RDE ENGINEERING AT THE ENGINE TEST BENCH

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Overview

- RDE challenges
- Engineering strategies
- Engine-in-the-loop [EiL] tool-chain
- RDE Data Analyzer
- Summary
RDE Engineering

Today and Tomorrow Organization

RDE could lead to an organisational change during the development phase.
# RDE Engineering Strategies

<table>
<thead>
<tr>
<th>Road test (PEMS)</th>
<th>Chassis dyno</th>
<th>Chassis dyno + engine test-bench</th>
<th>Vehicle simulation + engine test-bench [EIL***]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only real road tests</td>
<td>Stand-alone</td>
<td>Copy values to engine test-bench</td>
<td>Vehicle-, driver and track-simulation</td>
</tr>
</tbody>
</table>

## RDE Results

<table>
<thead>
<tr>
<th>RDE</th>
<th>RDE test</th>
<th>reproducibility</th>
<th>RDE tests/24h</th>
<th>multiple variants testing</th>
<th>RDE development w/o vehicle</th>
<th>HEV simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real Road</td>
<td>+++*</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chassis Dyno</td>
<td>0</td>
<td>++**</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Engine Test-bench</td>
<td>0</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Engine Test-bench [EIL]</td>
<td>0</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
</tbody>
</table>

+++ most suitable  ++ suitable  + useable  0 not efficient

*PEMS is legally relevant  **no robot driver  ***EIL – Engine-in-the-loop

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RDE Engineering
RDE-Analysis using Engine-in-the-loop (EiL)

- Longitude
- Latitude
- roadgrade

- Engine speed
- accelerator-pedal

GPS data of track 1

Simulation (InMotion/ CarMaker)

RDE engine test-bench

Engine

After-treatment

Measure Equipment

GPS data of track 1

RDE track 1

Latitude

Longitude

Distance [m]

altitude [kph]

speed [kph]

Engine torque

Emission

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RDE Frontloading

Setup

- **CANoe-PC**
- **Hardware Interface**
  - Vector
    - ch1/5
    - Ch A
    - Ch B
  - ch3/7
    - Ch A
    - Ch B
- **Electronic control unit**
  - Flexray
  - Mess-CAN
  - ETAS Interface module
    - ETK
    - CAN1
    - FLX1
    - Host
- **Engine**
- **Dyno**
- **Test-bench automation**
  - PUMA
    - CAN1
    - CAN3
- **Simulation**
  - CarMaker:
    - vehicle, track, traffic, gearbox
    - Residual bus
  - CAN1
  - CAN2
RDE Frontloading
Engineering competences in-house

- Depending on the project case different performance steps are possible.
RDE Frontloading

Example RDE project: Acceleration

▶ Torque demand from gear box simulation provided by CarMaker.
RDE Frontloading

Example RDE project: 1-2 upshift

► Torque request by TCU can be modified in the simulation (engineering).
RDE Frontloading
Simulation Real Driving at Engine Test-Bench

▶ Test bench: urban driving
  GPS tracks – simulated vehicles – simulated gearboxes – real engines
## RDE Engineering Matrix Test Configuration on Test Bench (EiL)

<table>
<thead>
<tr>
<th>RDE track</th>
<th>Driver characteristics</th>
<th>Boundary conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stuttgart RDE track</td>
<td>Mild</td>
<td>No traffic</td>
</tr>
<tr>
<td>Mountain track Austria</td>
<td>Aggressive (hot)</td>
<td>Heavy traffic</td>
</tr>
<tr>
<td>London city</td>
<td>Nervous</td>
<td>Traffic</td>
</tr>
<tr>
<td>Hannover flat RDE track</td>
<td>Normal</td>
<td>12- 35°C ambient temp.</td>
</tr>
</tbody>
</table>

- Multiple test situations (event-matrix) to enable a frontloading for RDE Engineering.
RDE Engineering

RDE Data Analyzer

► Automatic data analysis to improve efficiency.
System test for heavy traffic

Nervous driver worst case test

<table>
<thead>
<tr>
<th>Driver set-up</th>
<th>NOx %</th>
<th>CO2 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>easy going</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>normal</td>
<td>109.0</td>
<td>101.4</td>
</tr>
<tr>
<td>nervous</td>
<td>115.7</td>
<td>102.3</td>
</tr>
</tbody>
</table>
RDE Engineering

Summary

- The engine test-bench combined with a vehicle simulation enables to work in a reproducible area with a minimum demand for test vehicles.
- RDE Frontloading to save time and costs
- Variation of different tracks, traffic conditions and driver behavior…
- Evaluation of new components in the overall system.
- Special investigations possible (OBD, GPS-based functions, Aftertreatment performance)

Early variants approval for hard- and software optimizations before running PEMS-tests.
THANK YOU.

QUESTIONS?