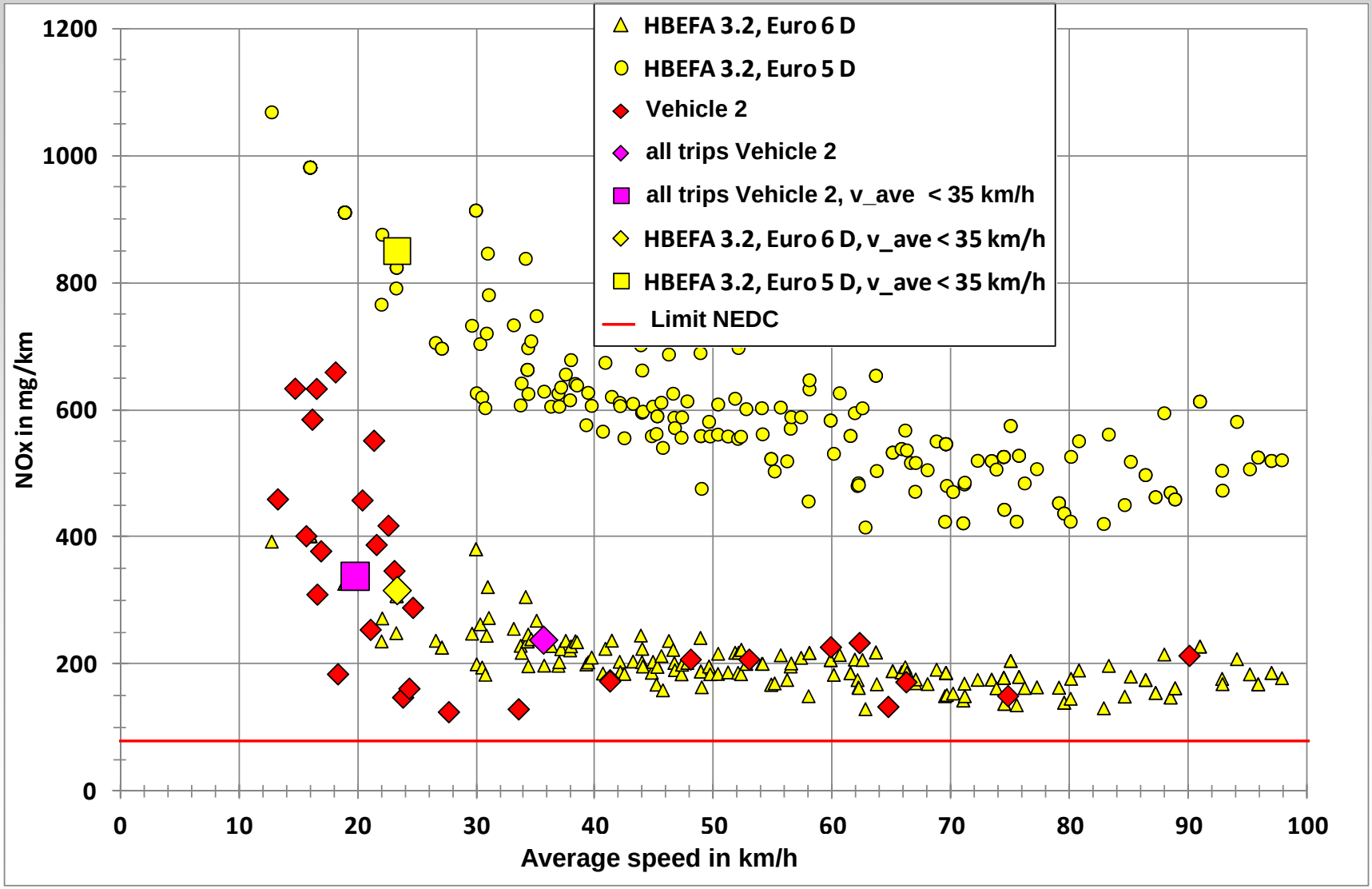
Rural / Motorway:

- **Length about 91,5 km**
- **Max. difference in altitude about 345 m**

