REAL DRIVING EMISSIONS (RDE)
Challenges for On-Road Tests
AVL M.O.V.E In-Vehicle Testsystem
REAL DRIVING EMISSIONS (RDE)
A REAL CHALLENGE FOR ON ROAD TESTING

RANDOMNESS
Driving style has a strong impact on the equipment – shocks and vibrations.

AMBIENT TEMPERATURE
Changing ambient temperatures can strongly impact the quality of RDE test data.

AMBIENT PRESSURE
Changing ambient pressure is the key decision criterion for the selection of PEMS analyzers.

TRAFFIC
EXTREME CONDITIONS
MOUNTAIN

URBAN
RURAL
HIGHWAY
Impact to Emissions

**Drive Cycles:**
Vehicles must be clean in a much larger area of the engine map:
- NEDC → WLTC
- Real Driving Emissions

**Drive Style:**
Drive style has a large impact (by factors) on emission:
- aggressive
- moderate

**Altitude:**
Impact of altitude:
- physical
- calibration, like when EGR is switched off

**Wind:**
Impact of wind is:
- crosswind
- traffic turbulences
- drafting (Windschatten)

**Example:**
- Vehicle power increase from 9kW to 13kW + 45%

**Example:**
- Wind impact:
  - crosswind
  - traffic turbulences
  - drafting (Windschatten)

**Example:**
- NOx emissions:
  - EU-6d Limit
  - NOx moderate / aggressive

**Example:**
- Altitude impact:
  - NOx levels at different altitudes:
    - 150m + 160%
    - 1000m + 180%
    - 2000m + 200%
    - 3000m

**Example:**
- Vehicle power increase from 9kW to 13kW + 45%
Impact of drive Cycles

Vehicles must be clean in a much larger area of the engine map:

- NEDC → WLTC
- Real Driving Emissions
- especially for down-sized engine concepts
Impact of driving style

Impact of driving style in the AVL Graz RDE route on
- Drive dynamic
- Engine map
- Emissions

Dynamic Driving Style

Moderate Driving Style
Impact of Altitude

**NOx**

- 150m: +160%
- 1000m: +180%
- 2000m: +200%
- 3000m: +200%

**Smoke**

- 150m: +25%
- 1000m: +75%
- 2000m: +25%
- 3000m: +170%

**CO**

- 150m: +30%
- 1000m: +70%
- 2000m: +155%
- 3000m: +155%

**THC**

- 150m: +90%
- 1000m: +160%
- 2000m: +90%
- 3000m: +280%

Source: MTZ 2016, Universitat Politècnica de València Spain, “Der Einfluss von Höhe auf die Emissionsmessung”
Impact of Wind:

For a typical car driving at highway speeds, about 50% of the energy is spent overcoming aerodynamic drag.

In the recent SAE paper (SAE 2015-01-1551), experimental on road measurements were gathered by comparing the energy consumption of the vehicle with the characteristics of the on road flow field, including traffic turbulence and crosswind, as measured by a pitot-static probe mounted on the roof of the vehicle.

The fluctuations in the measured wind are attributed mainly to turbulence caused by other vehicles on the road, while the measured yaw angle is attributed mainly to the prevailing crosswind and large-scale wind gusts.

Vehicle power increase from 9kW to 13kW

+ 45%

ON-ROAD TEST RESULTS
GERMAN MINISTRY OF TRANSPORT

Source: Overview of the laboratory and on-road test results of the vehicle testing program by the German Ministry for Transport
RDE IMPLEMENTATION WORLDWIDE

New: **RDE 4** voted on 3.5.2018
In force 1.1.2019

**EU:**
- Monitoring: 04/2016
- Conformity factors: 09/2017

**USA (CARB):**
- PEMS for detection of defeat devices

**South Korea:**
- 09/2017 (diesel only)

**Japan:**
- 2022 CF 2 (diesel only)
- Low Speeds
- Up to 2.400m

**China:**
- China 6 Monitoring from 07/2020
- CFs from 07/2023

**Brazil:**
- draft PROCONVE L7, L8
- Procedure to be published by 2020.
- 2022: monitoring?
- 2024/2027: CFs?
- Low Speeds & over 40°C

**India:**
- BS VI
- 04/2020: monitoring
- 04/2023: CFs

**Low Speeds & THC limit?**
### New characteristic of legislative development

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<td>UN-ECE Reg. 83</td>
<td>EU 2017/1151 (WLTP)</td>
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<td>NOx 2.1, PN 1.</td>
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</table>

**04/2016** RDE Monitoring

**09/2017** WLTP + RDE with CF-temp.

**01/2019** New ISC Procedure

**09/2019** New EVAP Procedure

**01/2020** RDE with final CF

No lead time for engineering / Last-Minute amendments

- **May 2018** RDE Package 4
  - In Service Conformity, Member State Surveillance

- **3Q 2017** revised evaporative emission testing
  - Canister aging, test procedures, sealed tank systems for hybrids, ...

