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Real Driving

EMISSIONS

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IQPC

International Quality & Productivity Center

POTENTIAL OF ADAPTION STRATEGIES FOR REAL DRIVING EMISSION IMPROVEMENT AND THEIR IMPACT ON RDE TESTING RESULTS

Aachen, 18.10.2017
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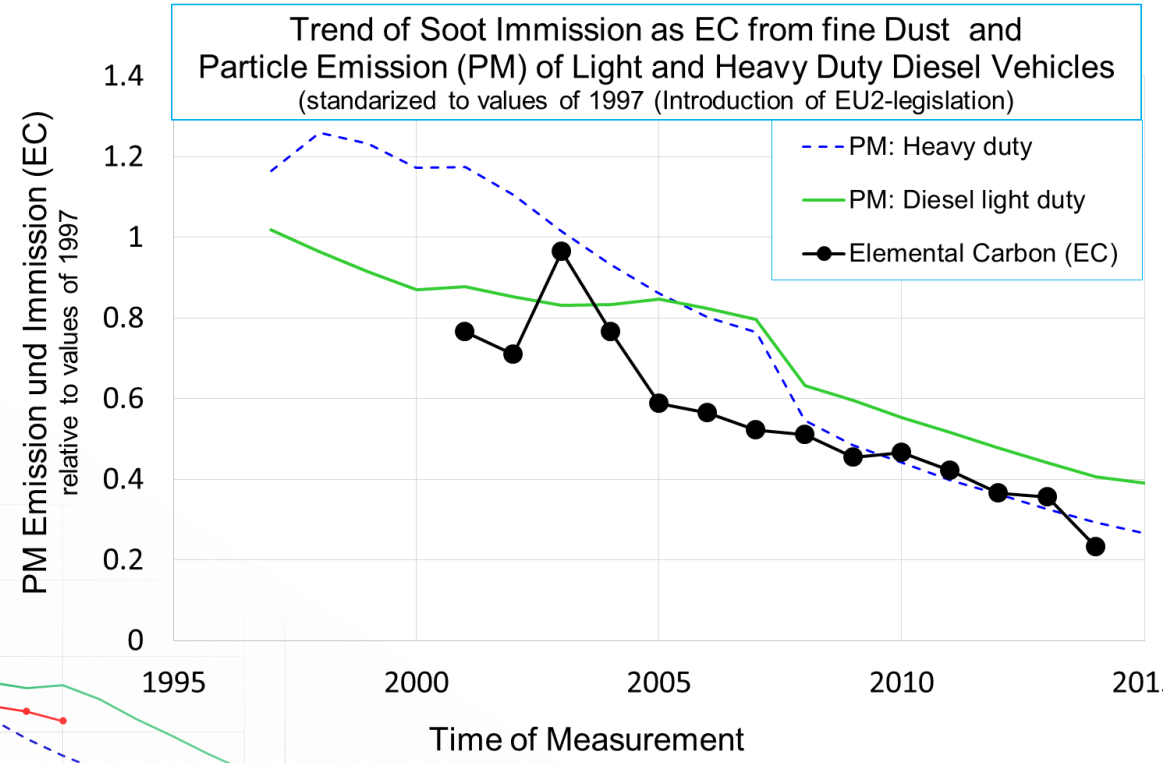
FEV