Results of PEMS tests with Euro 6 vehicles



Results of PEMS tests with Euro 6 vehicles



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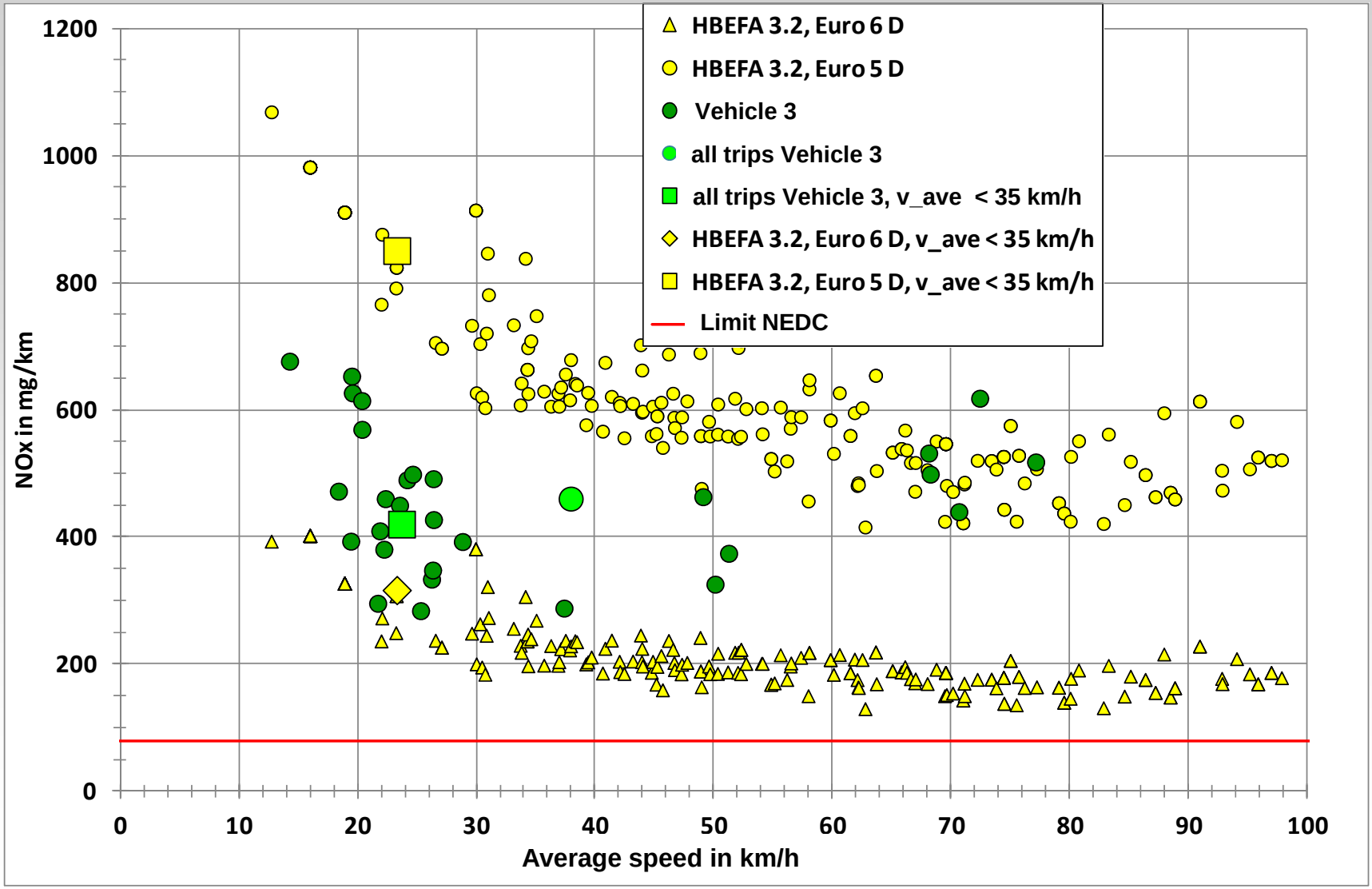