- **Jan. 2017** Guidance on AES and Defeat Devices
  - Documentation of AES, engine protection, impact assessment, defeat device testing, ...

- **Dec. 2016** RDE Package 3
  - PN Limit, Cold start, Hybrids

- **Feb. 2016** RDE Package 2
  - NOx Limit, Test Boundary Conditions

- **2015** RDE Package 1
  - Decision on PEMS, Monitoring from 2016
EU – NEW - Update RDE Package 4 (Vote)

- Corrections, clarifications, provisions for LCVs
- CLEAR not used anymore, EMROAD only for trip normality
- New emissions calculation method
- Reduced NO\textsubscript{x} margin
- In-service conformity requirements added

- Trip requirements
  - Urban, rural, motorway – Min. and max. speed
- Non-dynamic boundary conditions
  - Temperature
  - Altitude
- Dynamic boundary conditions
  - $v^{apos}$
  - RPA
- Trip normality, weighting
  - EMROAD
  - CLEAR
- Calculation of final RDE emission results
- Comparison of final emission results with limit
- In-service conformity testing

$\varepsilon = CF \times \text{Euro}$

CF

| 1.5 | 1.5 |
9.2. The trip validity shall be verified in a three-step procedure as follows:

**STEP A**
Annex IIIa
- Urban, Rural, Motorway, distance shares
- Altitude
- Ambient temperature
- Vehicle condition at cold start
- Urban Average Speed
- Stop Share
- …

**STEP B**
Annex 7a
- 95th Cumulative Percentile Speed x Acceleration below limit curve
- Relative Positive Acceleration above limit curve
- Both of the above for Urban, Rural and Motorway Driving

Appendix 7b
- Cum. Altitude Gain

**STEP C**
Appendix 5
- Moving Window
- Comparison of the windows CO₂ [g/km] with the reference values from the WLTP
- Trip validity for Urban, Rural and Motorway Windows

PEMS DATA Collected in accordance with Appendices 1 to 4

Main Trip Annex IIIa
- Y
- N

Invalid Trip

Dynamics and Altitude gain Appendices 7a, 7b
- Y
- N

Invalid Trip

Overall Dynamics Appendix 5
- Y
- N

Invalid Trip

Emissions Calculations Appendices 4 and 6

Valid Trip

Y Y Y
Step C: Appendix 5 – Verification of overall trip dynamics using the MAW method (I)

- Offset for P1, P2, P3 removed
  - P1: \( v = 18.882 \text{ km/h} \), CO\(_2\) emissions over WLTP low speed phase
  - P2: \( v = 56.664 \text{ km/h} \), CO\(_2\) emissions over WLTP high speed phase
  - P3: \( v = 91.997 \text{ km/h} \), CO\(_2\) emissions over WLTP extra high speed phase
Step C: Appendix 5 – Verification of overall trip dynamics using the MAW method (I)

- $\text{Tol}_{1\text{high}} = 45\%$ for urban, $40\%$ for rural and motorway driving
- $\text{Tol}_{1\text{low}} = 25\%$ for ICE and NOVC-HEV, $100\%$ for OVC-HEV
- Validity criteria:
  - $50\%$ of windows within tolerances.
  - For NOVC-HEV: $\text{tol}_{1\text{high}}$ can be extended to $50\%$. 