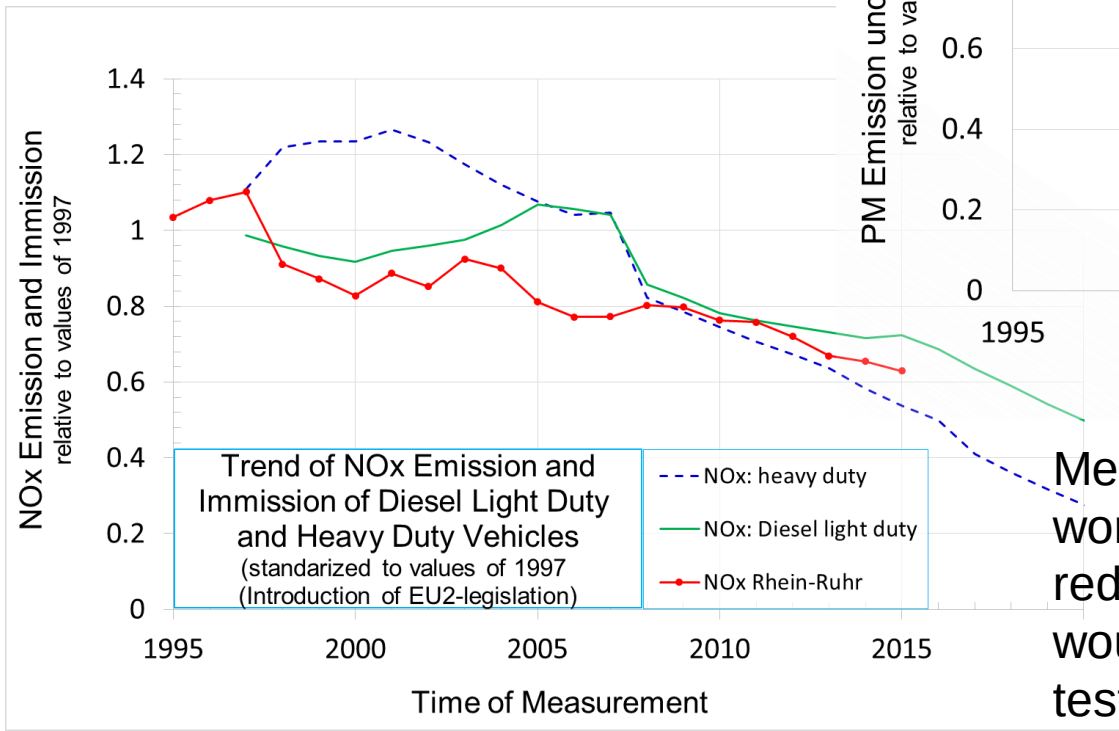
Agenda/Content

- Emission and immission
  Immission as measure for total emission
- Exhaust temperature as base of aftertreatment efficiency
  Potential impact of hybrid driving on exhaust temperature
- Detection of driving patterns as base of adaption to known traces
- Potential systems for adaption techniques
- Conclusion

Adaption strategies and RDE testing
Trend of immissions

Measured black carbon immission (BC) correlates very well with the trend of estimated total particulate emission based on the legislation threshold.

