Continental
The Future in Motion

Procedure and design of exhaust systems to fulfill all emission limits during real driving conditions; „In Use Conformity“

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Agenda

1 Introduction

2 Emission Calculation

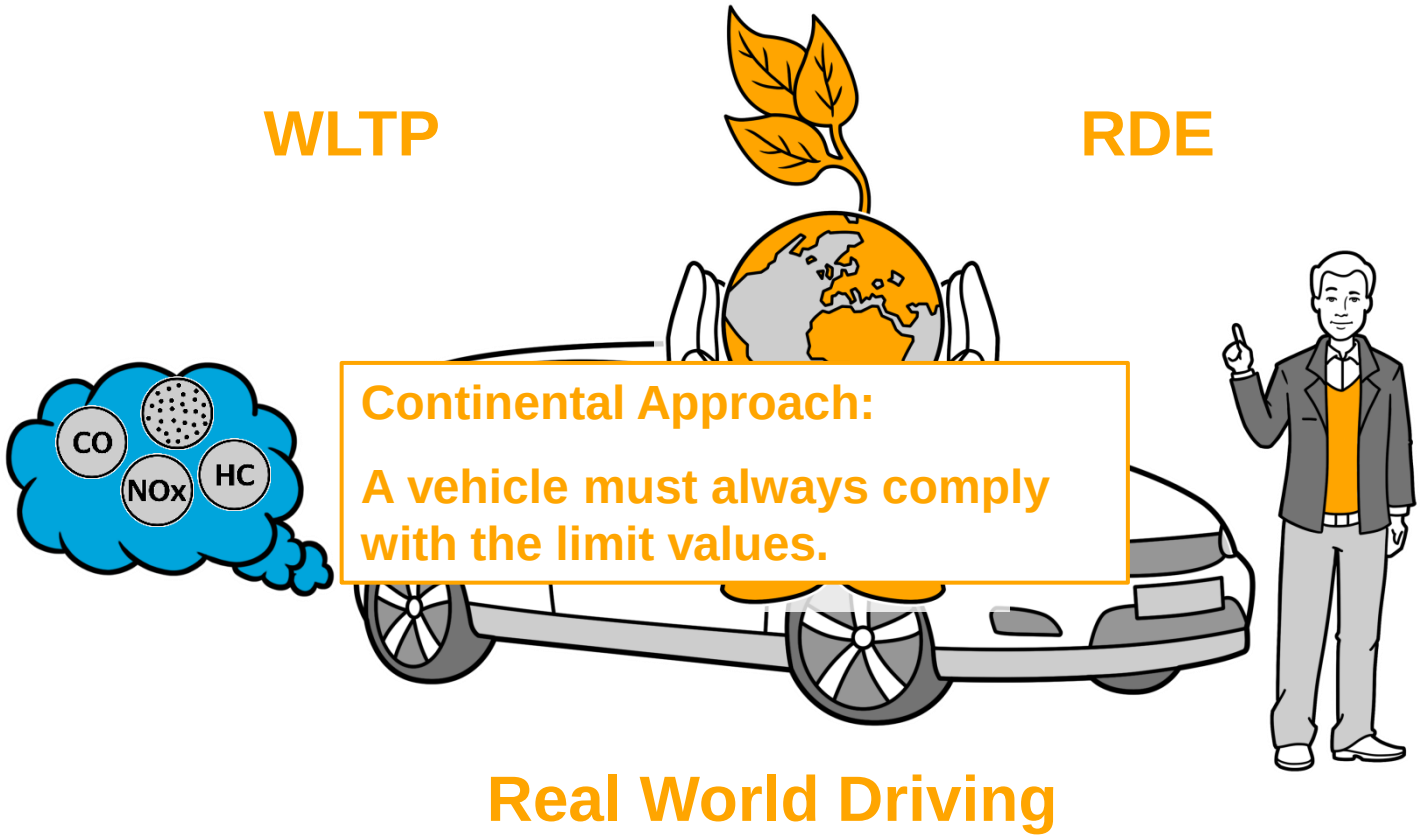
3 Identification of Critical Driving Conditions

4 Solutions for Emission Robust Catalyst System

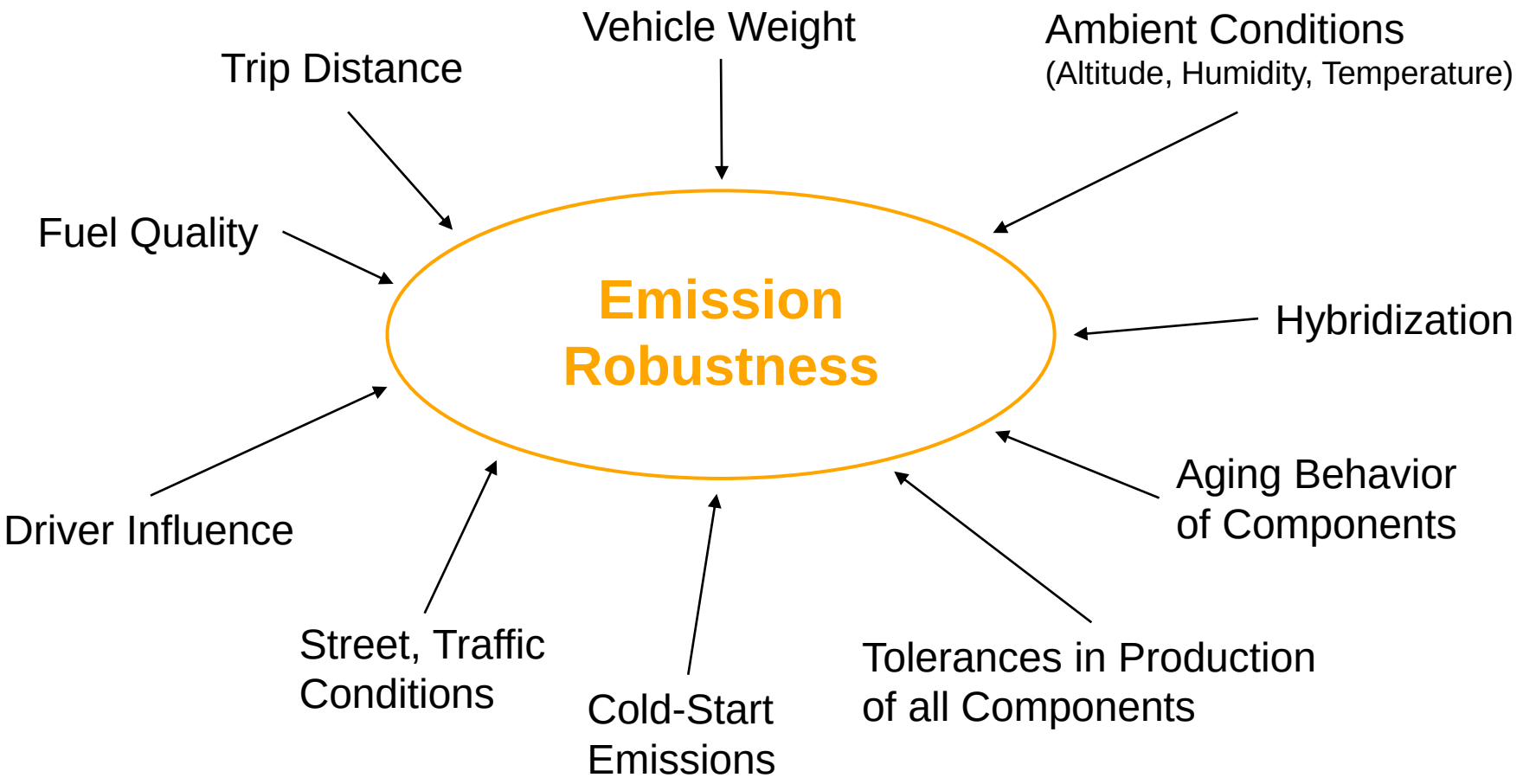
5 Summary / Outlook

Challenges for the Powertrain Development

Emission Robustness



Key Challenge: Emission Robustness



Key Challenge: Emission Robustness
General Discussion

› Should the electrical drive in a hybrid be used for power and torque increase or for compensation of the driver and ambient condition influence

➔ less dynamic on the combustion engine

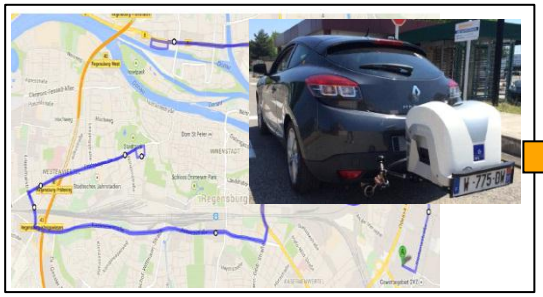
› Can an extreme driver “wish“ be prohibited / overruled by the engine management (digital driving; driver with high “p-controller“ behavior)

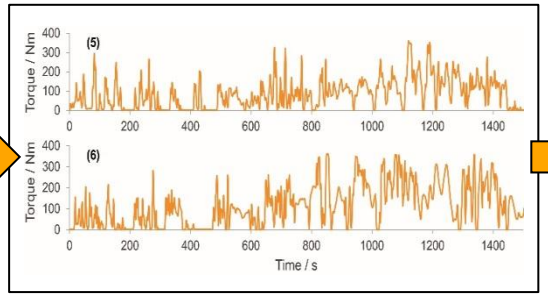
This is less an engineering decision, but a marketing decision!

