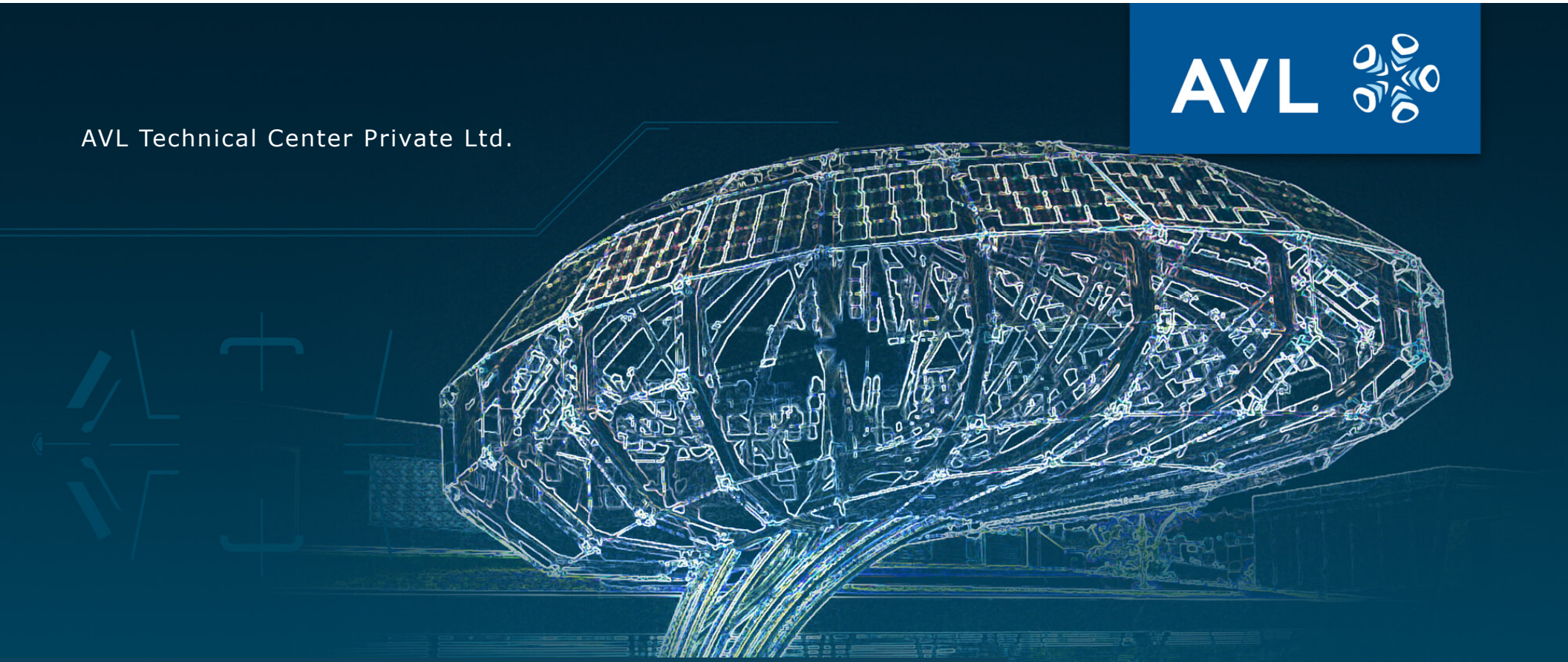
AVL Technical Center Private Ltd.