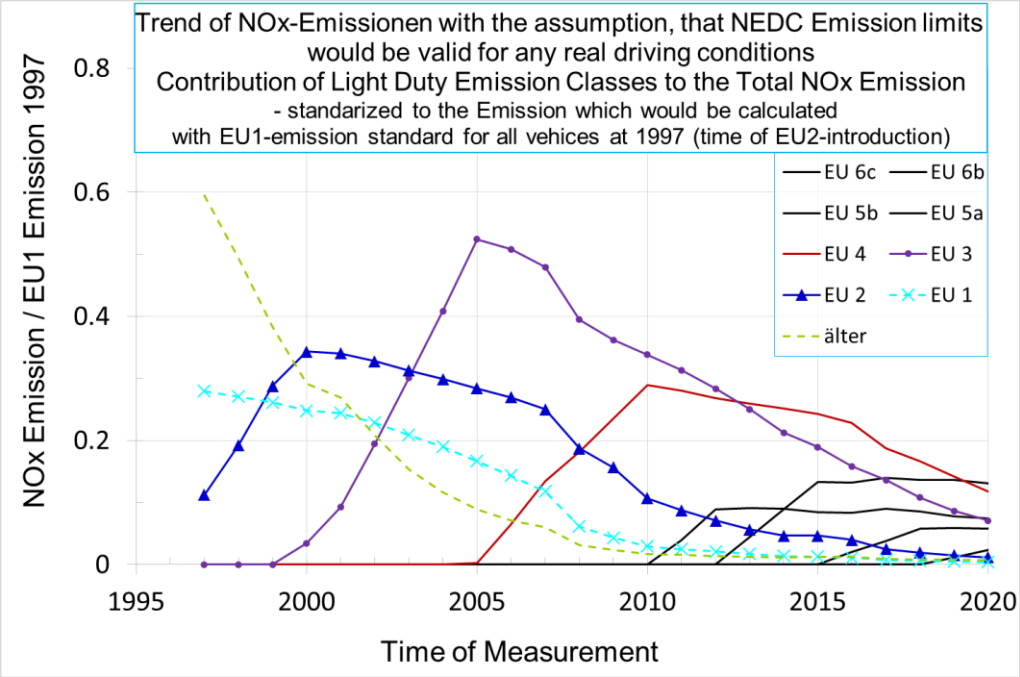


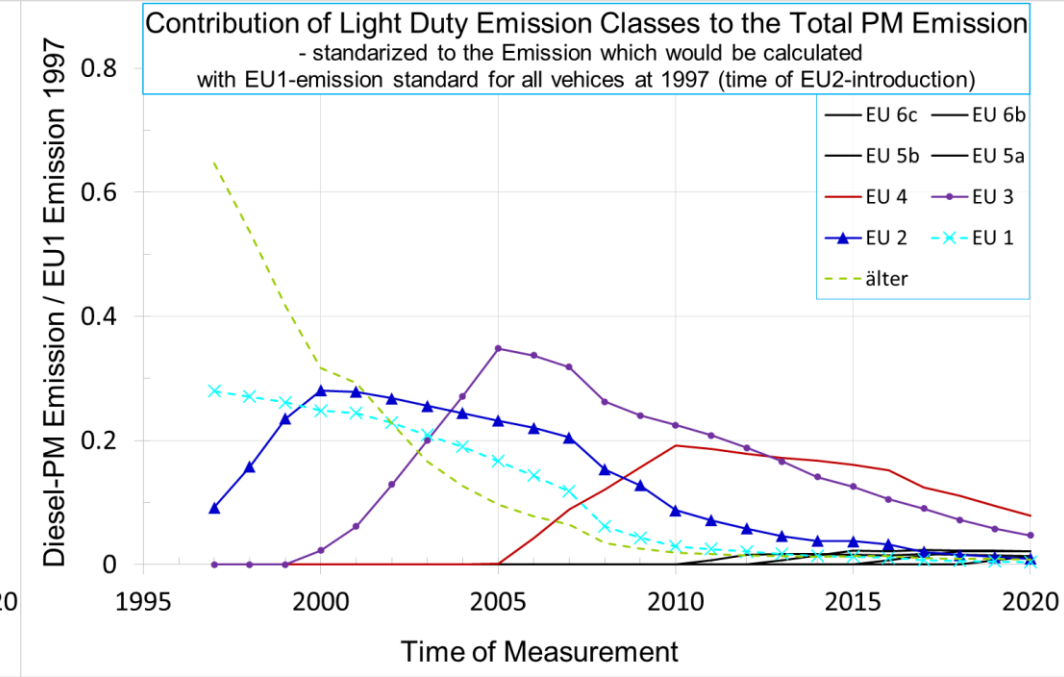


Measured NOx immission (BC) gives little worth correlation to the expected emission reduction by reduced thresholds. How would this picture change with RDE testing results?

Adaption strategies and RDE testing
Base of emission calculation (same is done for heavy duty)

In case, the NEDC emission would represent the total emission, calculation of the impact of all German diesel passenger cars shows that the actual particle emission is dominated by EU 3 and EU 4 vehicles without DPF.
Same calculation shows, that EU 5 and 6 cars have similar impact on total NOx emission like EU 3 and 4 cars.