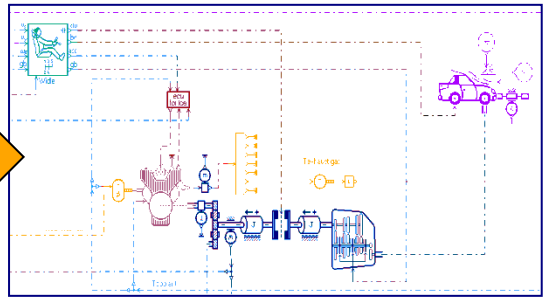
Methodology to Evaluate Robustness

Relevant for Individual Components and the Overall Vehicle

- RDE / Street Testing
  - Vehicle test
  - Engine test
- Critical driving events
- Pareto of most important parameters
- Model-in-the-loop
- Hardware-in-the-loop







Goal:
Statistical evaluation of boundary conditions and system tolerances

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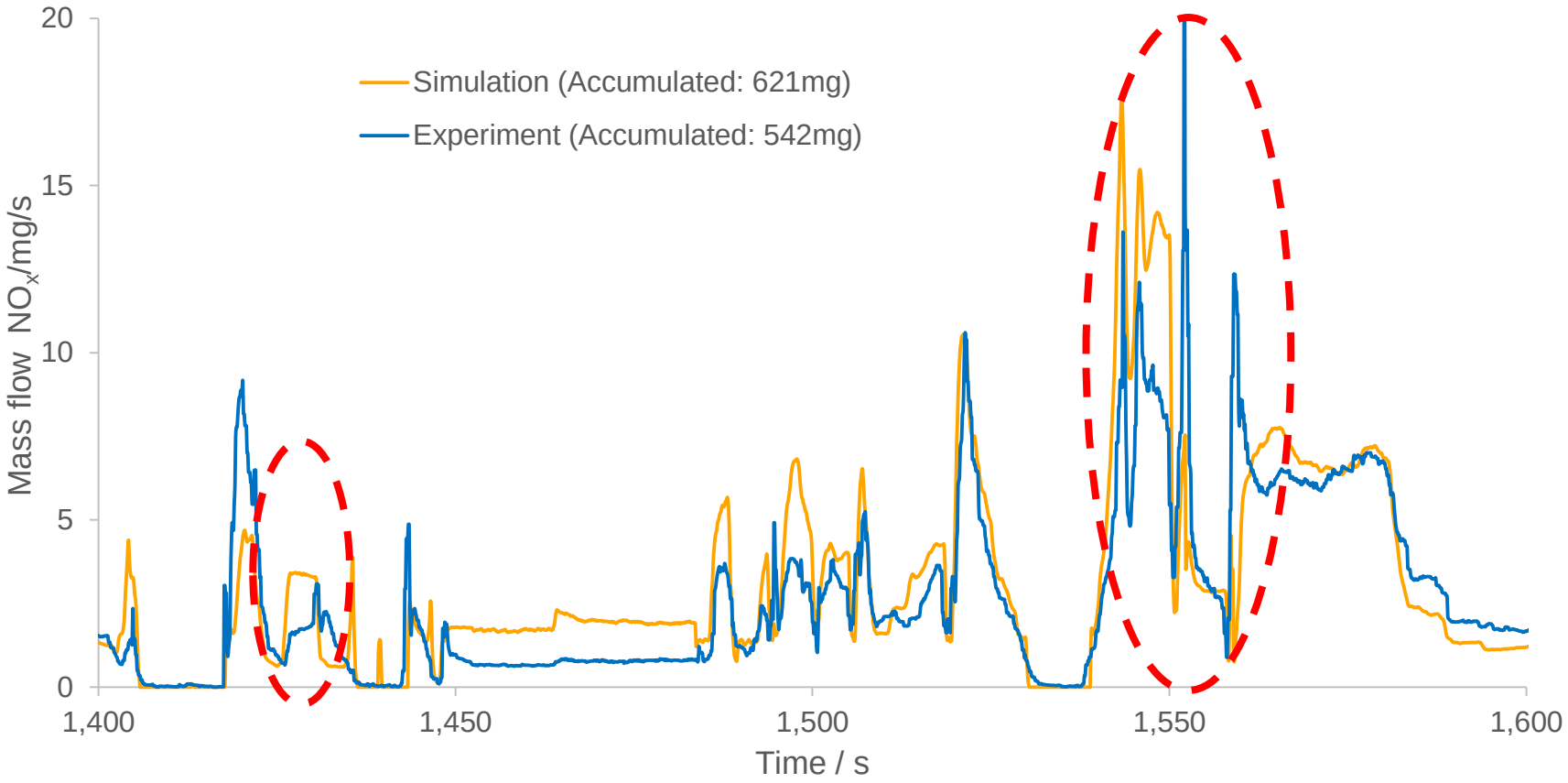
Key Challenge: Emission Robustness

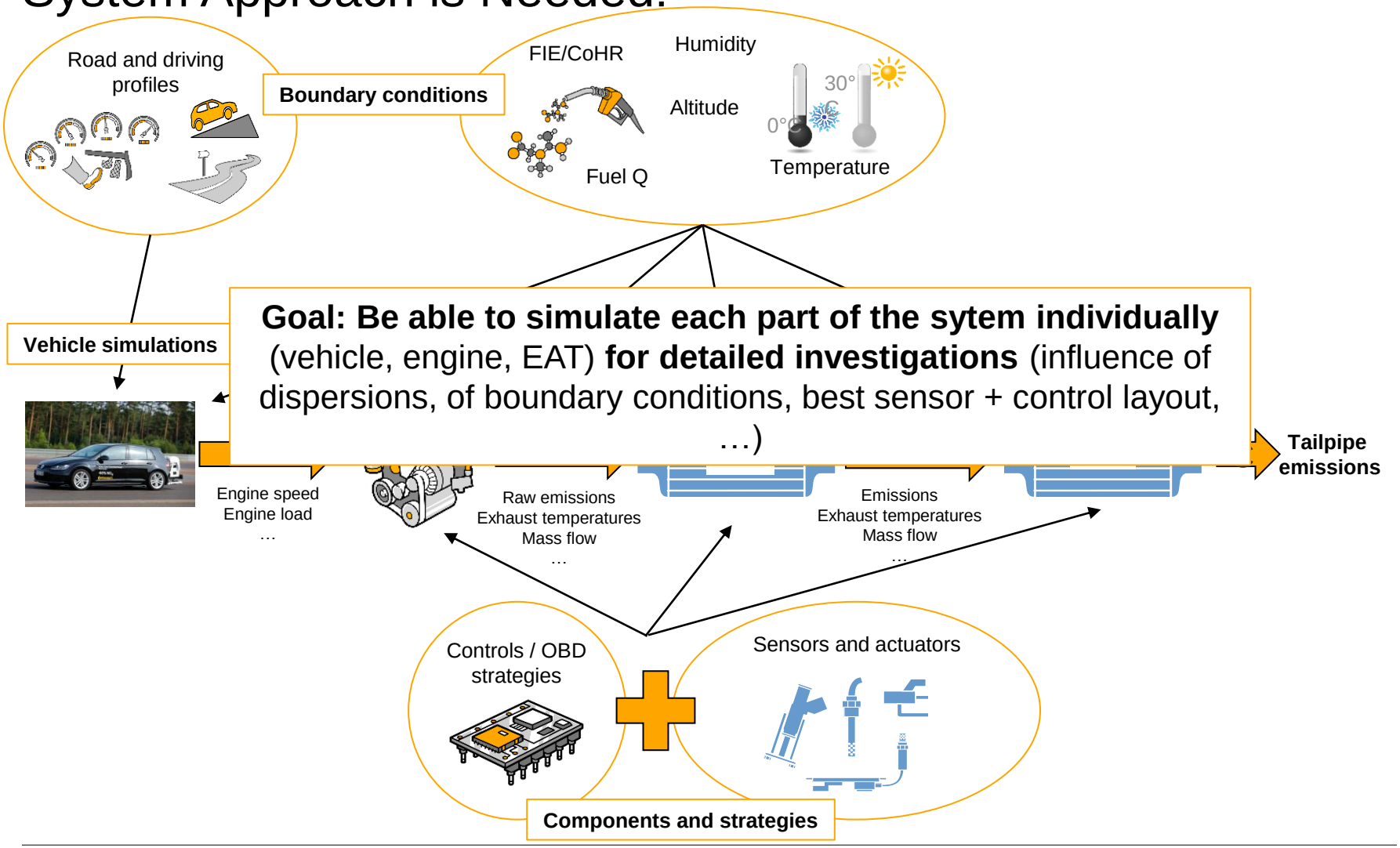
Emission Calculation



Simulation of RDE cycle is not fully suitable. especially in dynamic phases.

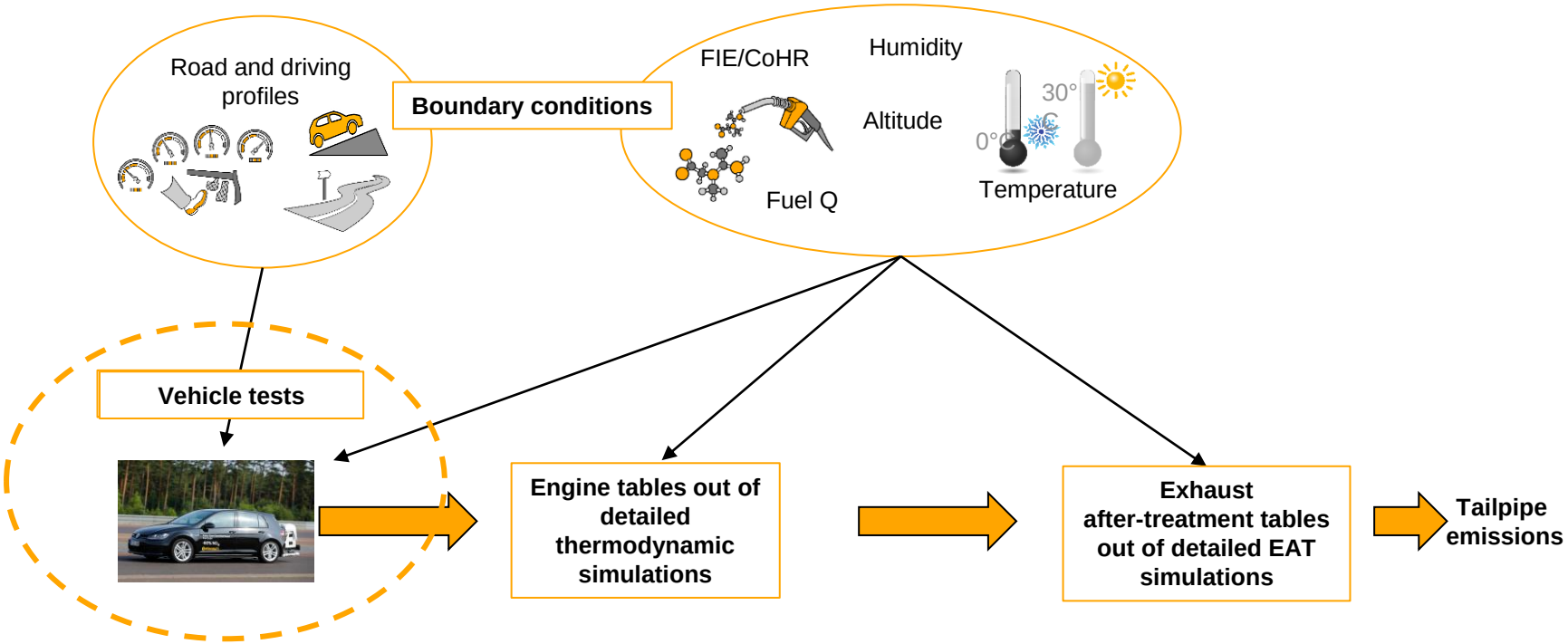
Key Challenge: Emission Robustness Gasoline

System Approach is Needed!