![CO₂ characteristic curve and tolerances for ICE and NOVC-HEV](image1)

![CO₂ characteristic curve and tolerances for OVC-HEV](image2)
Appendix 7c (evaluation for OVC-HEV)

Appendix 7c (evaluation procedure for OVC-HEV) is deleted.
Evaluation of trip validity for OVC-HEV is included in Appendix 5 (MAW method)
Emissions calculation method is included in Appendix 6 (new emissions calculation method)
New Appendix 6 – Calculation of the final RDE emissions results – ICE and NOVC-HEV

For valid trips, the final RDE results are calculated as follows (k = t for total trip, u for urban part):

\[ M_{RDE,k} = m_{RDE,k} \times RF_k \]

*Index (k) refers to the category (t=total, u=urban, 1-2=first two phases of the WLTP cycle)*

\( m_{RDE,k} \) ... pollutant emissions during RDE trip in [mg/km] or [#/km]

\( RF_k \) ..... RDE Evaluation Factor

\( M_{RDE,k} \) ..... Final RDE result [mg/km] or [#/km]

Value of \( RF_k \) is dependent on ratio of \( CO_2 \) emissions [g/km] during RDE trip to \( CO_2 \) emissions during WLTP

\[ r_k = \frac{M_{CO_2,RDE,k}}{M_{CO_2,WLTP,k}} \]

For type approvals before 01.01.2020:

\( RF_{L1} = 1.20 \) and \( RF_{L2} = 1.25 \)

For type approvals from 01.01.2020:

\( RF_{L1} = 1.30 \) and \( RF_{L2} = 1.50 \)
New Appendix 6 – Calculation of the final RDE emissions results – OVC-HEV

For valid trips, the final RDE results are calculated as follows (For either the urban or the total driving):

\[ M_{\text{RDE},k} = m_{\text{RDE},k} \times RF_k \]

*Index (k) refers to the category (t=total, u=urban, 1-2=first two phases of the WLTP cycle)*

\[ m_{\text{RDE},k} \] ... pollutant emissions during RDE trip in [mg/km] or [#/km]

\[ RF_k \] ... RDE Evaluation Factor

\[ M_{\text{RDE},k} \] ... Final RDE result [mg/km] or [#/km]

Value of \( RF_k \) is dependent on ratio of CO\(_2\) emissions [g/km] during RDE trip to CO\(_2\) emissions during WLTP (charge sustaining mode)

\[ r_k = \frac{M_{\text{CO}_2,\text{RDE},k}}{M_{\text{CO}_2,\text{WLTP-CS},t}} \times \frac{0.85}{IC_k} \]

\[ IC_k = \frac{d_{\text{ICE},k}}{d_{\text{ICE},k} + d_{\text{EV},k}} \]

\[ d_{\text{ICE},k} \] ... Distance driven [km] with ICE on for OVC-HEV during RDE

\[ d_{\text{EV},k} \] ... Distance driven [km] with ICE off for OVC-HEV during RDE

For type approvals before 01.01.2020: \( RF_{L1} = 1.20 \) and \( RF_{L2} = 1.25 \)
For type approvals from 01.01.2020: \( RF_{L1} = 1.30 \) and \( RF_{L2} = 1.50 \)
Not-to-exceed limits, conformity factors

Throughout its normal life the emissions of a vehicle type emitted at a RDE test shall not be higher than the following not-to-exceed (NTE) values:

\[
\text{NTE}_{\text{pollutant}} = \text{CF}_{\text{pollutant}} \times \text{TF}(p_1, \ldots, p_m) \times \text{EURO-6}
\]

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>NO\textsubscript{x}</th>
<th>PN</th>
<th>CO\textsuperscript{1}</th>
<th>THC</th>
<th>THC+NO\textsubscript{x}</th>
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<td>\text{CF}_{\text{pollutant}}</td>
<td>2.1</td>
<td>\textit{1 + margin PN with margin PN} = 0.5</td>
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<td>\text{Final CF NO}\textsubscript{x} (from 09/2017)</td>
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<tr>
<td></td>
<td>NO\textsubscript{x}</td>
<td>PN</td>
<td>CO\textsuperscript{1}</td>
<td>THC</td>
<td>THC+NO\textsubscript{x}</td>
</tr>
<tr>
<td>\text{CF}_{\text{pollutant}}</td>
<td>\textit{1 + margin NO\textsubscript{x} with margin NO\textsubscript{x} = 0.43}</td>
<td>\textit{1 + margin PN with margin PN} = 0.5</td>
<td>-</td>
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<tr>
<td>\text{Final CF NO}\textsubscript{x} (from 01/2020)</td>
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</table>
\textsuperscript{1}CO emissions shall be measured and recorded at RDE test.
"margin" is a parameter taking into account the additional measurement uncertainties introduced by the PEMS equipment, which are subject to an annual review and shall be revised as a result of the improved quality of the PEMS procedure or technical progress.

NTE requirements shall be fulfilled for the \textit{urban part} and \textit{the complete PEMS trip}.  