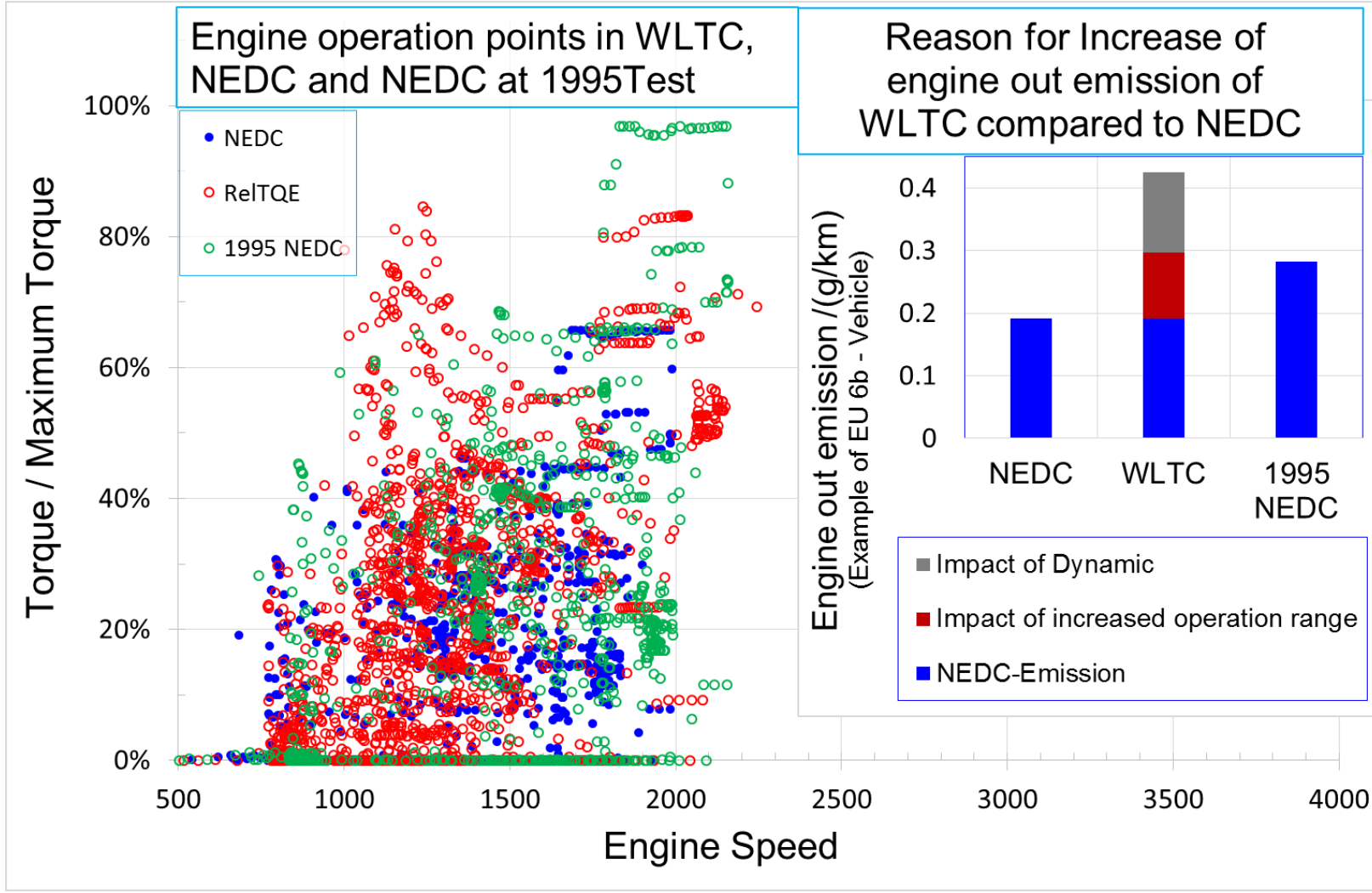




Adaption strategies and RDE testing
Reason for RDE testing – NEDC – WLTC Comparison

WLTC as well as NEDC focus on average driving at moderate conditions

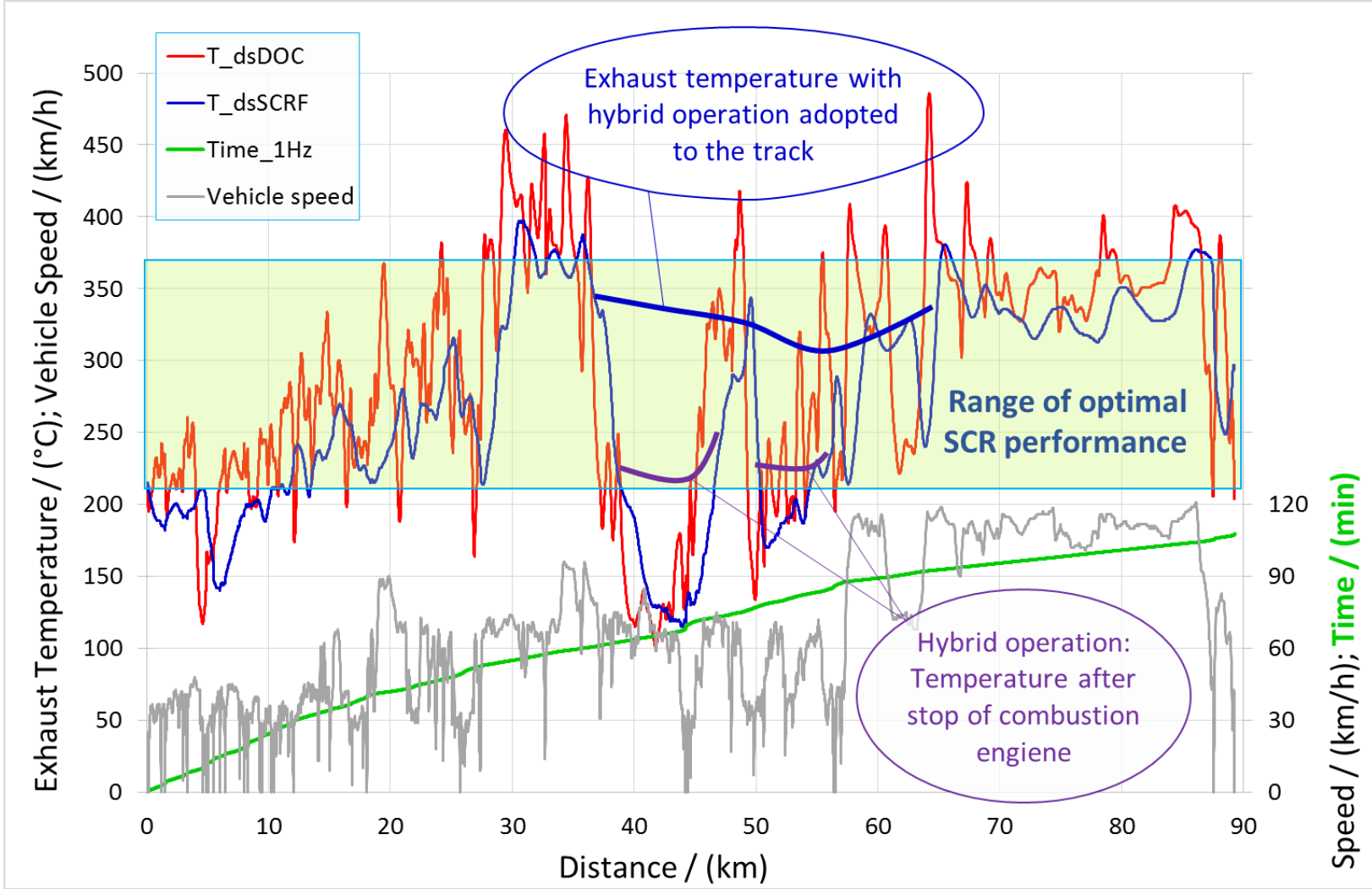
RDE testing can prove the validity of the calibration for normal driving (Normal is not average)



Adaption strategies and RDE testing
Example of exhaust temperature at real driving

Impact of hybrid driving adaption on exhaust temperature.