Key Challenge: Emission Robustness

System Approach is Needed!



➔ **Be able to faster simulate RDE cycles and Real World Driving**

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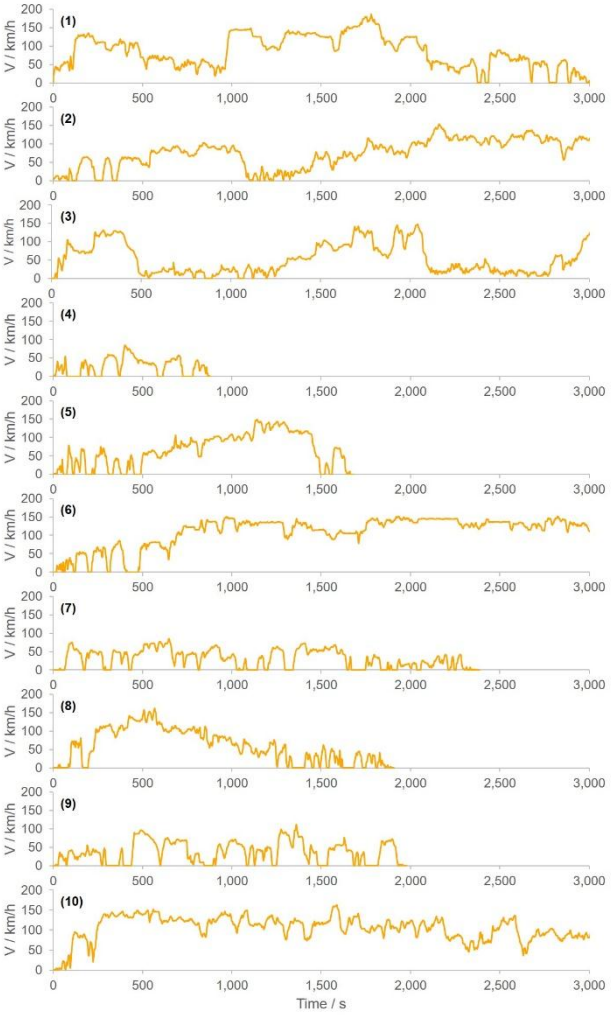
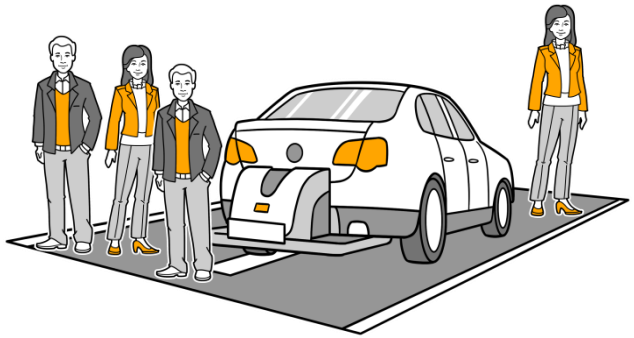
Steps for Developing Emission Robustness

Step 1

- **Recording Real World Driving Data**
- Several hundred driving hours with different drivers and under different environmental conditions were recorded, evaluated, and joined together

Recording Real World Driving Data

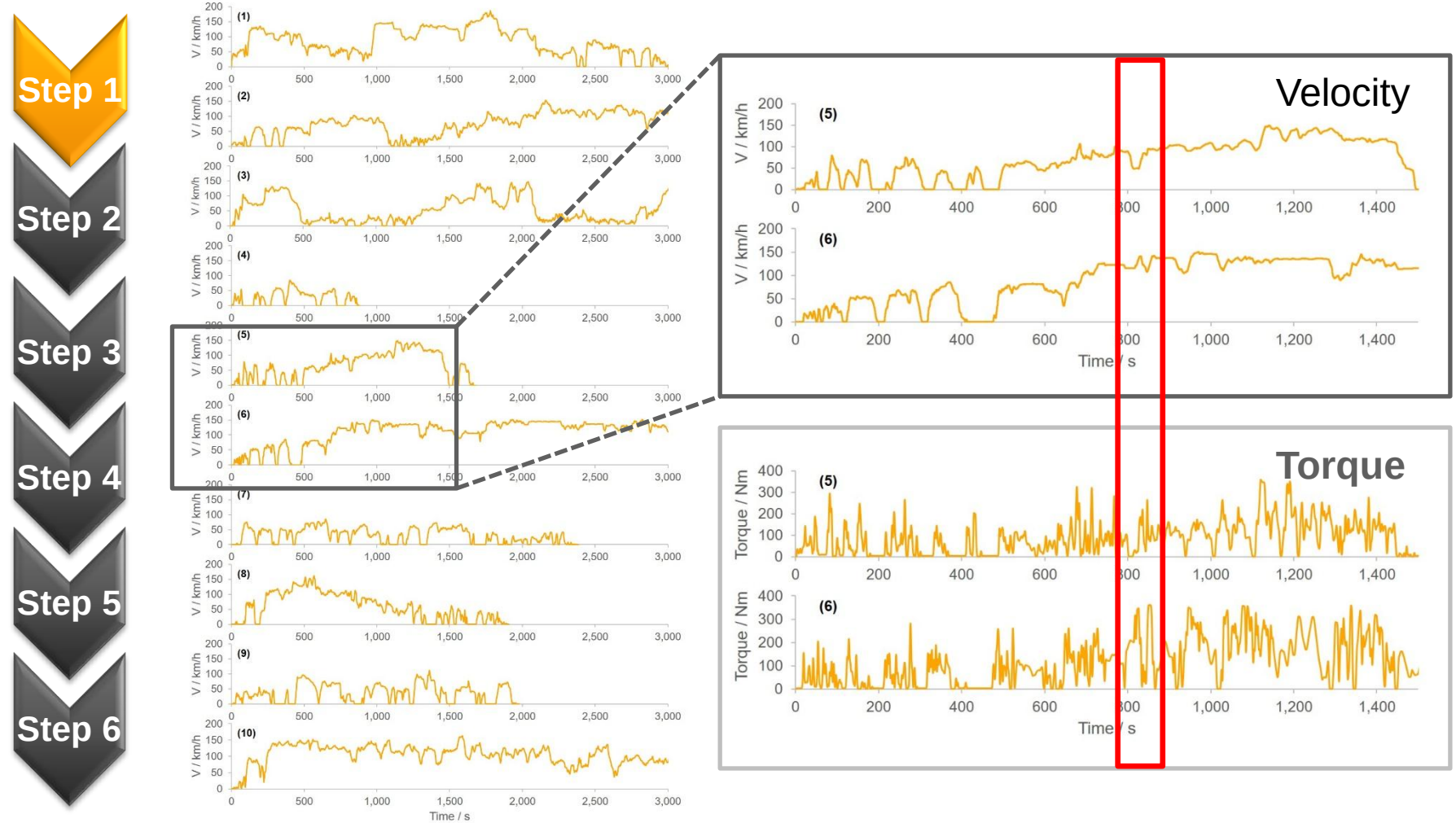




Simulation of Real World Driving conducted by different drivers, streets, ambient conditions, …