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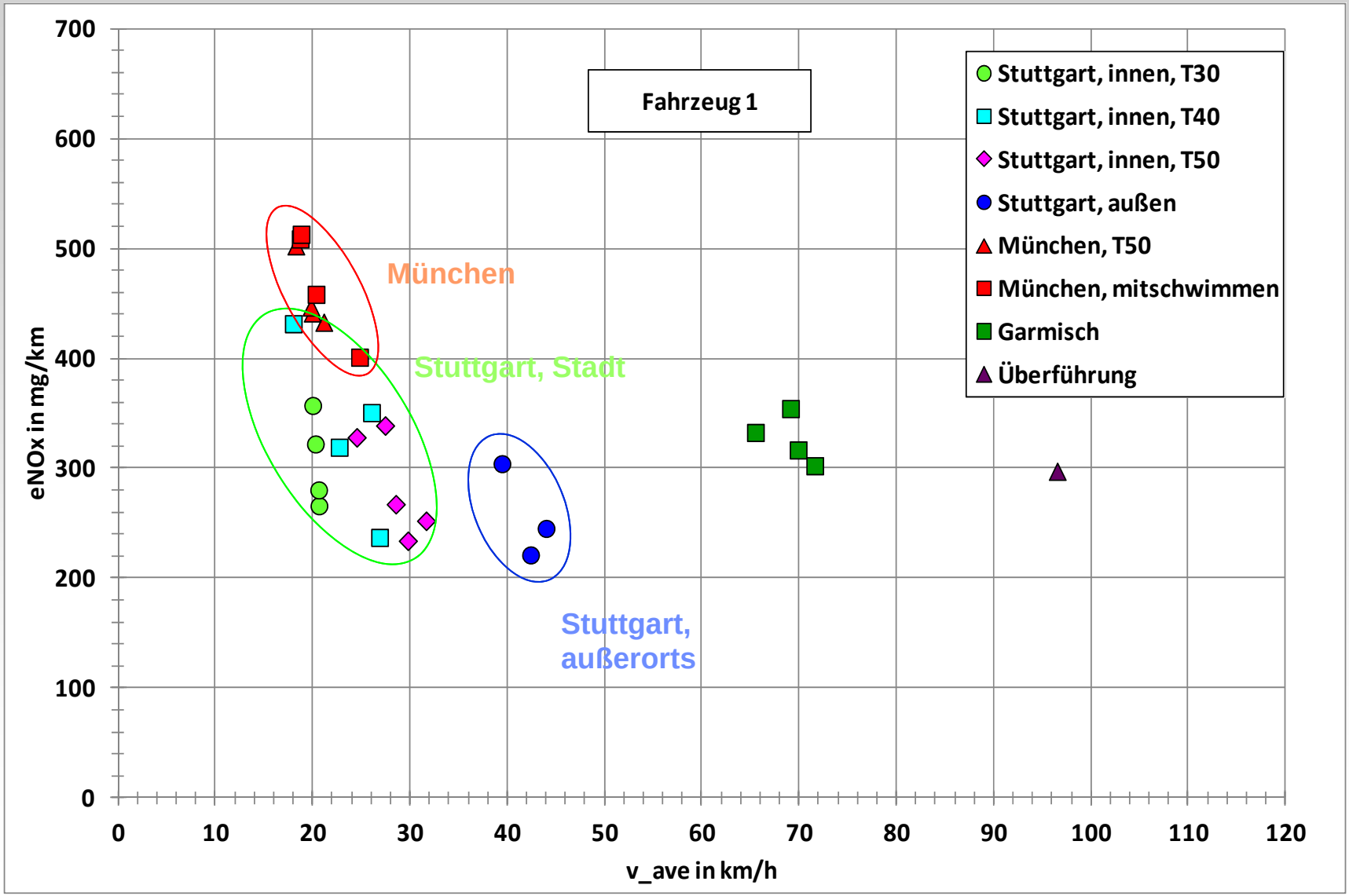

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