Euro 6d-TEMP

Euro 6d

Draft RDE package 4
AVL Solutions
(A comprehensive approach to RDE)
AVL M.O.V.E
The Industry Standard to Measure Real Driving Emissions (RDE)
COMPLETE RDE TEST SYSTEM

AVL M.O.V.E iS System
- GAS PEMS iS
- PN PEMS iS
- EFM iS
- System Control
- Concerto 5™ - M.O.V.E Data Toolbox

... done more than 40,000 RDE tests @ 100+ customers with 300+ systems!

AVL M.O.V.E iS
The Industry Standard to Measure Real Driving Emissions (RDE)
AVL M.O.V.E MARKET LEADERSHIP
CUSTOMER REFERENCES

AVL GAS PEMS 140+
AVL PM PEMS 120+

AVL GAS PEMS iS 300+
AVL PN PEMS iS 230+
AVL M.O.V.E – an In-Vehicle test platform which is aligned with the In-Lab test platform

Light duty vehicle on Real Driving Emission testing:
- Portable Emission Measurement System (PEMS) to measure CO2, CO, NOx, PN, Exhaust flow, Speed and GPS data.
- Implementation: EU 2017, Korea 2018, China 2019, India 2020, Japan 2022

Limits:
- CF NOx: 2.1 → 1.43
- CF PN: 1.5 → 1.x (in discussion)
- 1 calculation method for all types – focusing on raw emissions

RDE Test requirements:
- 30min conditioning drive, 5-56h soak time, cold test and hot start test
- RDE Drive between 90 to 120min in normal traffic.
- 34% Urban (<60km/h), 33% Rural (60 ... 90km/h), 33% Motorway (>90km/h)
- max. Speed 145km/h (can be extended to 160km/h on test track)
- positive altitude gain < 1200m/100km
- OVC Hybrid test in Charge–Sustaining mode
- Periodical Regeneration w/o Regeneration use ki-factors

Ambient conditions:
- 0°C to 30°C (extended range -7°C to 35°C)
- up to 700m (extended range 1300m) (China 2400m)

Randomness of real driving
- Realistic testing will be tough to meet requirements
- Wide range of environmental conditions
- Low emissions under all conditions
HOW TO GET A VALID TEST?
TRIP REQUIREMENTS...

KEY IS POST PROCESSING!!!
AVL CONCERTO 5™ - M.O.V.E DATA TOOLBOX
LEGISLATIVE POST PROCESSING
AVL CONCERTO 5™ - M.O.V.E Data Toolbox
LEGISLATIVE POST PROCESSING

AVL CONCERTO 5™
M.O.V.E Data Toolbox
LDV-HDV-NRMM
AVL CONCERTO 5™ - M.O.V.E DATA TOOLBOX
Example LDV - RDE 3 Results

NEW: Quick View

RDE TÜV Certified!
TÜV Certified
For correct legislative implementation

TÜV certificate:

- HD (EU) No. 582/2011 Annex II and (EU) No. 64/2012
- RDE Package 1 – 2016/427
- RDE Package 2 – 2016/646
- RDE Package 3 - 2017/1154
AVL CONCERTO 5™ - M.O.V.E DATA TOOLBOX
RDE 4 Implementation coming soon

SW Release - RDE 4 Implementation Plan:

- End of July 2018 – Final Vote implemented as „EU RDE4 development mode“
- End of 2018 – EU RDE 4 certification mode available

MOVE Software Subscription Customers will receive it automatically!
Further Applications

AVL M.O.V.E In-Vehicle Testing
### Emission Measurement

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<tr>
<th>Region</th>
<th>Standard/Regulation</th>
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<tr>
<td>EU-4</td>
<td>2016 based on UN-ECE-Regulation 40/47 and GTR-2</td>
<td>Introduction of PM limits for CI and GDI engines, only</td>
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<tr>
<td>EU-5</td>
<td>2020 based on UN-ECE GTR-2</td>
<td>open discussion (Effect study) in-use conformity, off-cycle emissions and PN</td>
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<td>USA</td>
<td>EPA Motorcycle Standard [g/km]</td>
<td>no change since 2010</td>
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<tr>
<td>USA</td>
<td>CARB Motorcycle Standard [g/km]</td>
<td>no change since 2008</td>
</tr>
<tr>
<td>Asia</td>
<td>(India): still Leading the MC emission regulations</td>
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</table>

**Start of discussion about RDE**
Is „Real Driving Emission“ Measurement on Motorcycles possible?
Case Study with TU Graz
Setup Motorcycle with actual RDE equipment
AVL M.O.V.E iS
CO2 Testing – Real Fuel Consumption