ECU needs Information, what the drivers action might be in future



Adaption strategies and RDE testing
Example of exhaust temperature at real driving

Besides the optimization of the optimal working range of the combustion engine with hybrid operation, it can be adapted for example:

Engine mode for DPF regeneration, LNT regeneration or desufatisation

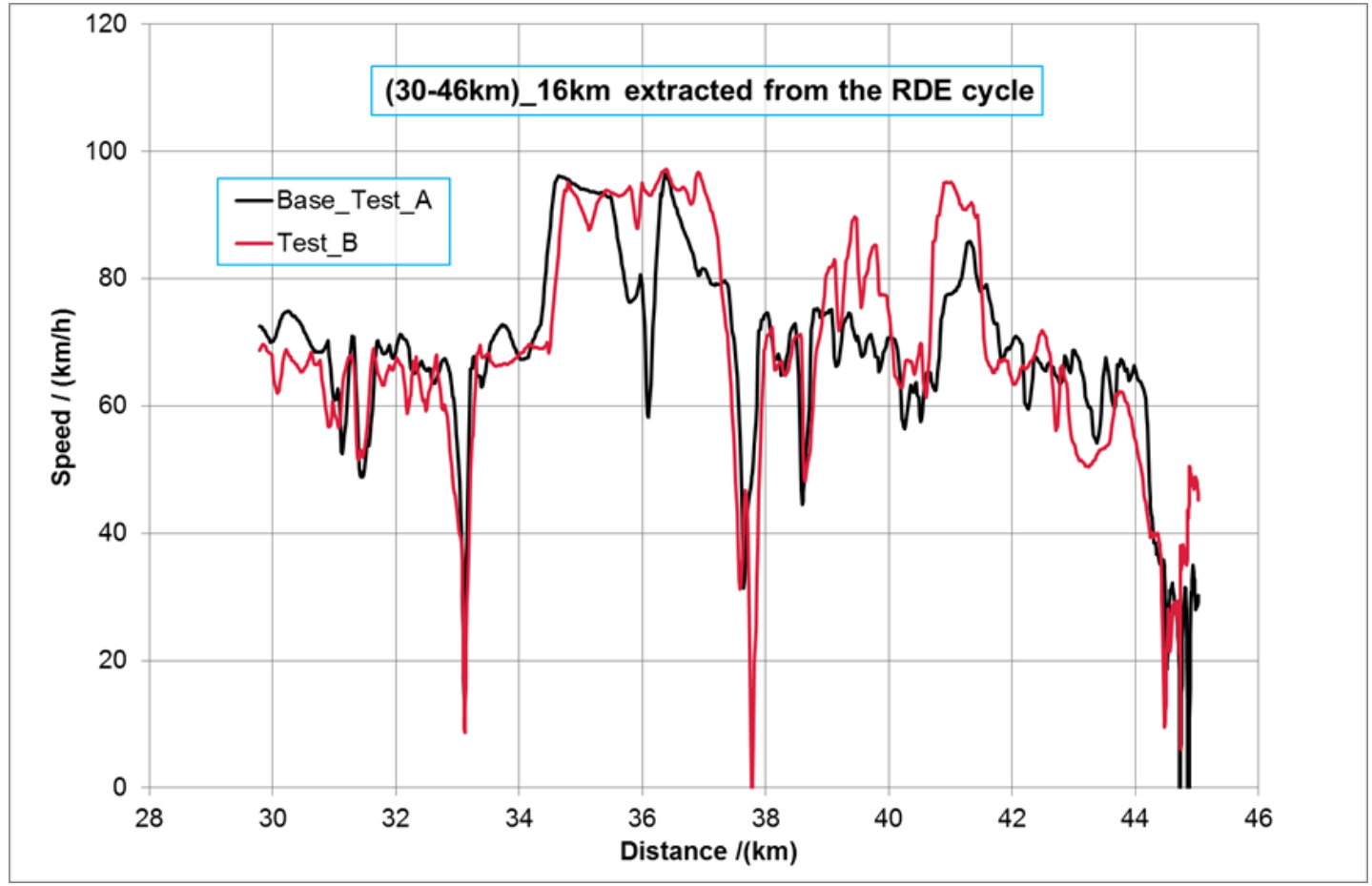
Temperature for optimal LNT of optimal SCR operation