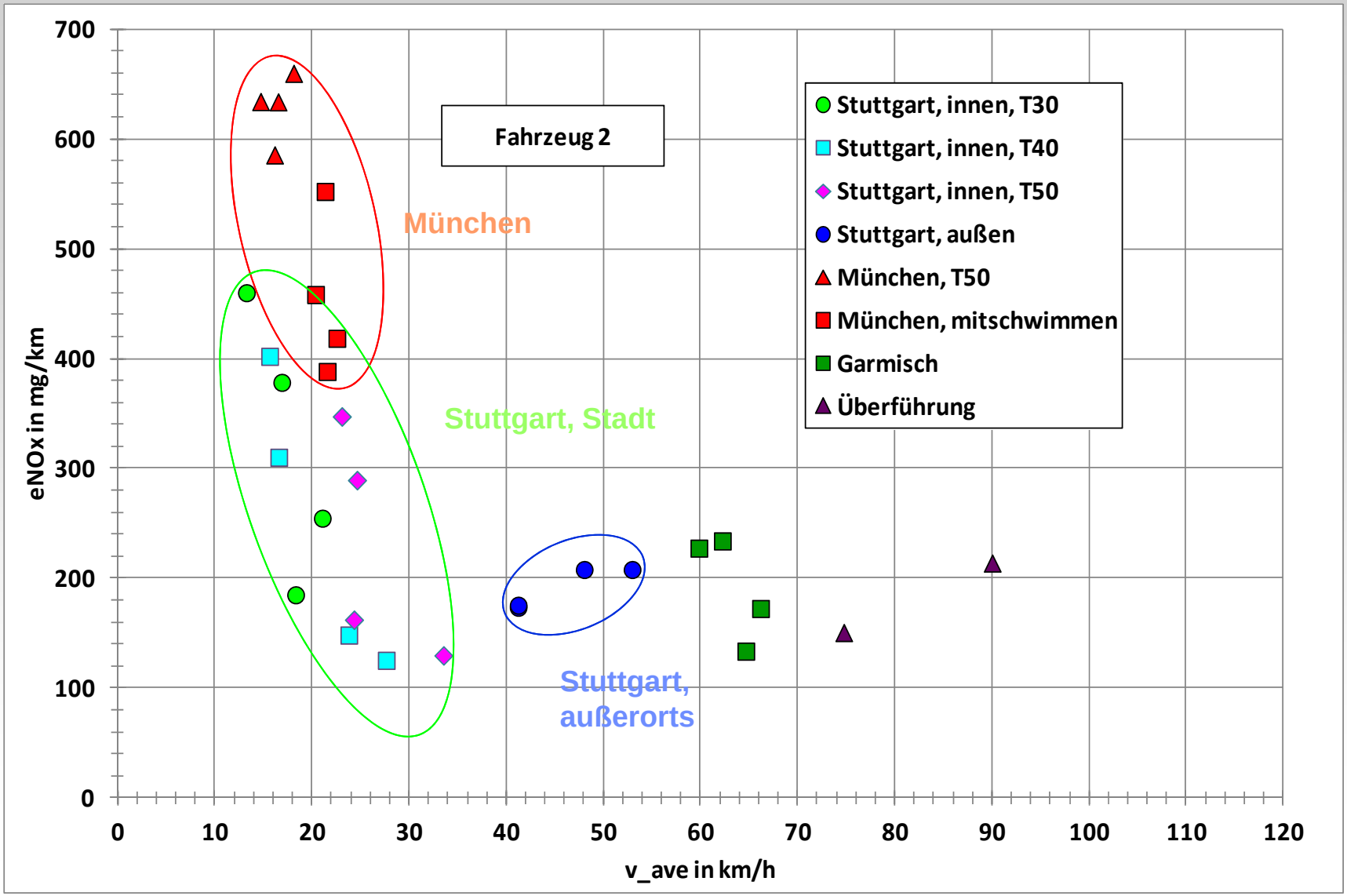

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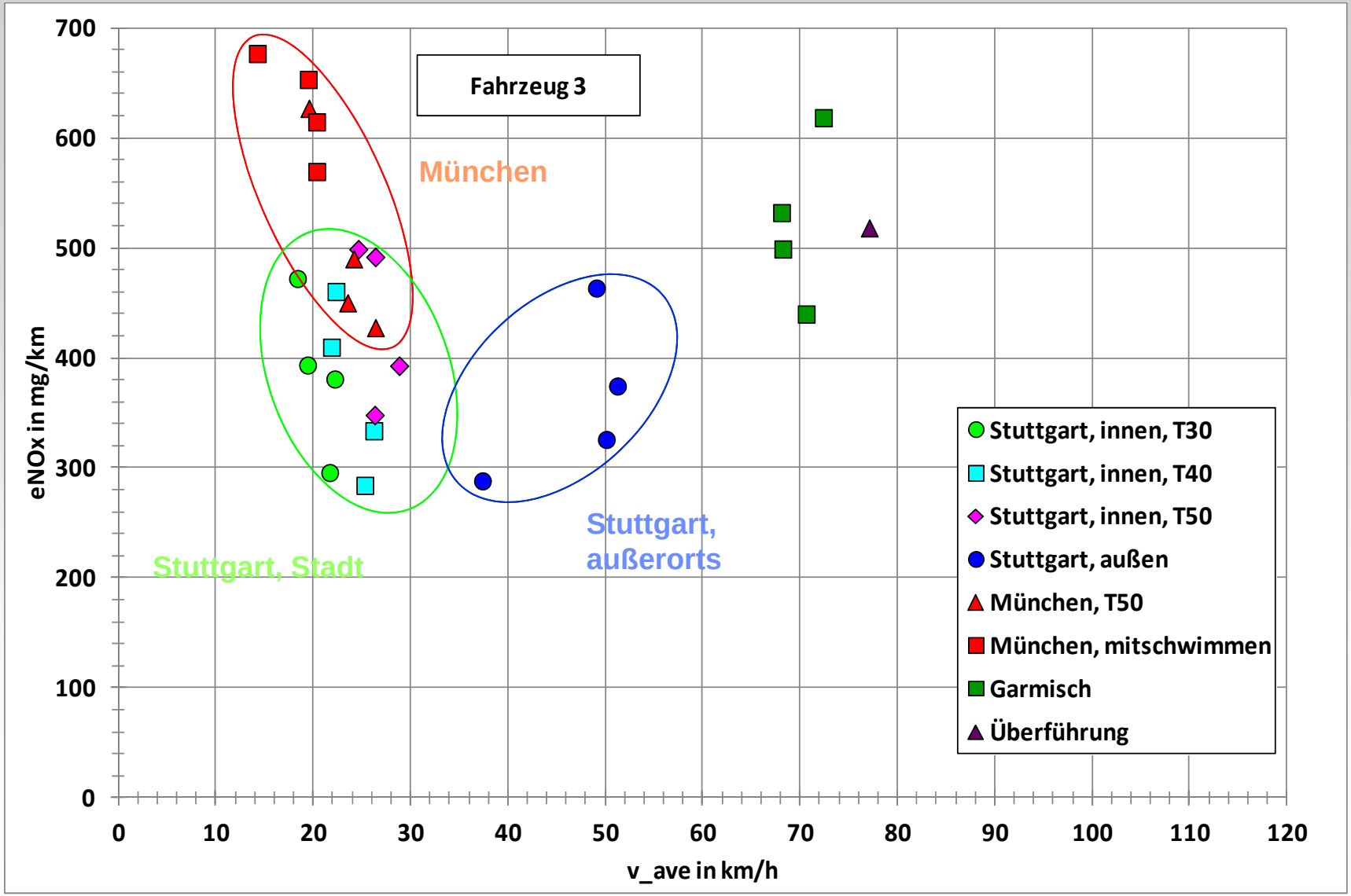