- Fast connection to your onboard fuel system
- Provides online result by l/km (also via MAP data)
- Full integration with AVL M.O.V.E and thus PEMS testing
- Highest accuracy for real driving fuel consumption at low flows
AVL M.O.V.E iS
RDE DEVELOPMENT – FUEL EXTENSION

GAS PEMS iS
CO, CO2, NO, NO2, O2

PN PEMS
Particle Number

AVL M.O.V.E EFM
Exhaust Mass Flow

AVL PLUtron™
Fuel Flow

SYSTEM CONTROL

GPS
T, p, %

OBD II

Online Tools

MOVE Data Toolbox

Advanced Analysis Tools

Reporting

AVL M.O.V.E – an In-Vehicle test platform which is aligned with the In-Lab test platform
AVL M.O.V.E - Energy Efficiency Evaluation
CO2 & E-Power Measurement Extension

- Easy add-on of hybrid key figures into System Control (real fuel consumption, battery state of charge, Recuperated energy, charging modes, HCU information)
- High speed power measurement for exact battery aging effects determination
- Extended Reporting of total energy efficiency for better evaluation of vehicle strategy
AVL M.O.V.E HEAVY DUTY TESTING

AVL M.O.V.E PEMS TESTING
Heavy duty in-service conformity with PEMS

USA and Canada
HDIUT – In-use Testing with PEMS equipment and field-testing procedures 1 January 2005

EU
Euro VI: 1 January 2013 all new vehicle types

South Korea
Euro VI: PEMS requirements from 1 January 2016

Japan
under discussion, earliest introduction 2022

China
Phase V: 1 October 2017 all newly approved vehicle type
Phase VI (Draft): 1 January 2020 Phase VIa (urban vehicles) 1 January 2021 Phase Via (all vehicles) 1 January 2023 Phase VIb

Australia
Euro VI under discussion

Brazil
PROCONVE P-8 (Draft): 1 January 2027

India
Bharat VI: 1 April 2020 monitoring 1 April 2023 limitation (CF)

Singapore
Euro VI: 1 January 2018 PEMS only in TA

USA and Canada
HDIUT – In-use Testing with PEMS equipment and field-testing procedures 1 January 2005
Heavy Duty – PEMS Testing

In-Service Emissions conformity (compliance):

- “Real Life” Test on the street with PEMS (Portable Emission Measurement System). First in-service test should be conducted at the time of type approval testing
  - CO2, CO, NOx, THC, PM (PN in discussion for EU)
  - Exhaust flow rate, Speed, n, M and GPS data.

PEMS Test

- EU testing is conducted over a mix of urban (0-50 km/h), rural (50-75 km/h) and motorway (> 75 km/h) conditions, with exact percentages of these conditions depending on vehicle category.

Ambient conditions

- Temperature and Altitude as defines for off cycle emission requirements

Limits and Result calculation

- Limits are based on the laboratory limits multiplied by 1.5
- EU Result calculation by “Work based window”
- US Result calculation by NTE-Events (during ≥30seconds operation with high enough engine torque, speed and power
**HDV – In Service Compliance Testing**

**PN Introduction**

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**PEMS PN procedure with conformity factors**

- The assessment of JRC in 2015 has proved a technical feasibility of the PEMS equipment to measure particulate number
- PEMS PN procedure will be introduced together with the 10% power threshold requirement – 1.09.2018 for new types, one year later for all new vehicles
- On-going tests on different vehicles
- Proposal to be prepared still in 2017

---

**2015:**
PM will be replaced by PN

**2017:**
PN for HDV will be introduced delayed by 2019
### Legislative Reports

#### Case: Truck

<table>
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<tr>
<th>Parameter</th>
<th>Reference Work kWh</th>
<th>EU Power Threshold %</th>
<th>Data Coverage No.</th>
<th>Max. Power %</th>
<th>Work Windows total</th>
<th>Work Windows %</th>
<th>Conformity Factor AOS</th>
<th>Valid Windows No.</th>
<th>Conformity Factor Particles</th>
<th>Valid Windows %</th>
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<tr>
<td>Mass Particles (BS NOx)</td>
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<td>Mass Particles (BS PM)</td>
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<td>Conformity Factor CH4</td>
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<td>Conformity Factor NOx</td>
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</table>