The ammonia storage quantity at SCR to the expected temperature (preventing ammonia break through)

Adaption strategies and RDE testing
Detection of driving patterns

Speed comparison for the same track at different time and with different drivers:

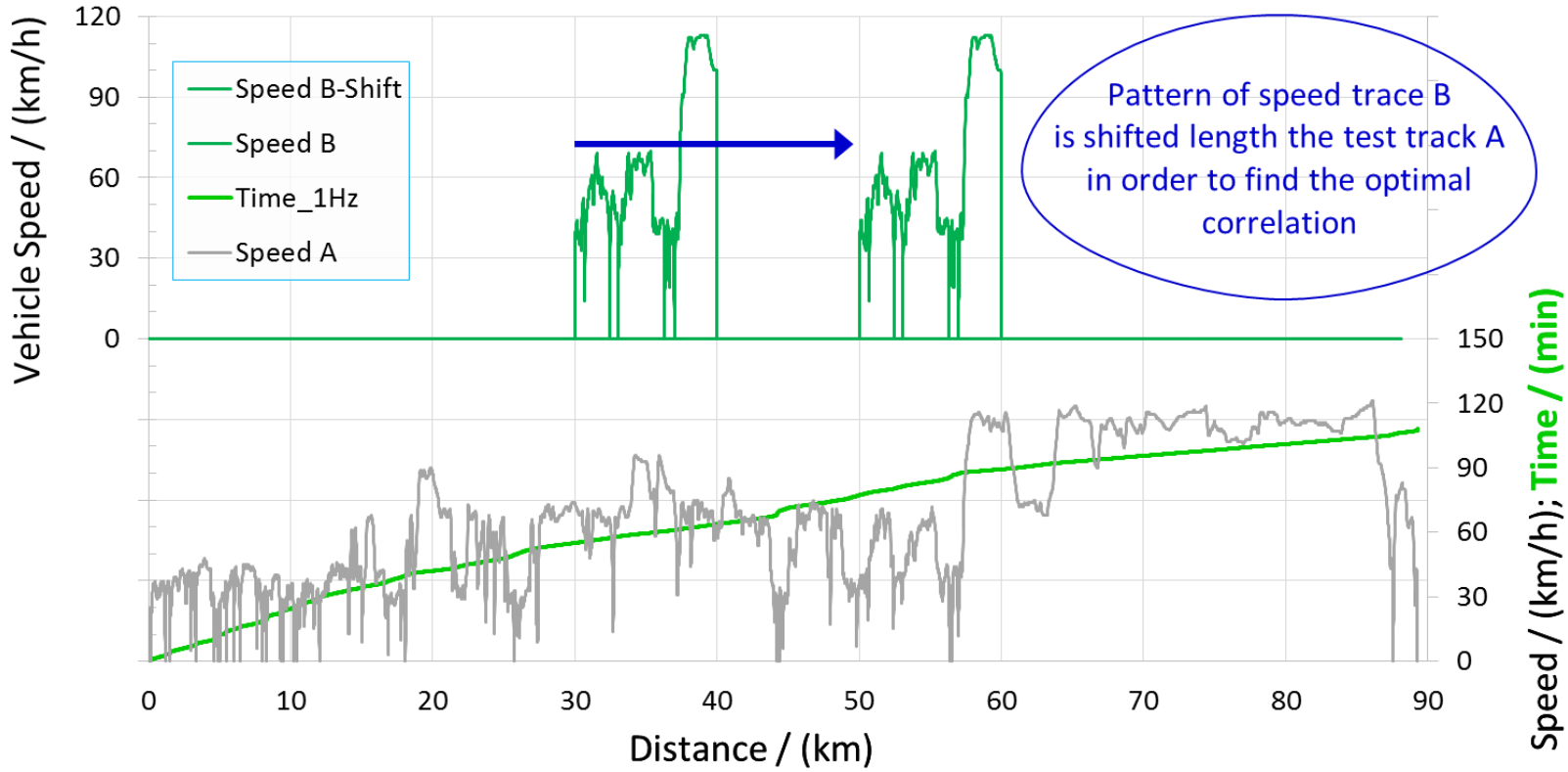
While the overall signal follows a similar trace, in detail the speed differs significantly as expected by different driving situations.



Adaption strategies and RDE testing
Detection of driving patterns

The best correlation between Test A and Test B was evaluated by shifting test B along test A.
Beside the speed the ΔPower signal (difference between measured and calculated fuel consumption) was compared.

If the sequences compared to each other are very similar, their product shows a maximum.