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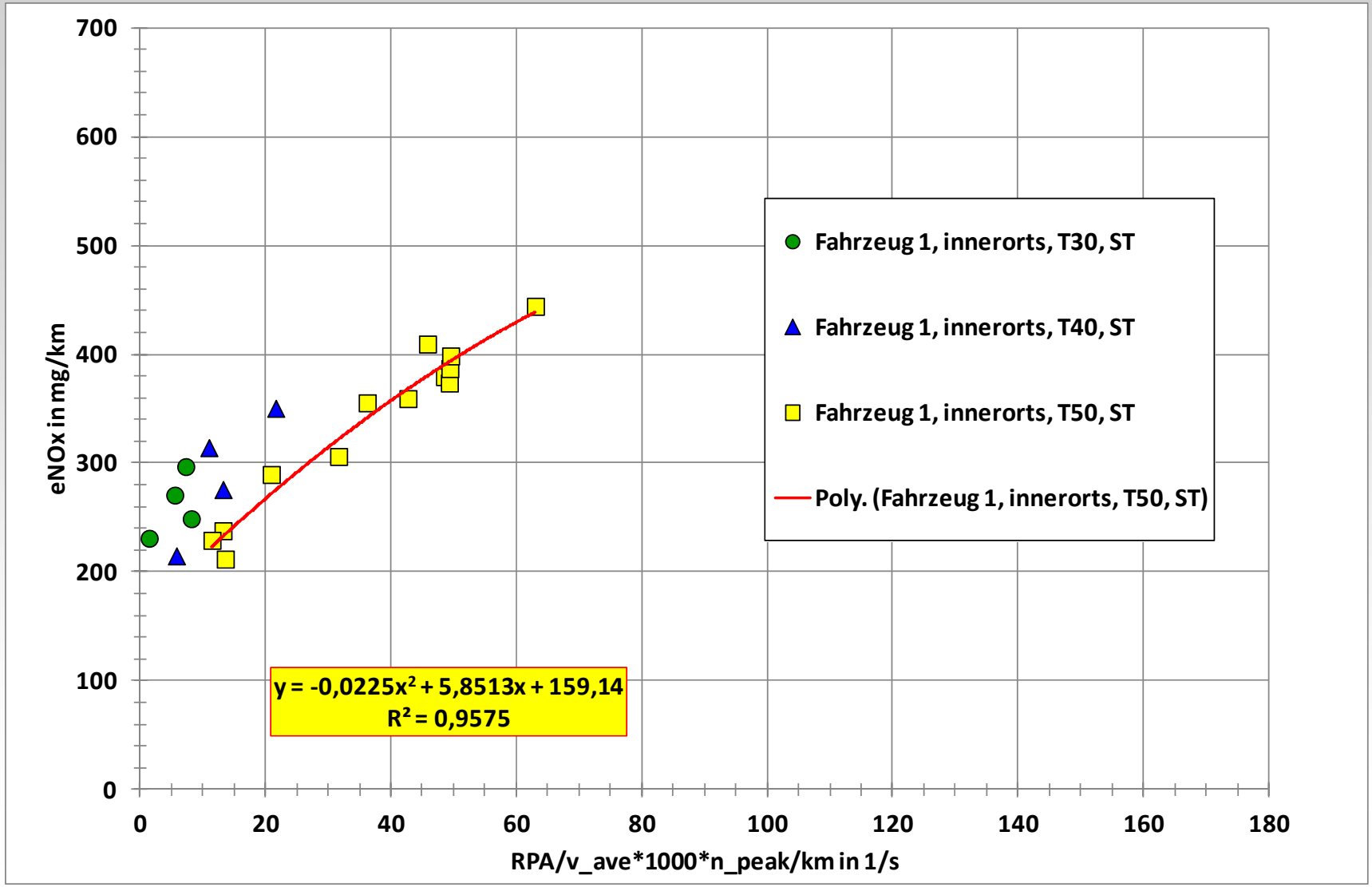

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