#### Consistency Checks

- **CO2 mass window percentage of valid windows**: 71.9
- **CO2 mass window-duration (s)**: 690.0
- **Fuel consumption consistency ratio**: m = 0.03
  
  ![Graph of consistency checks](image_url)
NON-ROAD MOBILE MACHINERY (NRMM) IN-USE TESTING

AVL M.O.V.E PEMS TESTING
Non-road in-service monitoring/conformity with PEMS

**EU**
- Stage V: 1 January 2018/2019,
  submission of first results: end of 2022

**China**
- Draft China IV:
  ISC from 2020
  CF NOx = 2.5

**India**
- Bharat Stage V:
  ISC from 1 April 2023-26, details tbd
Setup consisting of

- PM PEMS
- Gas PEMS
- System Control
- Sensors EFM
- Generator
- E-Box
- Battery pack
- Rugged cases
HDIUT EXAMPLES – OFF ROAD
HDIUT EXAMPLES – OFF ROAD – RESULT DATA
NRMM – IN SERVICE CONFORMITY (ISC) FIRST DRAFT IMPLEMENTED
Different Applications
Different Solutions

Application

<table>
<thead>
<tr>
<th>MOVE iS</th>
<th>&amp; FID iS+*</th>
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<tr>
<td>move1</td>
<td>move2</td>
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<table>
<thead>
<tr>
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<th>&amp; FID iS+*</th>
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<tbody>
<tr>
<td>move3</td>
<td>move4</td>
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</tbody>
</table>

* FID iS+ from Q1/2019
RDE Development
RDE Type Approval on the Road
R&D in the Lab

RDE testing is "random"

Lab tests can be "reproduced"

Lab tests allow "defined variations"

Lab tests measure "precise"
Powertrain Development Process

Concept
- Simulation
- Powertrain Elements
- Elements Testing

Development
- Road testing
- Chassis Dyno testing
- Powertrain Testing
- Propulsion Testing
- HiL Testing

Type Approval

In-Service
- RDE READY

Simulation Levels:
- Simulation Level 4
- Simulation Level 3
- Simulation Level 2
- Simulation Level 1
RDE Use Cases

Use Case 1: Reproduction
- Re-production of a road test
  - one individual road test is reproduced for the identical vehicle
  - Traffic simulation
  - How: Engine “α” replay and vehicle speed
  - Why: Root cause analysis

Use Case 2: “Conventional Drive Cycles”
- Standard- or OEM specific Drive Cycles
- Random Drive Cycles
- Re-Run of road testing
  - What: Variation of vehicle and some boundary conditions
  - How: Vehicle speed over time
  - Why: Conventional Development

Use Case 3: Virtual Development
- 100% Software simulation
- HiL Testing and ECU Front Loading
- Combinations of Simulation and testbeds
  - What: Variations of all properties
  - How: Traffic simulation
  - Why: Concepts and Front loading

Concepts and Front loading
Powertrain Development Process

1st VEH. cal

Data Freeze

SOP

Offices

VTB
Conc. Desc.
Critical variants/ scenario identification

VTB RDE
Emi-Valid.
Var-matrix

VTB
SW/Data val.
Supplier/rotating

XIL

ENGINE
TEST BED

CHMA

Standard Emissions
Development
Mature emissions status with new/aged EAS
W/LTC/FC (HP/CO2), MEDC/CPG (PC)

RDE
Pre-Vel.
25/75C

PN EO
Optimization
High load Cold

RDE Eml.
Dev. Lead
variant
RDE repl. cycles
incl. worst case sc

Final Emi.
Robustness
Doc./Valid.

CHASSIS
DYNO

ROAD
TESTING

ROAD
PEMS
Emission
variables

RDE Eml.
Valid.
Var-matrix
RDE repl. cycles
incl. worst case sc

POWERTRAIN
TESTBED

Start/ Warmup / STST / CoM

Emi. Para
m. Iterations

Fin EmiR
ob PTIB share
RDE Validation Impact for Testing Environments

- RDE Road Measurement
- RDE Testing on Chassis Dyno
- RDE Testing and Calibration on ETB
- RDE Calibration on Virtual Test Bed

Same Results

- Same Models
- Same Tests
- Same Tools
- Same Data Storage
- Same Analysis
AVL Road-2-Lab
Efficient Testing & Development for RDE
RDE compliance is a must

RDE legislation is implemented on global scale

RDE development focusing on boundary conditions asks for new development approach

Additional aspects will follow like Fuel Consumption & Energy Efficiency