Recording Real World Driving Data

Examination of Torque



Recording Real World Driving Data

Starting in the morning; just 2 neighbours

Step 1

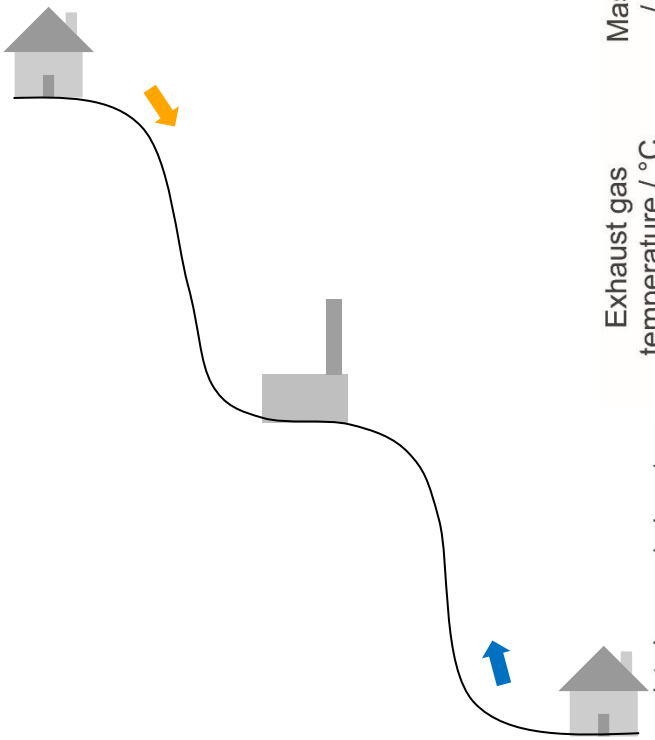
Step 2

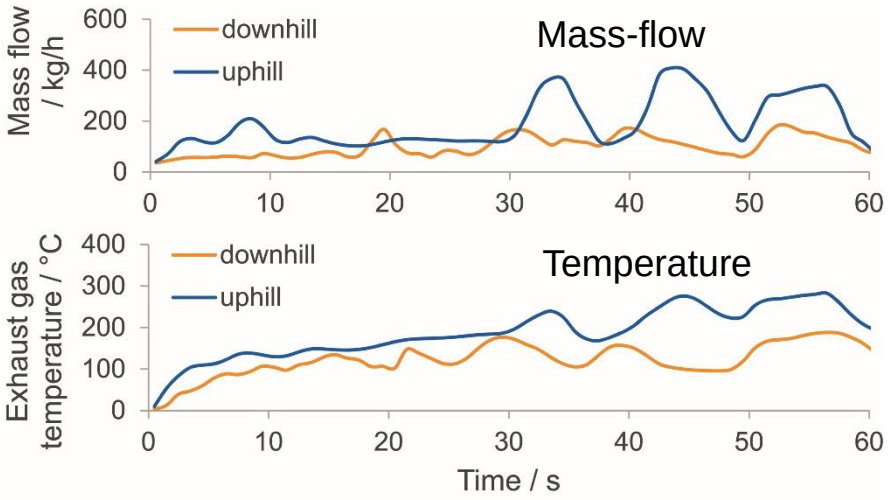
Step 3

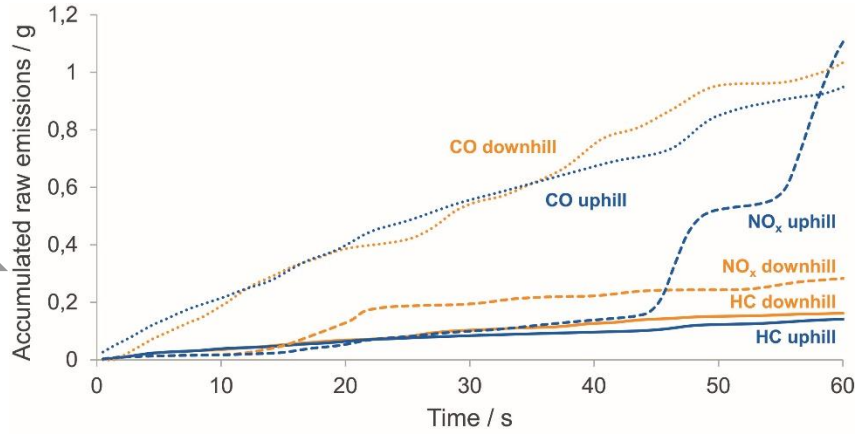
Step 4

Step 5

Step 6



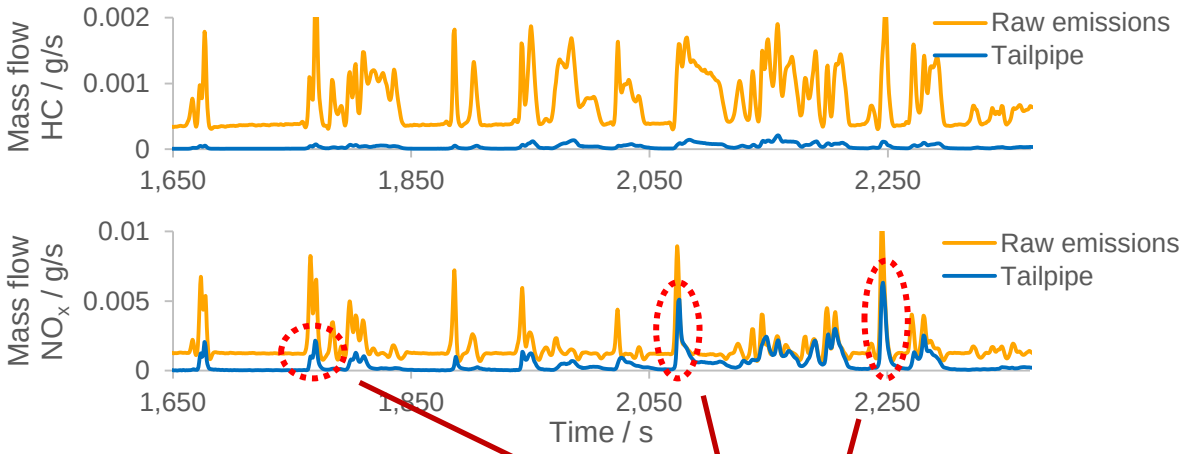




Reproduce Recorded Data on Engine Test Bench

Step 1
Step 2
Step 3
Step 4
Step 5
Step 6

Example 1:
Low-load urban journey

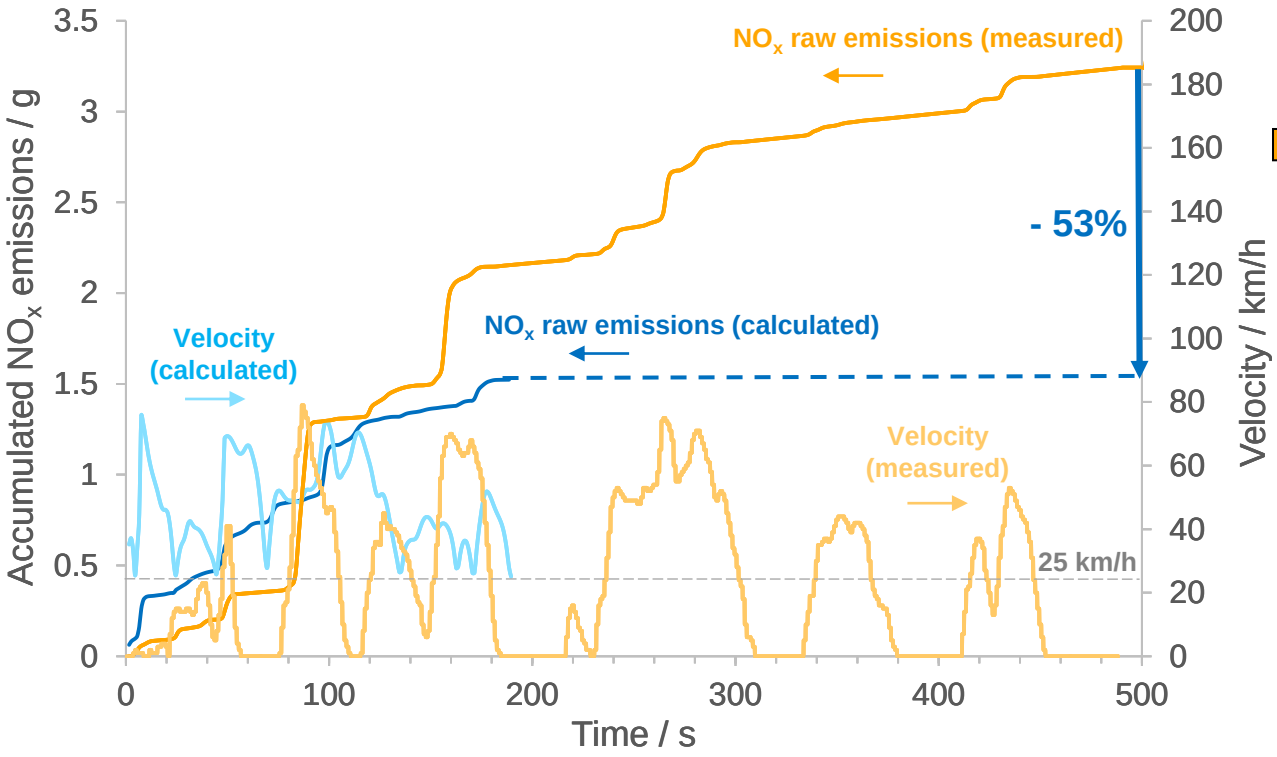


NO_x slip (tailpipe) **due to long red traffic light period** (catalyst temperature drops) **and subsequent acceleration**

Reproduce Recorded Data on Engine Test Bench

Step 1
Step 2
Step 3
Step 4
Step 5
Step 6

Example 2:
Urban approach road



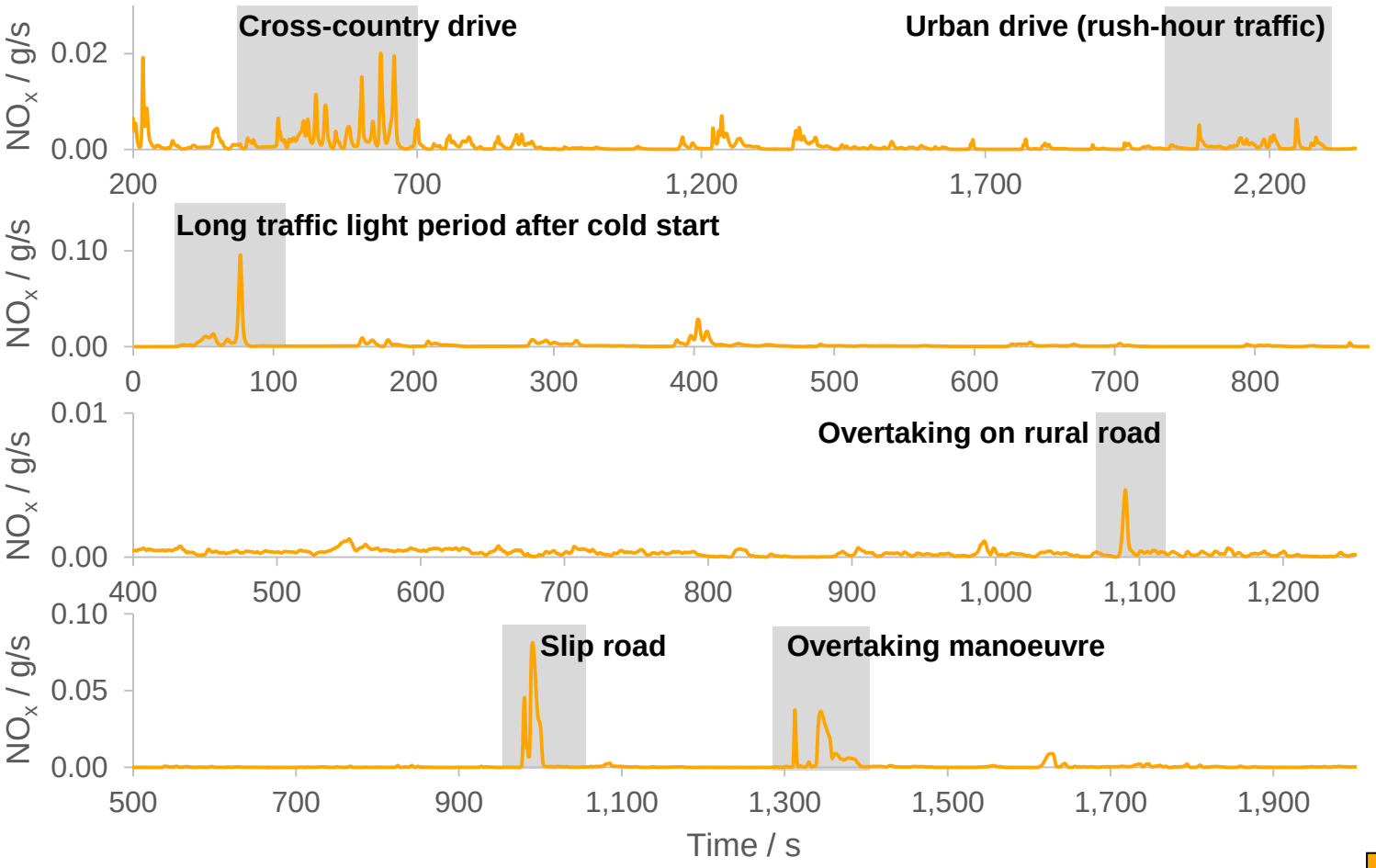
Original driving sequence (measured)
Removed phases < 25 km/h (calculated)