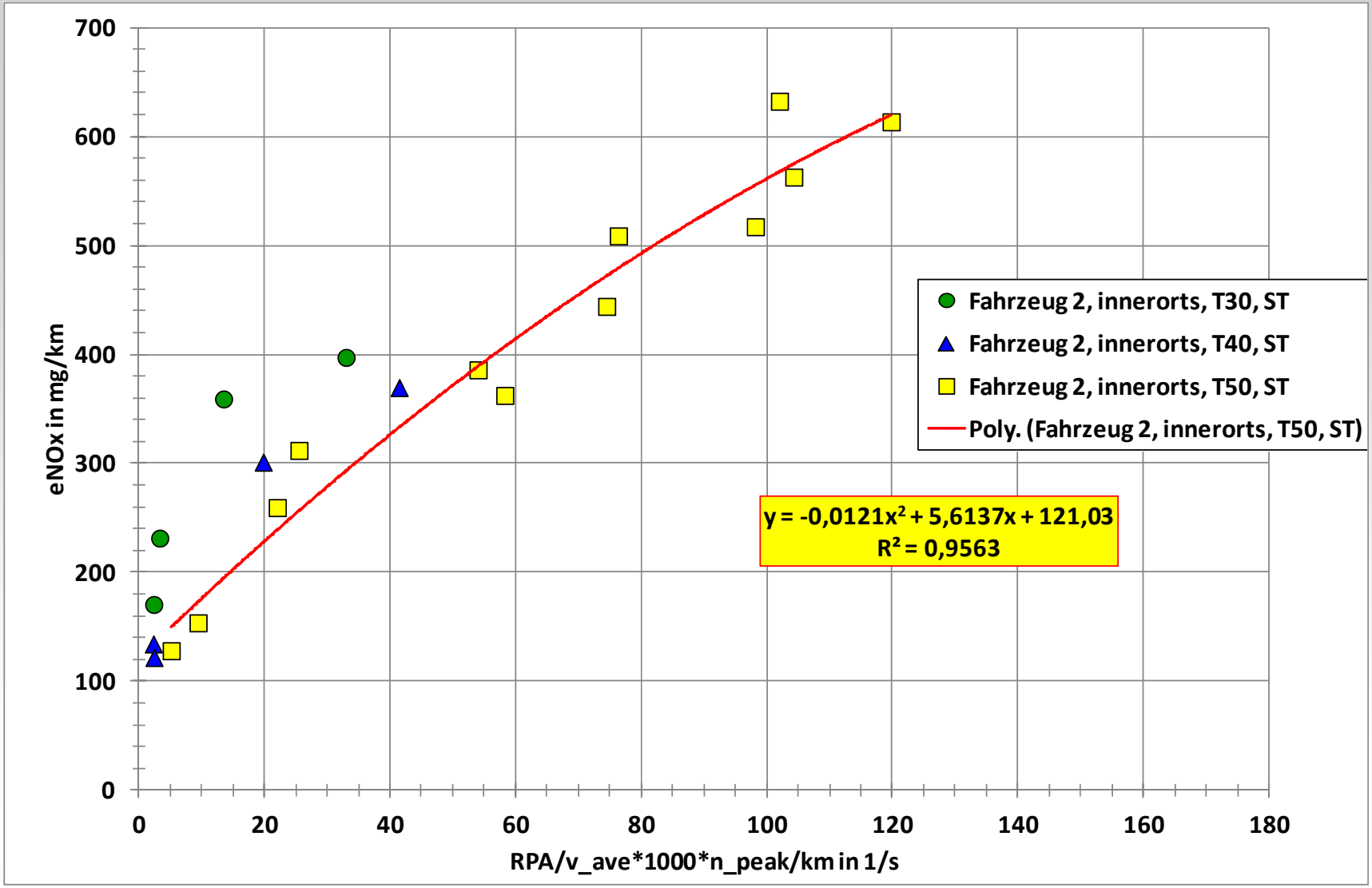

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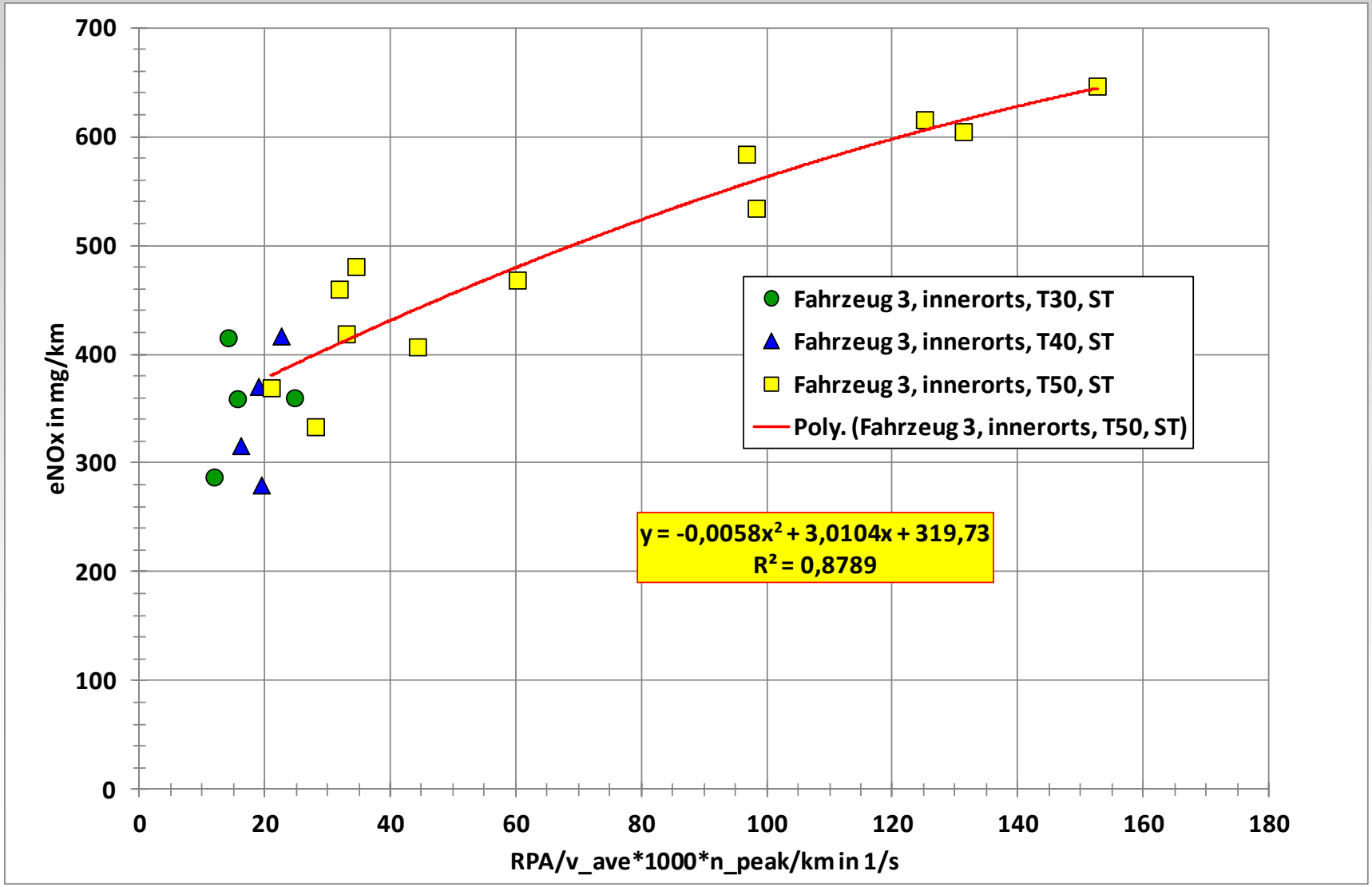