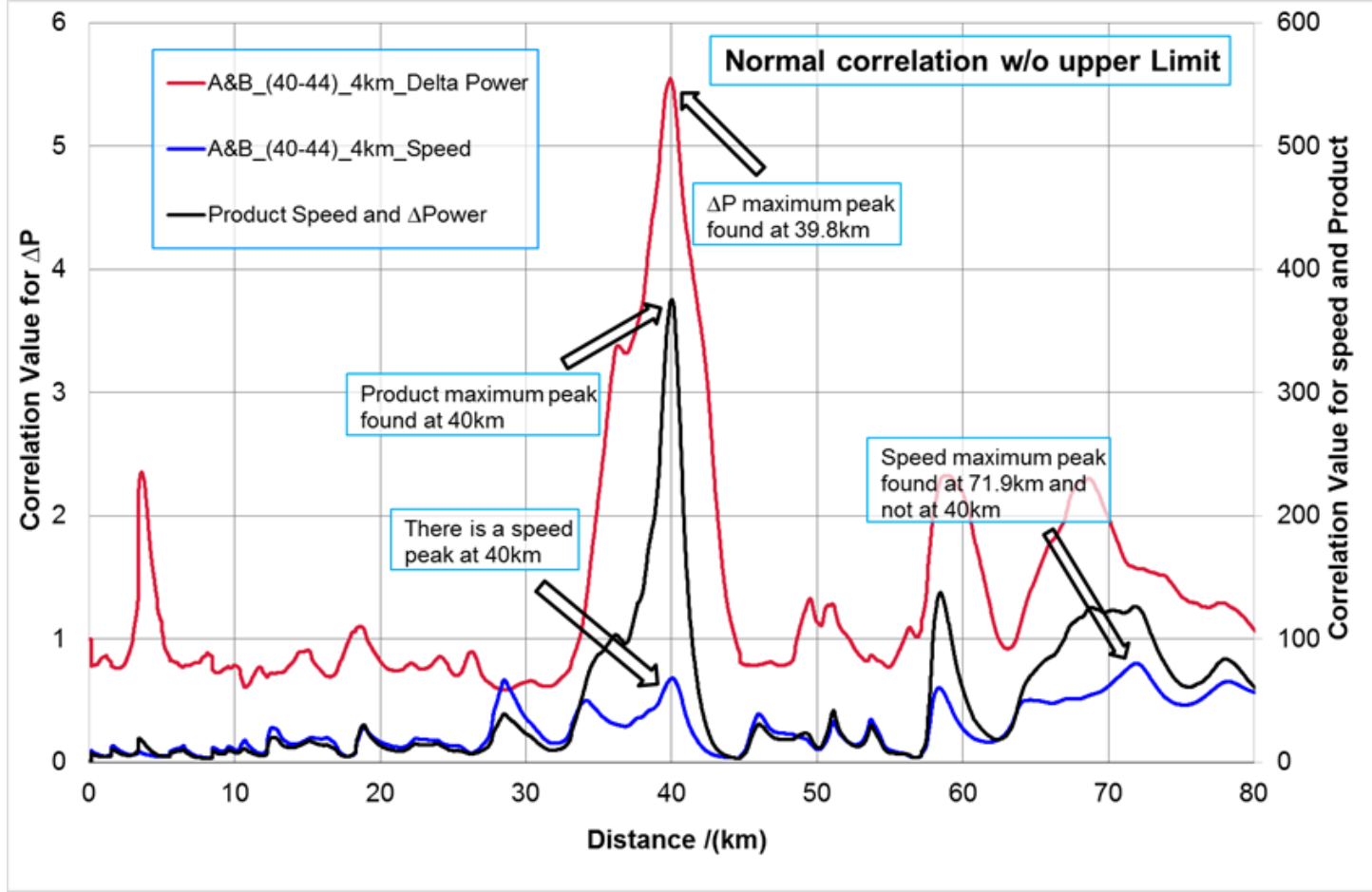


Adaption strategies and RDE testing
Detection of driving patterns

Comparison of speed and Δ Power correlation with 4 km track B:

The speed correlation give no significant signal and it's best correlation was found at the wrong part of the track.

The product of both correlations give a significant signal at the desired part of the trace.