Intelligent traffic routing can reduce raw emissions

Analysis of Tailpipe Emissions

Creation of „Critical“ Test Profile

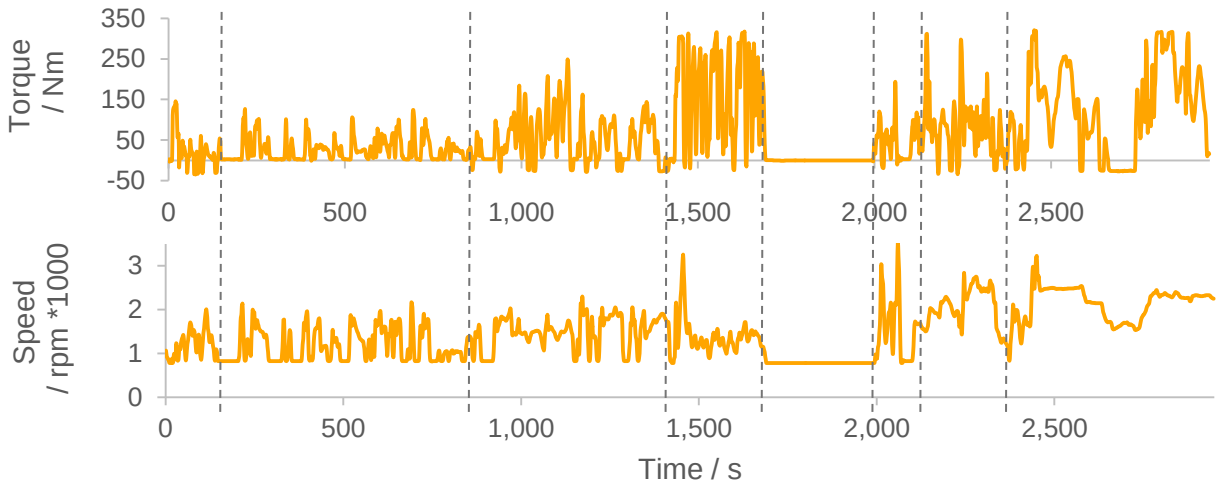
Step 1
Step 2
Step 3
Step 4
Step 5
Step 6



String criticial situations with pre- and post-run times together

Creation of Critical Profiles

Step 1
Step 2
Step 3
Step 4
Step 5
Step 6

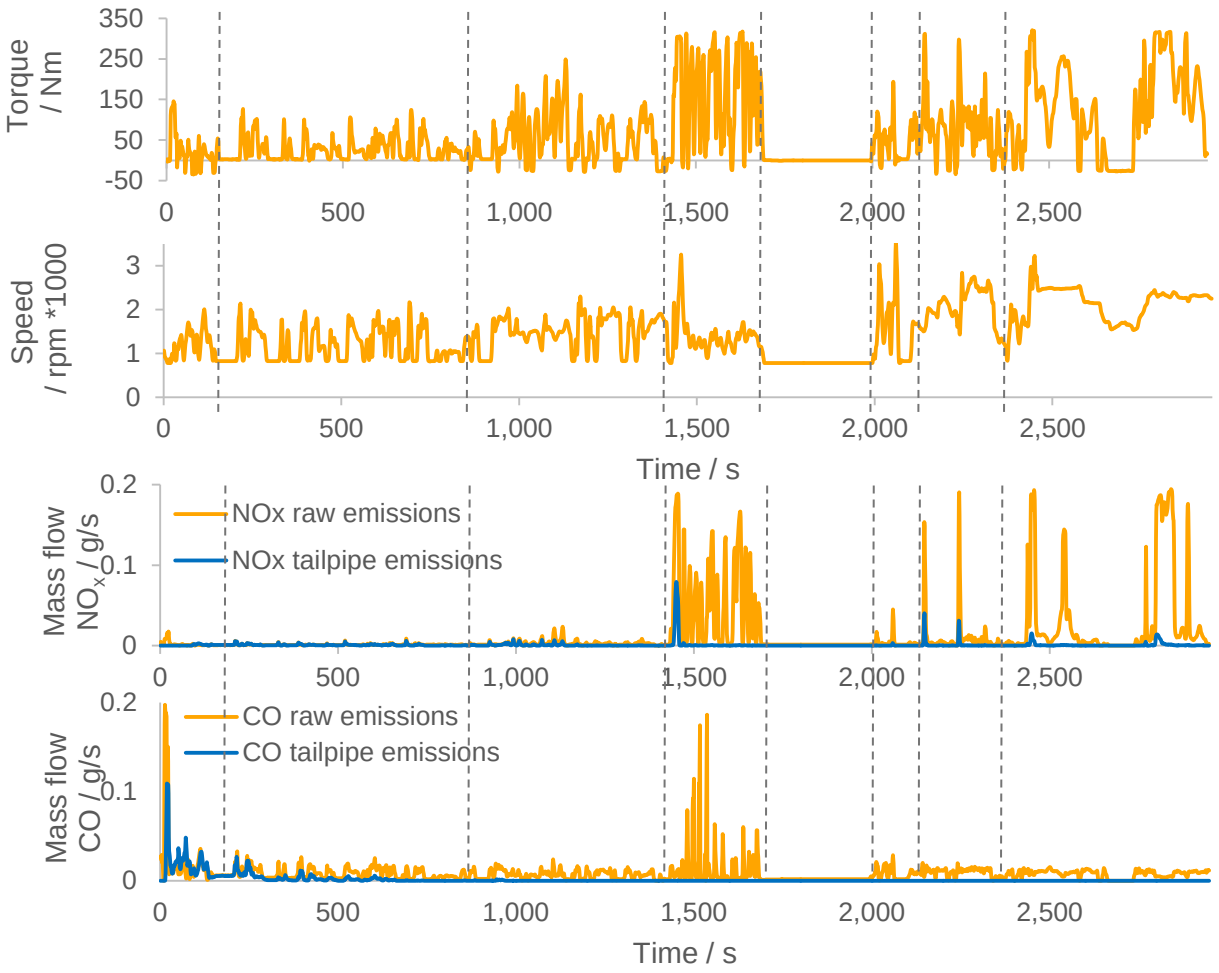


Procedure

- String together well-chosen driving situations
  - Pre-run time ca. 3 min / post-run time 0.5 min
- Addition of idle time to reduce system temperature
- Smoothen the transitions