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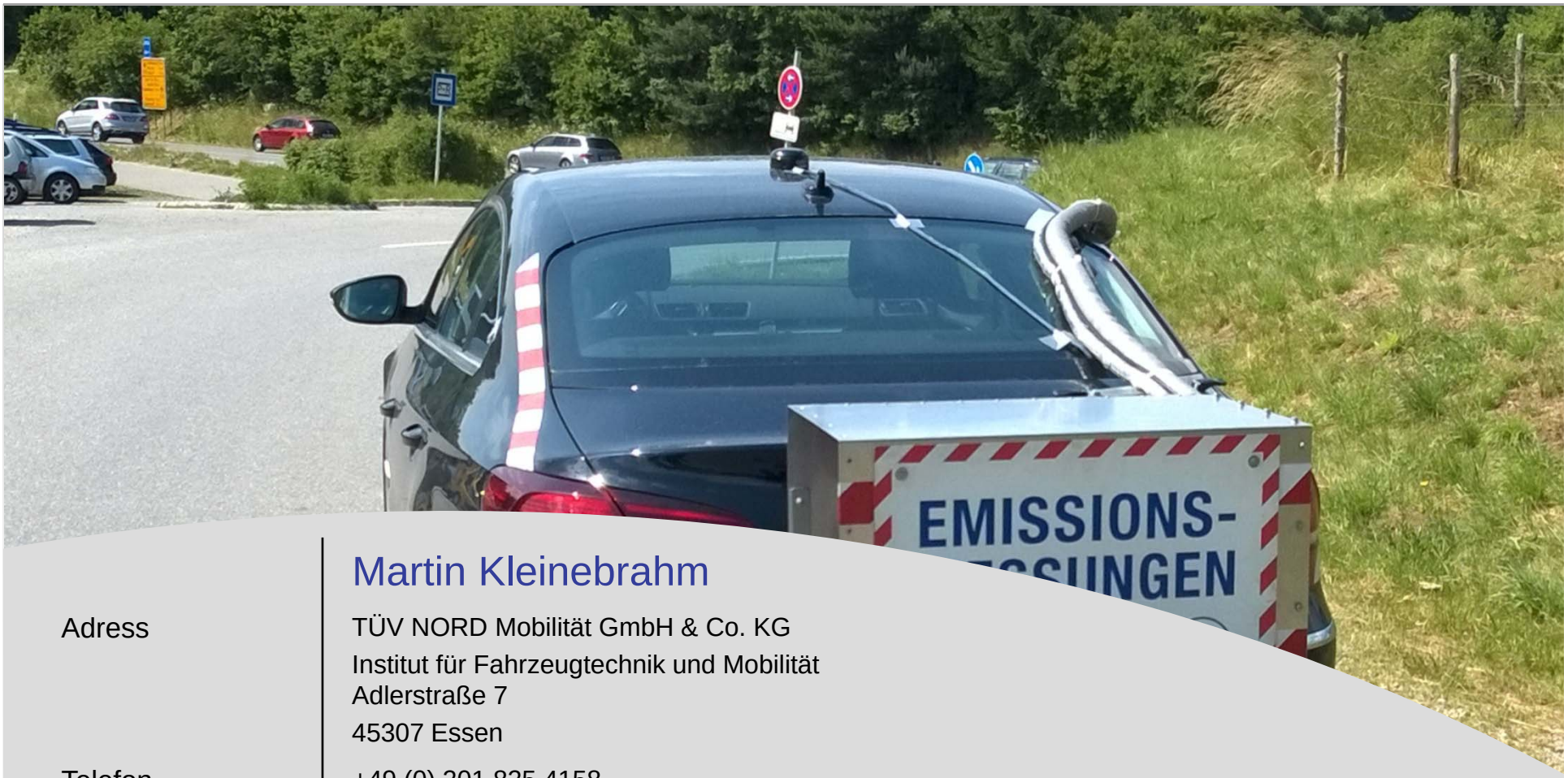

Martin Kleinebrahm

Adress	TÜV NORD Mobilität GmbH & Co. KG Institut für Fahrzeugtechnik und Mobilität Adlerstraße 7 45307 Essen
Telefon	+49 (0) 201 825 4158
Fax	+49 (0) 201 825 4109
Email	mkleinebrahm@tuev-nord.de