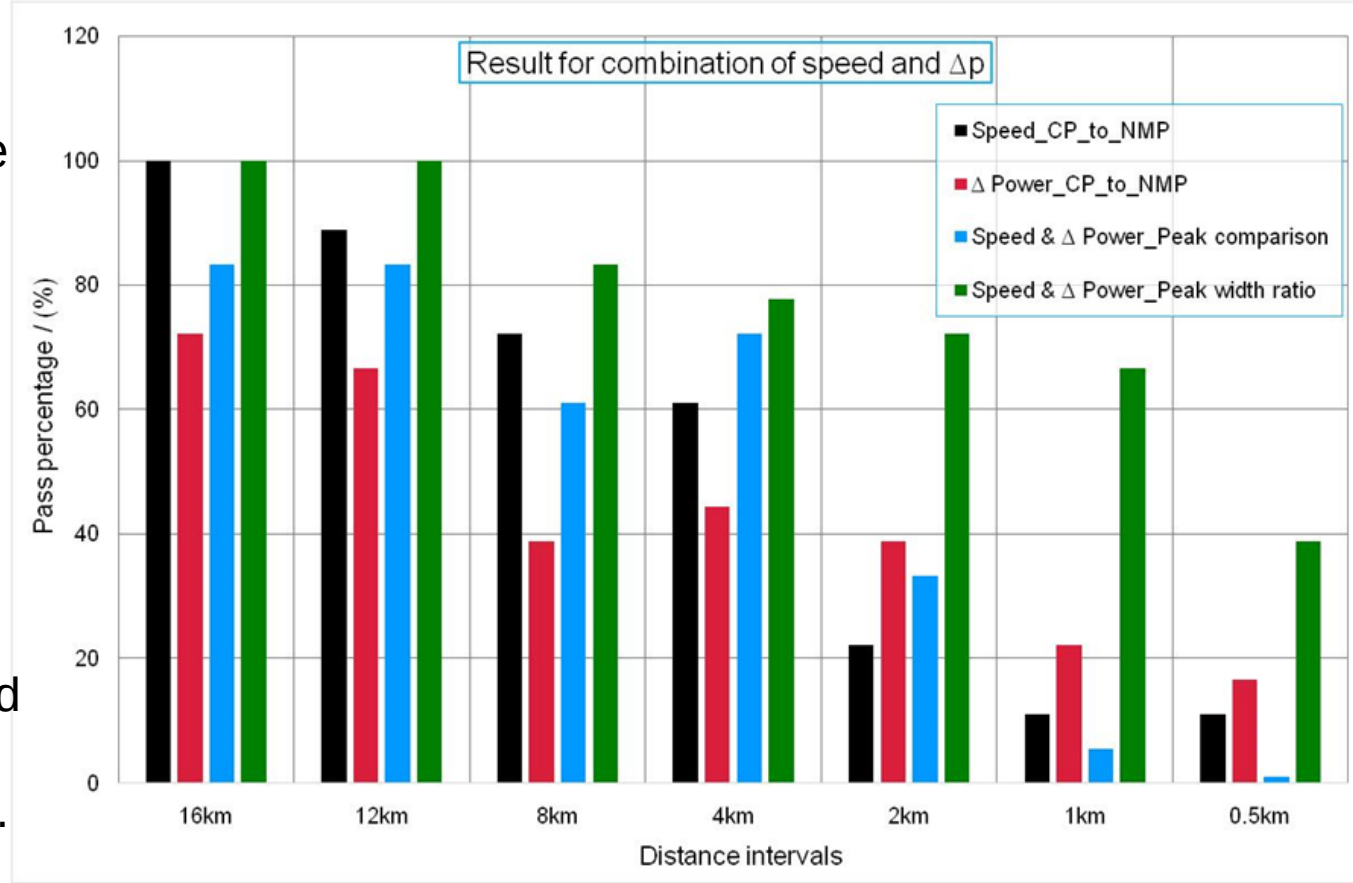


Adaption strategies and RDE testing
Probability of true detection of driving patterns

By further peak shape analysis using the second deviation of the correlation function, all cases, which give no satisfying correlation could be detected. With this aid, the probability of correct correlation can be evaluated.

This probability rises with increasing correlation time. Even for this simple example correlating two independent signals, the probability of correct detection reaches 67% after 1 km driving distance.

Besides speed and torque several other signals can be used for improved detection of known driving patterns and of course, GPS position, actual time and day will help.



Adaption strategies and RDE testing
Possibilities of adaption to an estimated driving pattern

With defined probability of known driving pattern in advance, the engine operation as well as the exhaust aftertreatment control can be adopted to optimal efficiency.

Exhaust temperature can be predicted and time for DeNOx, DPF regeneration, Urea dosing can be optimized.

Especially with hybrid technology engine operation with non optimal exhaust purification can be provided.

Probably the complexity of the aftertreatment system can be reduced with hybrid technology including a heating device by forcing the combustion engine to only operation at sufficient temperature of the exhaust system

With sufficient exhaust quality sensors, also parts of the engine calibration can be done during real life adopted o the drivers environment and driving manner.

During lifetime simple try and error experiments as well as physical based investigations can improve the exhaust quality while the vehicle is running.

What does this mean for RDE-testing?

At actual state of RDE discussion: **Nothing**

Regarding the actual state of RDE discussion, there will be absolutely no benefit by all adaption possibilities shown up to now.

And as long, as there is no benefit, no manufacturer will spend any money in investigating such a system.

Relative expensive state of the art aftertreatment technology with high demand on control structure and calibration will be preferred compared to self-adapting systems, because such self-adapting systems are only optimal at the conditions of their daily use.

Especially the hybrid technology will suffer by increasing system costs while it will be impossible to use the adaption technology for reduction of exhaust aftertreatment costs.

Probably the actual state of RDE discussion is not the final state.