Perform sequence on engine test bench

Testing of New Test Sequence



Testing of New Test Sequence

Step 1

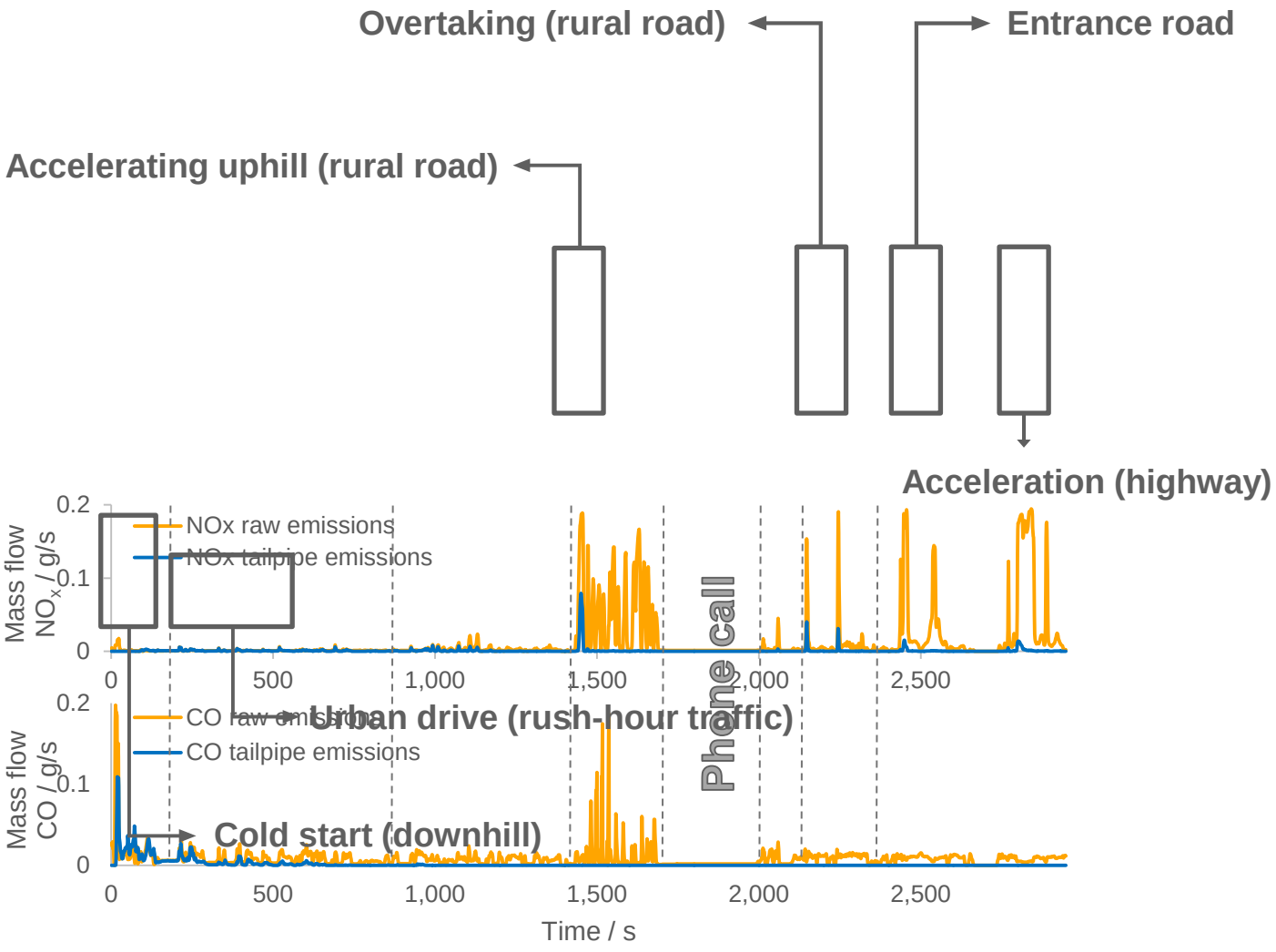
Step 2

Step 3

Step 4

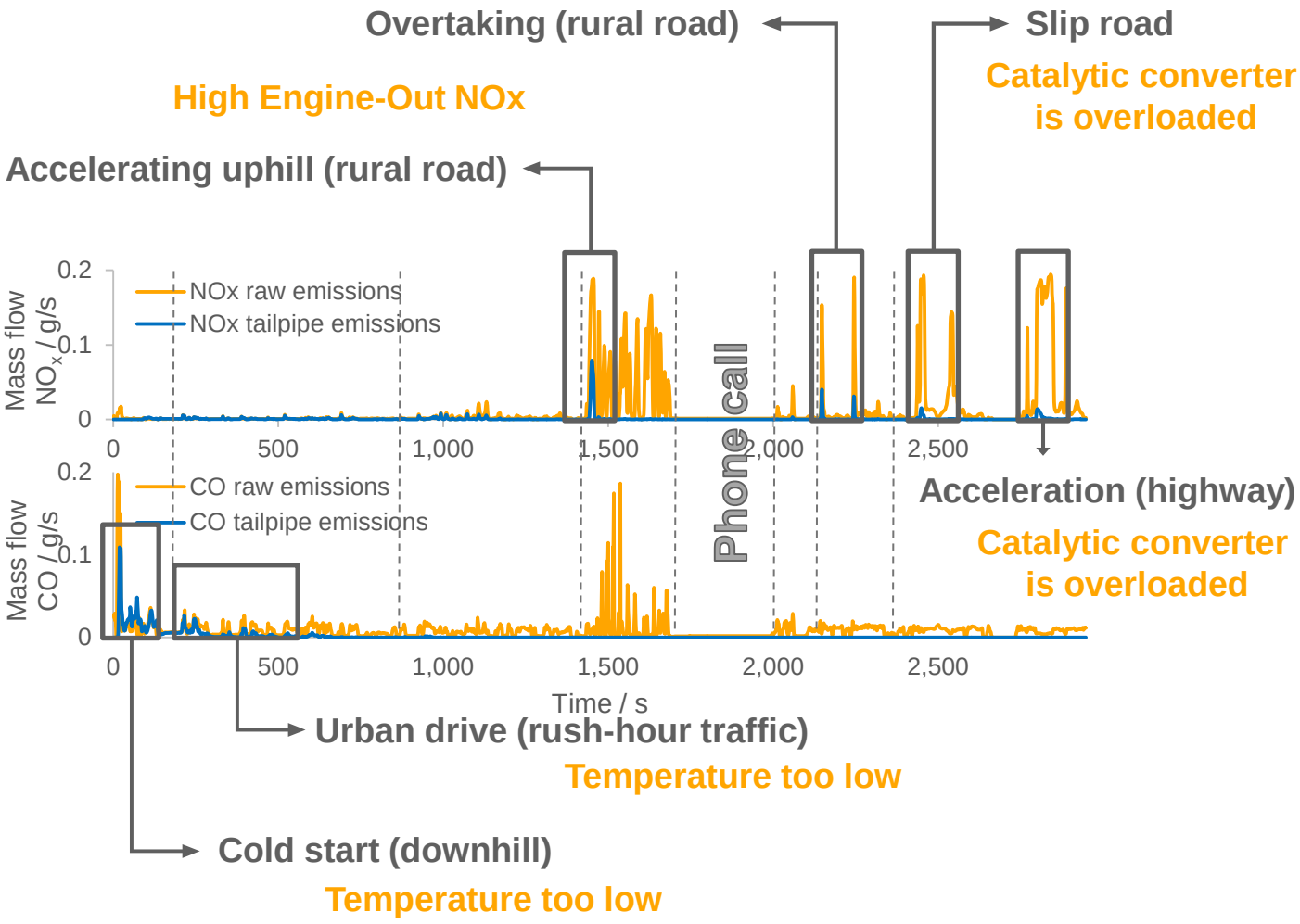
Step 5

Step 6



Evaluation

Step 1
Step 2
Step 3
Step 4
Step 5
Step 6



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Solution for Emission Robust Catalyst System

Evaluated tailpipe emissions reasons (our challenges):

› The exhaust-gas temperature is too low

Our solutions @ Continental:

› Heating-up engine-out gas using an EMICAT®

Solution for Emission Robust Catalyst System

Evaluated tailpipe emissions reasons (our challenges):

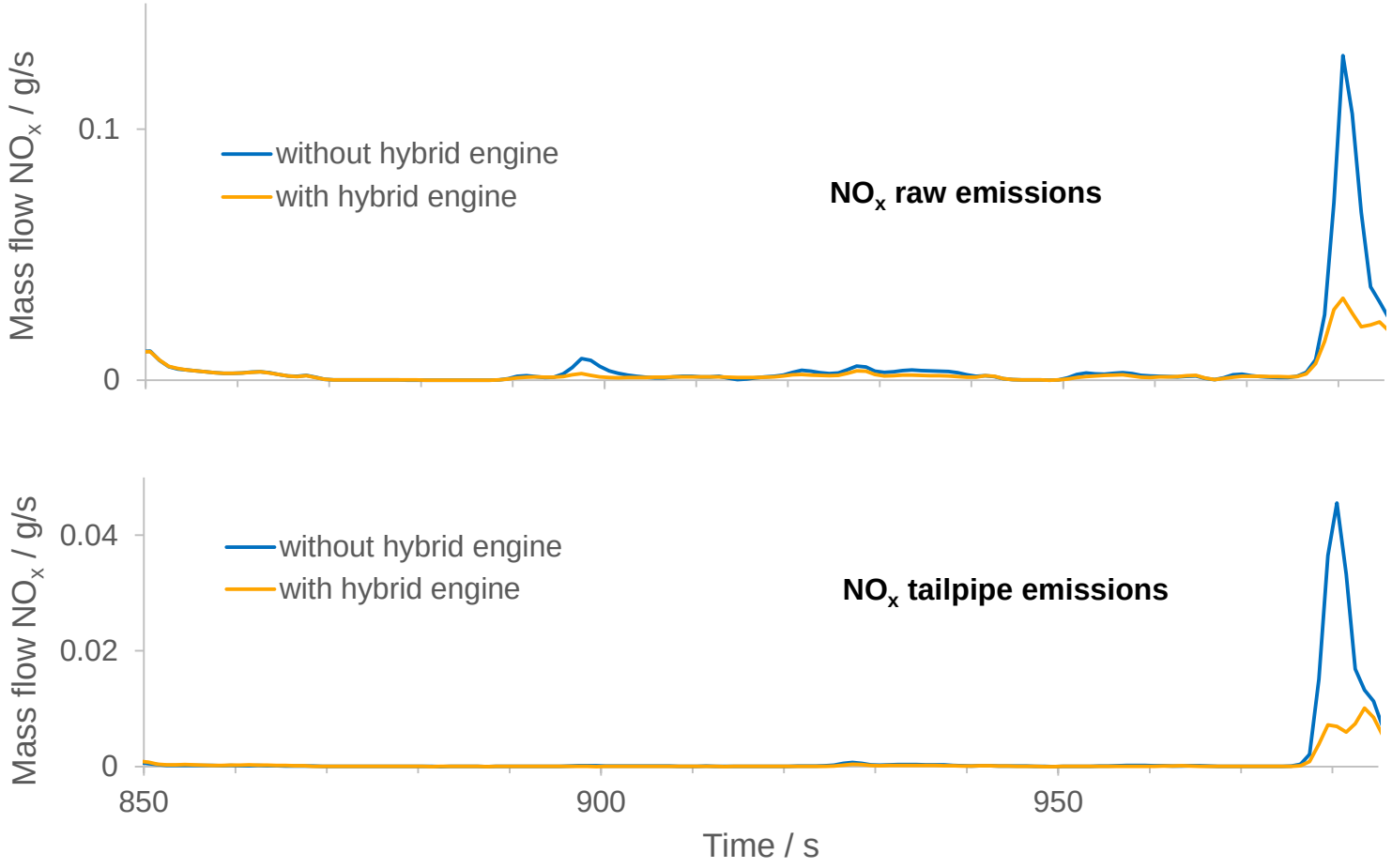
- The exhaust-gas temperature is too low
- The catalytic converter is overloaded (space velocities too high)

Our solutions @ Continental:

- Heating-up engine-out gas using an EMICAT®
- Reducing torque peaks using a mild hybrid
- Increasing catalytic volume or, more effectively, enlarge the mass transfer using innovative cell structure like the crossversal structure

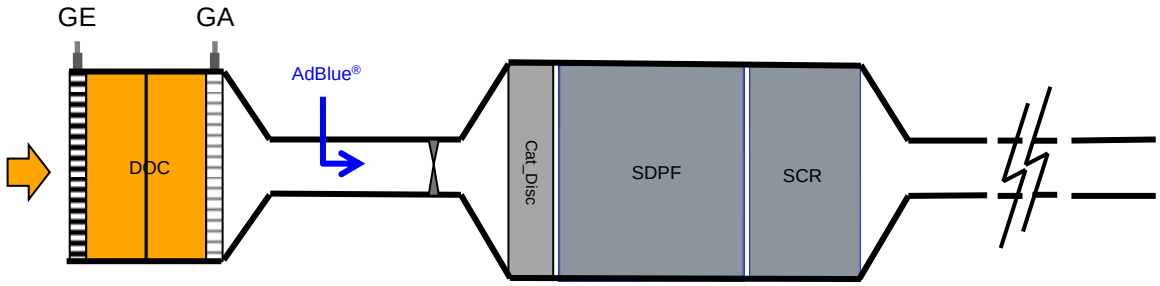
Reduction of NOx-Engine Out and Tailpipe Emissions

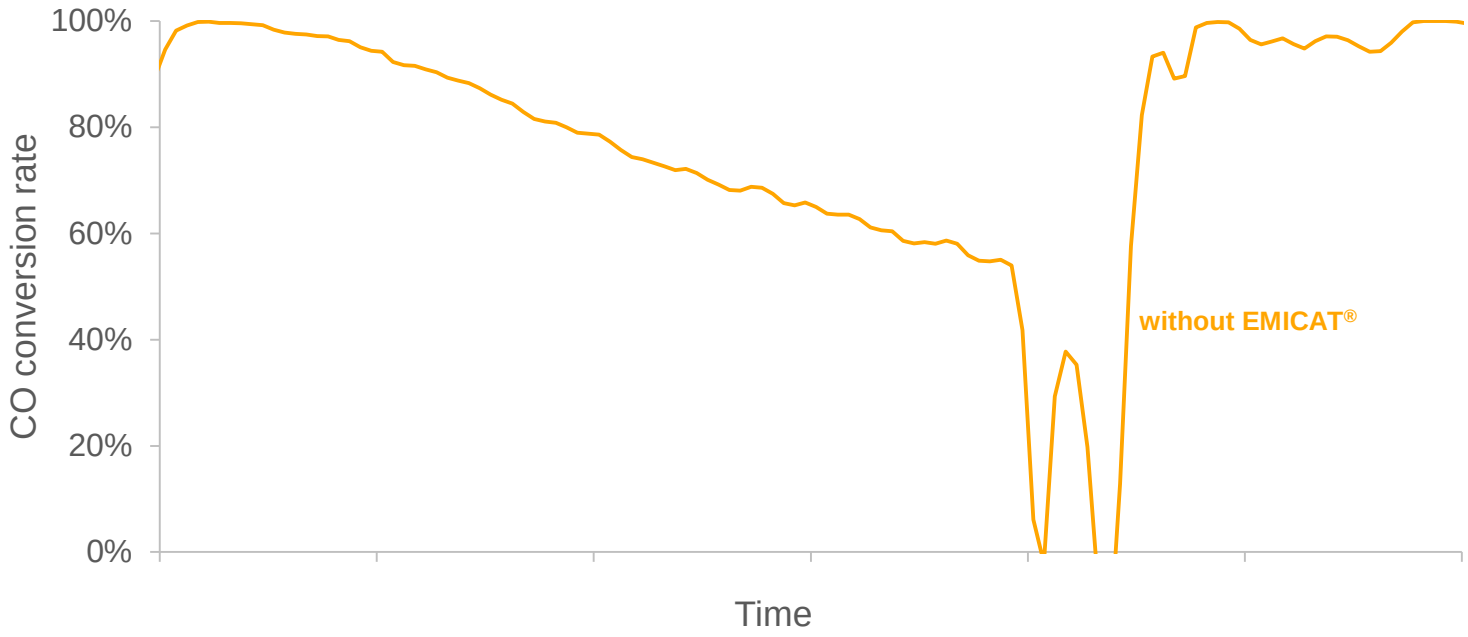
Reduction of Torque by Using Hybrid Motor



Red Traffic Light CO Peak; Diesel

Usage of an Electrically-Heated Catalyst





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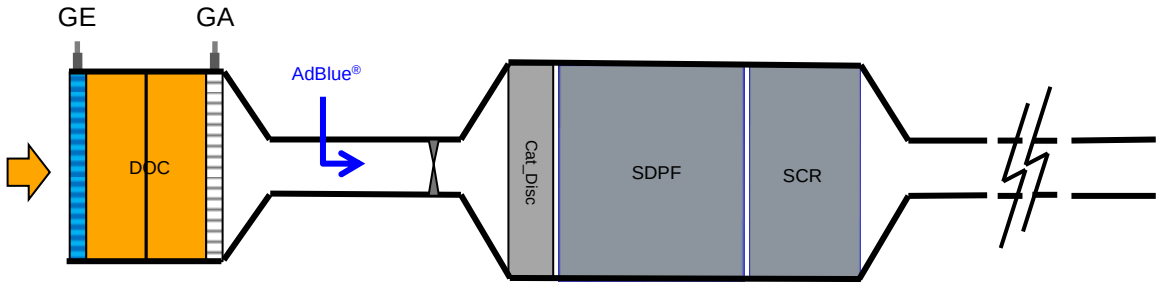
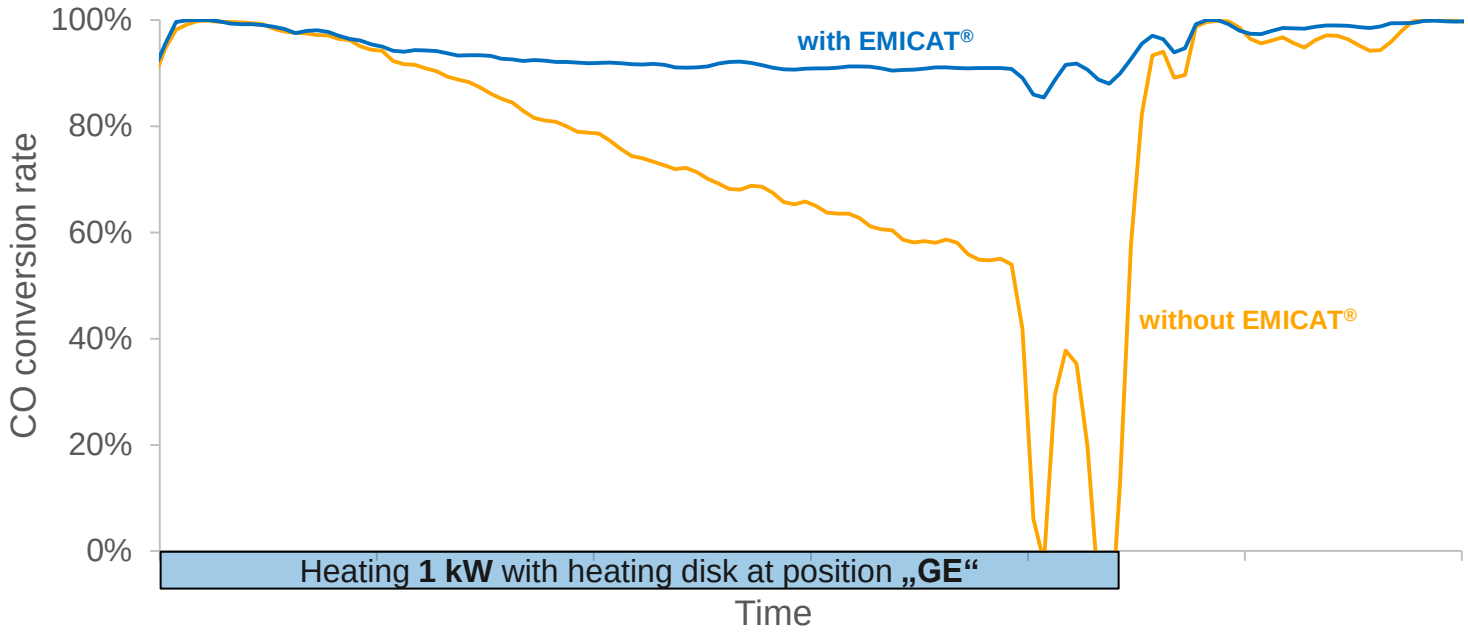
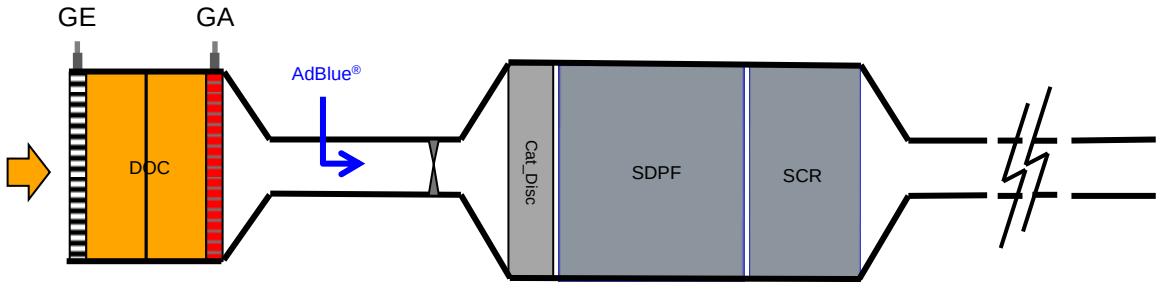


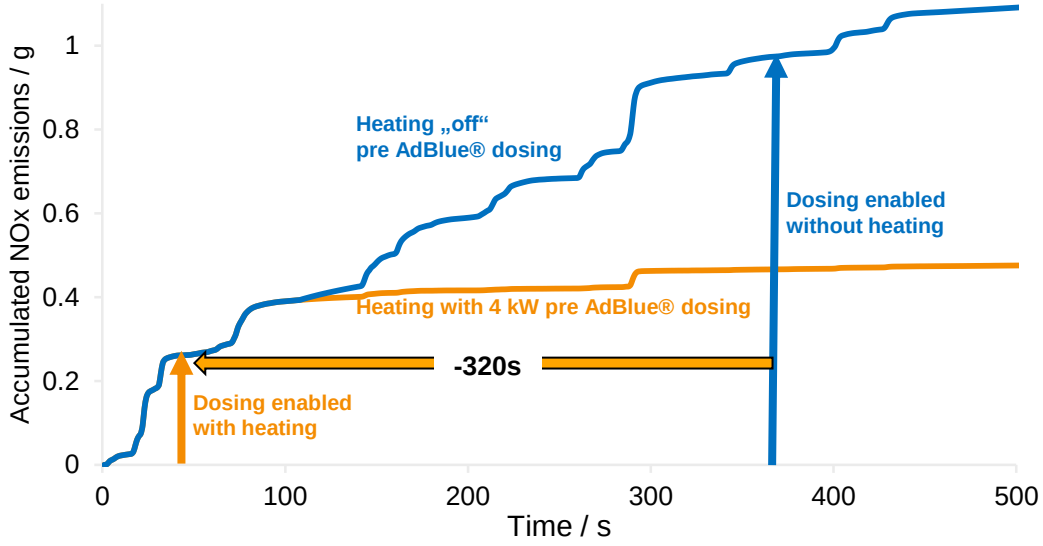


EMICAT® prevents blow out of catalytic converter

Cold-Start NOx-Emissions; Diesel

Usage of an Electrically-Heated Catalyst

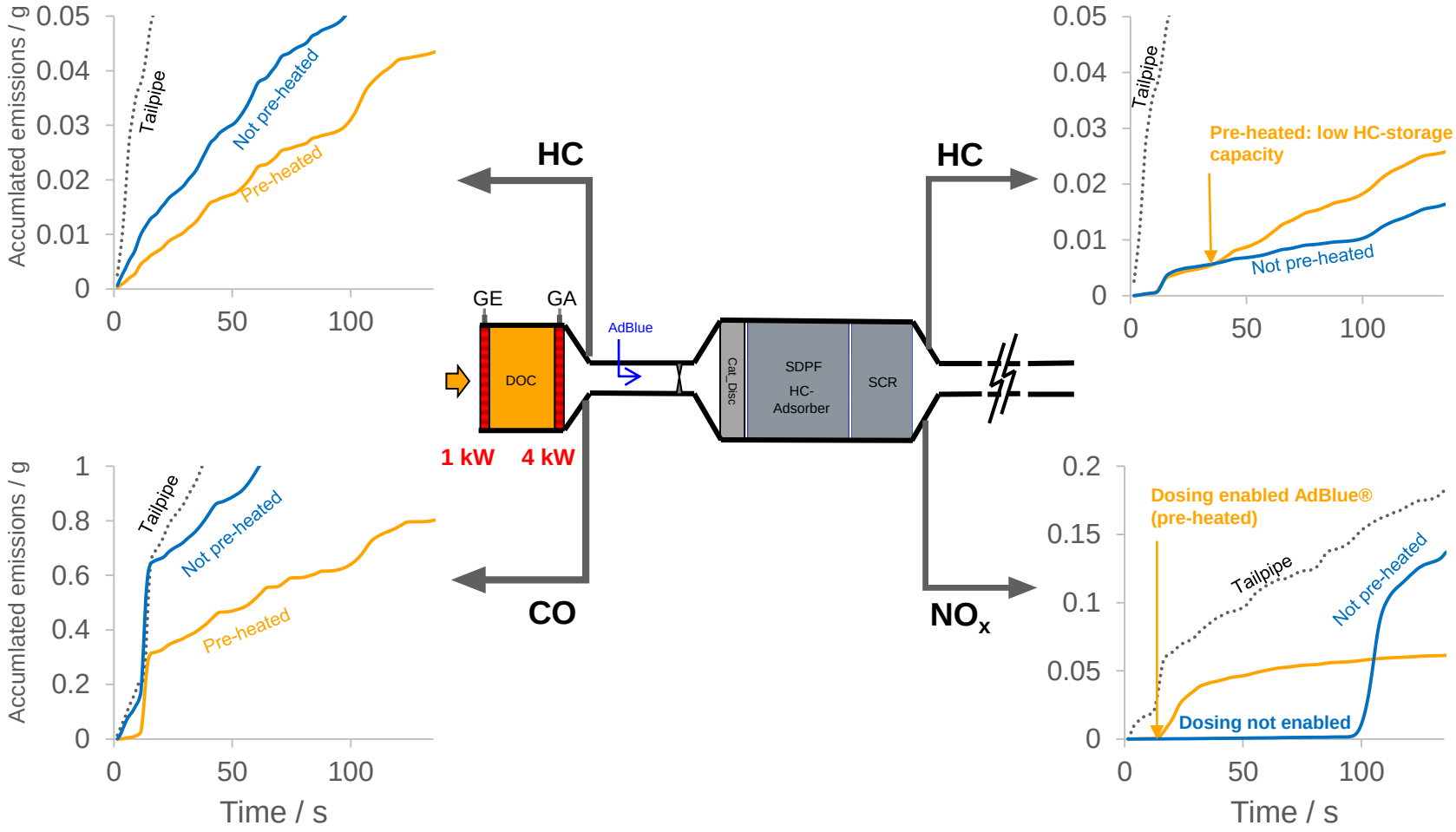




Pre-heating of SCR function results in earlier AdBlue® dosing and thus lower NOx-emissions

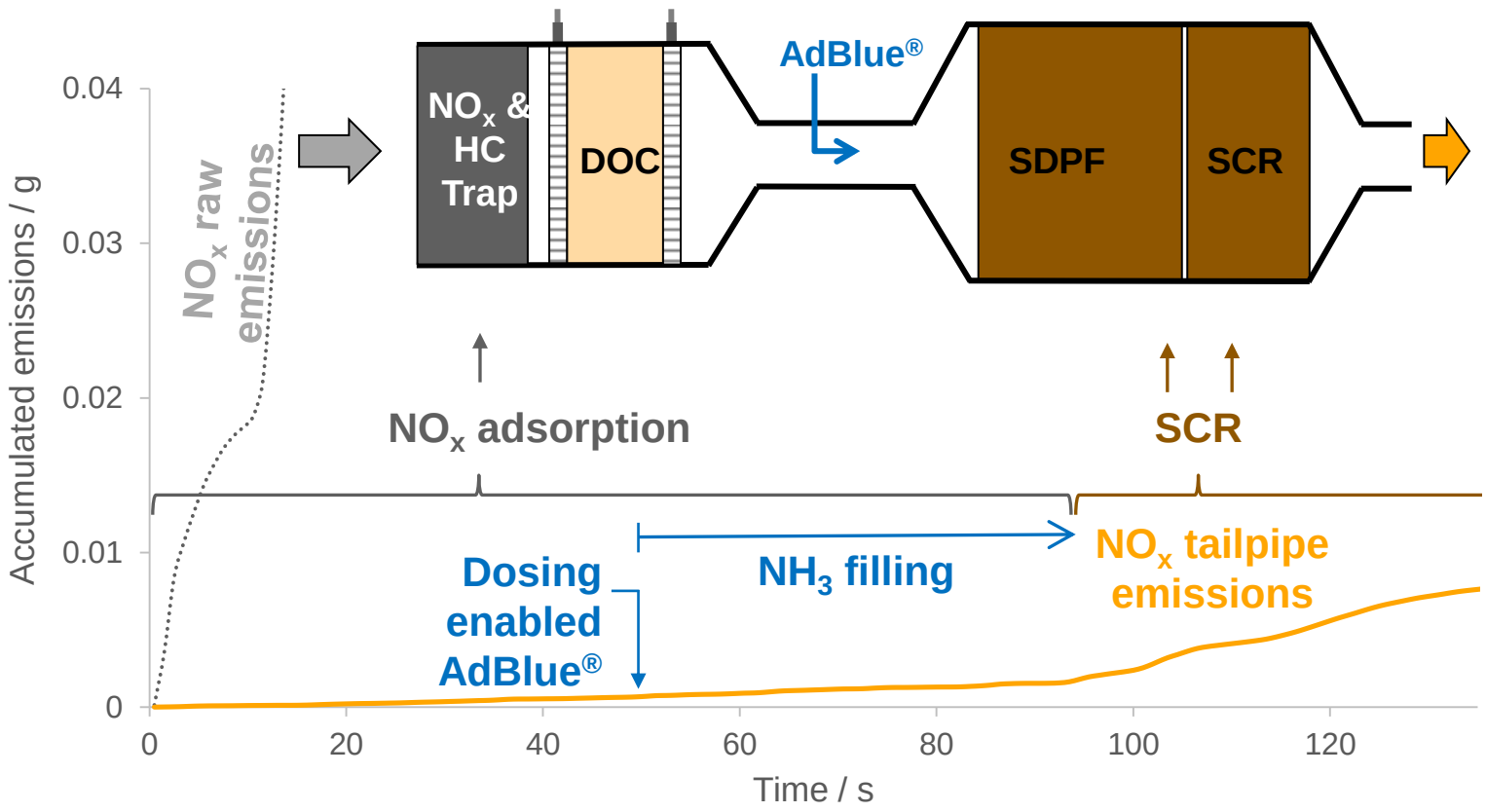
Emission Free Cold-Start

Possibility of Catalyst Preheating



Emission Free Cold-Start

Combination of Adsorber Technology with Heated Catalyst



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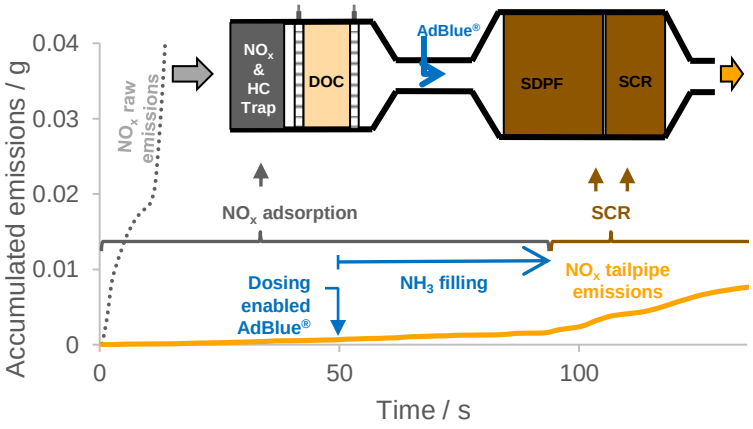
Summary / Outlook

- Real World “Critical” Driving Cycle
  - for engine test benches
  - based on real journeys

  is available.
- Critical driving conditions to fulfill emission regulations identified.



- System Configurations for gasoline and diesel engines are available, but have to be adapted to the vehicle configuration