REAL DRIVING EMISSIONS

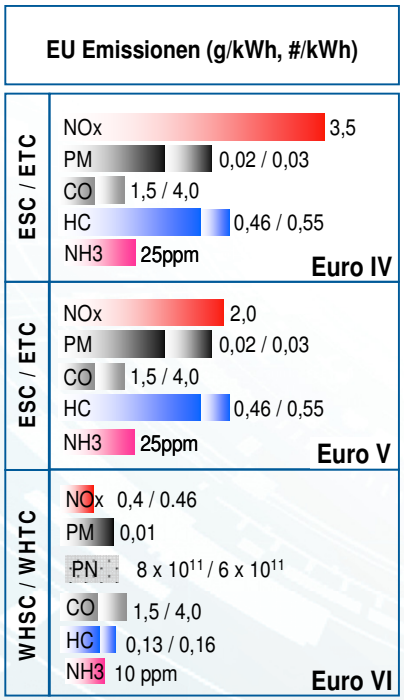
Challenges and Solutions

Dinesh Goyal

India

- 2020 from Bharat IV to VI, with UNR-83 and 90km NEDC
- 2020 RDE monitoring (TA and COP) & 2023 RDE Limits
- 2021 Fuel consumption target reduced 5.5 to 4.7 l/100km

Bharat stage VI
Main Changes from BS IV to BS VI



Euro IV to Euro VI	BSVI
Test procedures change from ESC & ETC to WHSC & WHTC	Same as EUVI
New reference fuel B0 → B7	Same as EUVI
NOx emissions will be reduced NOx 88.6 % • **Steady state test from 3.5 g/kWh to 0.4g/kWh** • **Transient test from 3.5 g/kWh to 0.46 g/kWh**	Same as EUVI
PM emissions will be reduced PM 66.7 % • **Steady state test from 0.02 g/kWh to 0.01 g/kWh** • **Transient test from 0.03 g/kWh to 0.01 g/kWh**	Same as EUVI
Definition of particulate number limit	Same as EUVI
Documentation of CO_2 emissions & fuel consumption	FC limits in discussion
Additional „Not-To-Exceed Area"	Same as EUVI
Vehicle in-service conformity, emission durability	Same as EUVI
Advanced OBD regulation	OBD-1, OBD-2

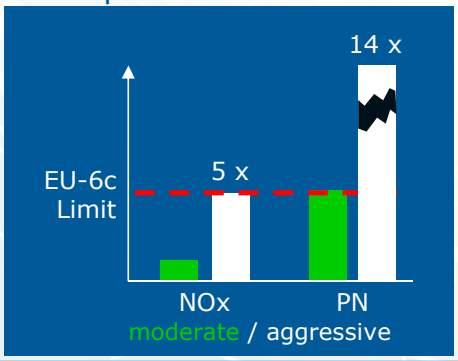
Impact to Emissions - Examples

Drive Style:

Drive style has a large impact (by factors) on emission:

- aggressive
- moderate

Example:

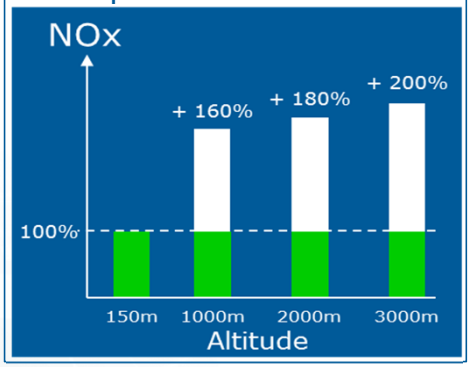


Altitude:

Impact of altitude:

- physical
- calibration, like when EGR is switched off

Example:

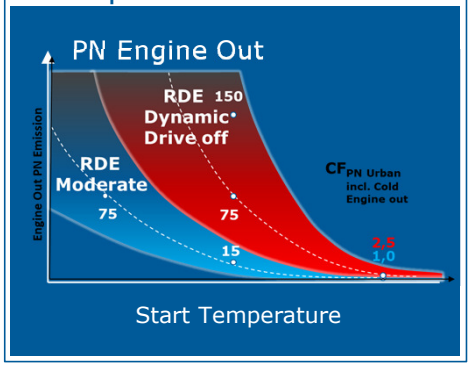


Cold Start:

Impact of cold start:

- critical for GPF
- critical when test start with a high driving dynamic

Example:



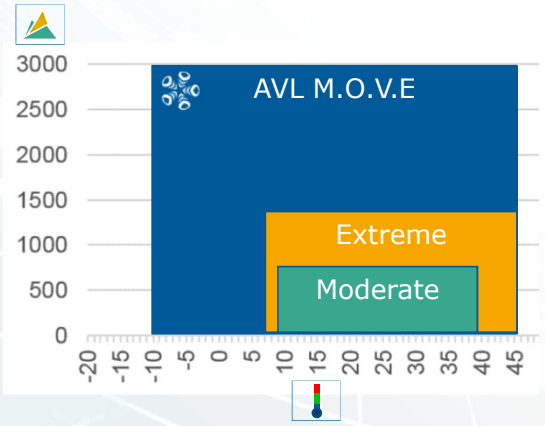
INDIA - RDE REQUIREMNTS

INDIA RDE TEST REQUIREMENTS
Final Draft AIS 137- Part 3 (LDV)

Application

Standard

Indian Real Driving Emissions (published in The Gazette of India (G.S.R. 889(E)), technical details in AIS137- Part 3 (RDE))



Light duty vehicle on Real Driving Emission testing:

- Portable E… TBD, Exha… randomness of real driving
- Implementation India: 2020 Monitoring , 2023 with CF Limits

Limits:

- CF NOx: … low emissions under all conditions
- 1 calculation method – …

RDE Test requirements:

- Cold start … realistic testing will be tough to meet requirements
- RDE Drive…
- 34% Urban, 33% Rural, 33% Motorway (M1 & N1)
- For M1: U (0-45km/h), R (45-65km/h), M (>65km/h) ; 75km/h for 5 min
- For N1: U (0-40km/h), R (40-60km/h), M (>60km/h) ; 70km/h for 5 min
- 50% Urban, 50% Rural (M1 & N1 low powered vehicle)
- For M1/N1 LPV: U (0-45km/h), R (>45km/h); 55km/h for 5 min
- New Dynamic criteria for RPA & V*Apos

Ambient cond…

- 10°C to … wide range of environmental conditions
- up to 700m (extended range 1300m)

INDIA RDE TEST REQUIREMENTS
Final Draft AIS 137- Part 4 (HDV)

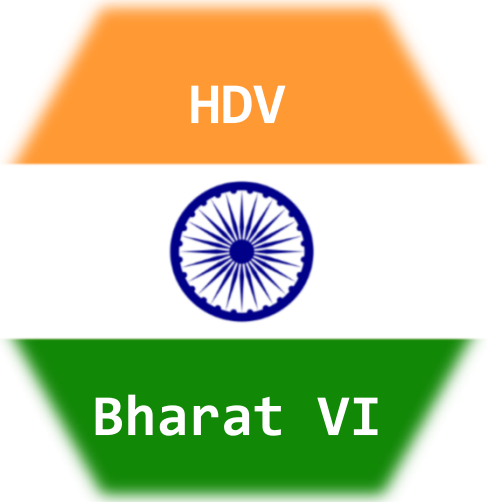
Test validation and post processing calculation are same as
UNECE -R49 rev.6 Supplement 3 (Equivalent to 582/2011/EC)

India Specific Amendments:

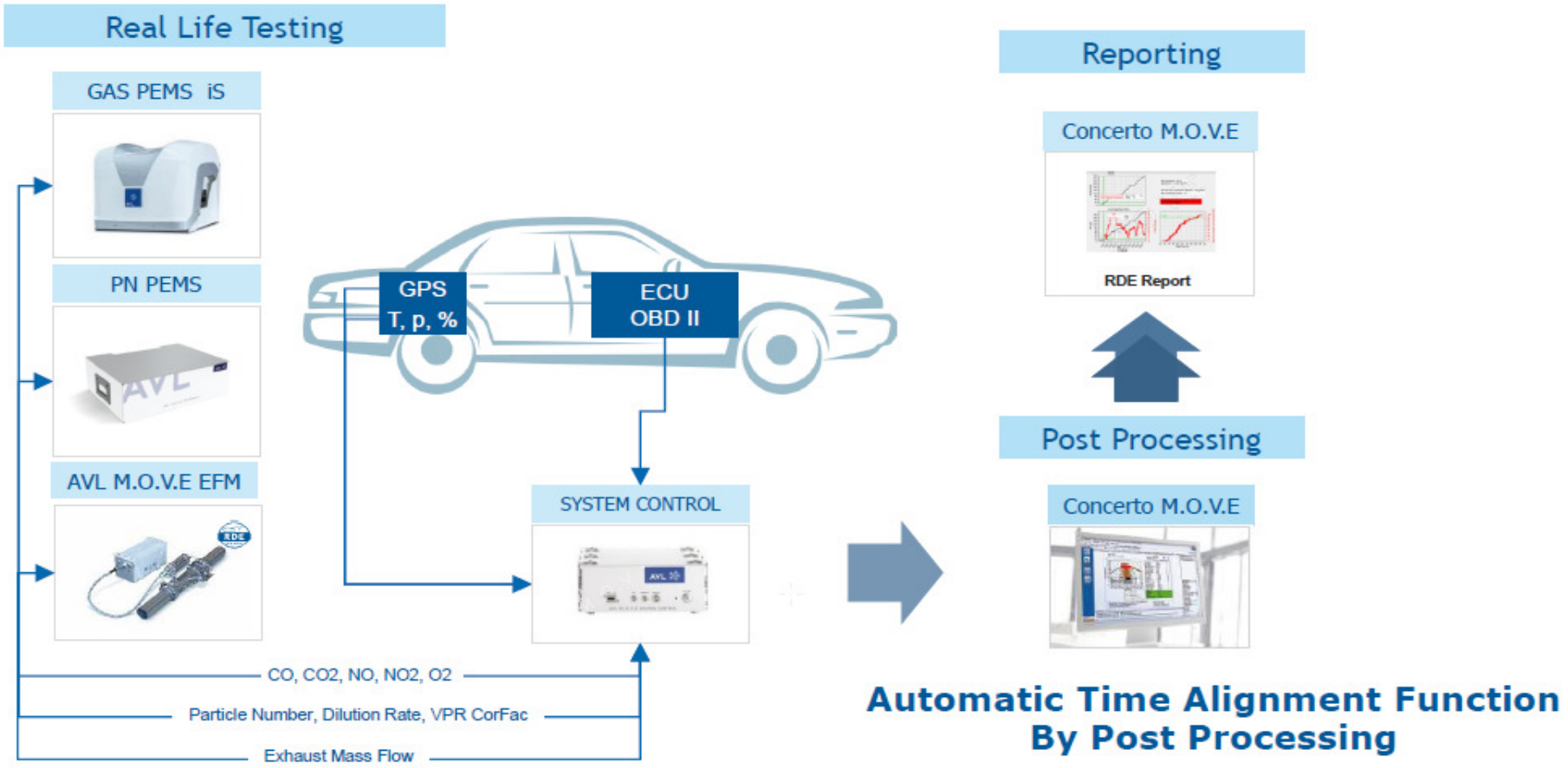
- Speed Range : U 0-40 km/h, R 40- 60 km/h, M >60 km/h
- Trip Shares:

Shares	M2, M3 (M3 Type I)	Shares N2, (N3)
Urban	20% (70%)	25% (20%)
Rural	35% (30%)	35% (35%)
Motorway	45% (0%)	40% (45%)

- Ambient Temperature: 0 to 42 Deg. C
- PEMS Monitoring from 2020 for TA & COP
- Euro VI limits
- In-Service Compliance (ISC / PEMS) CFs from 2023, values tbd

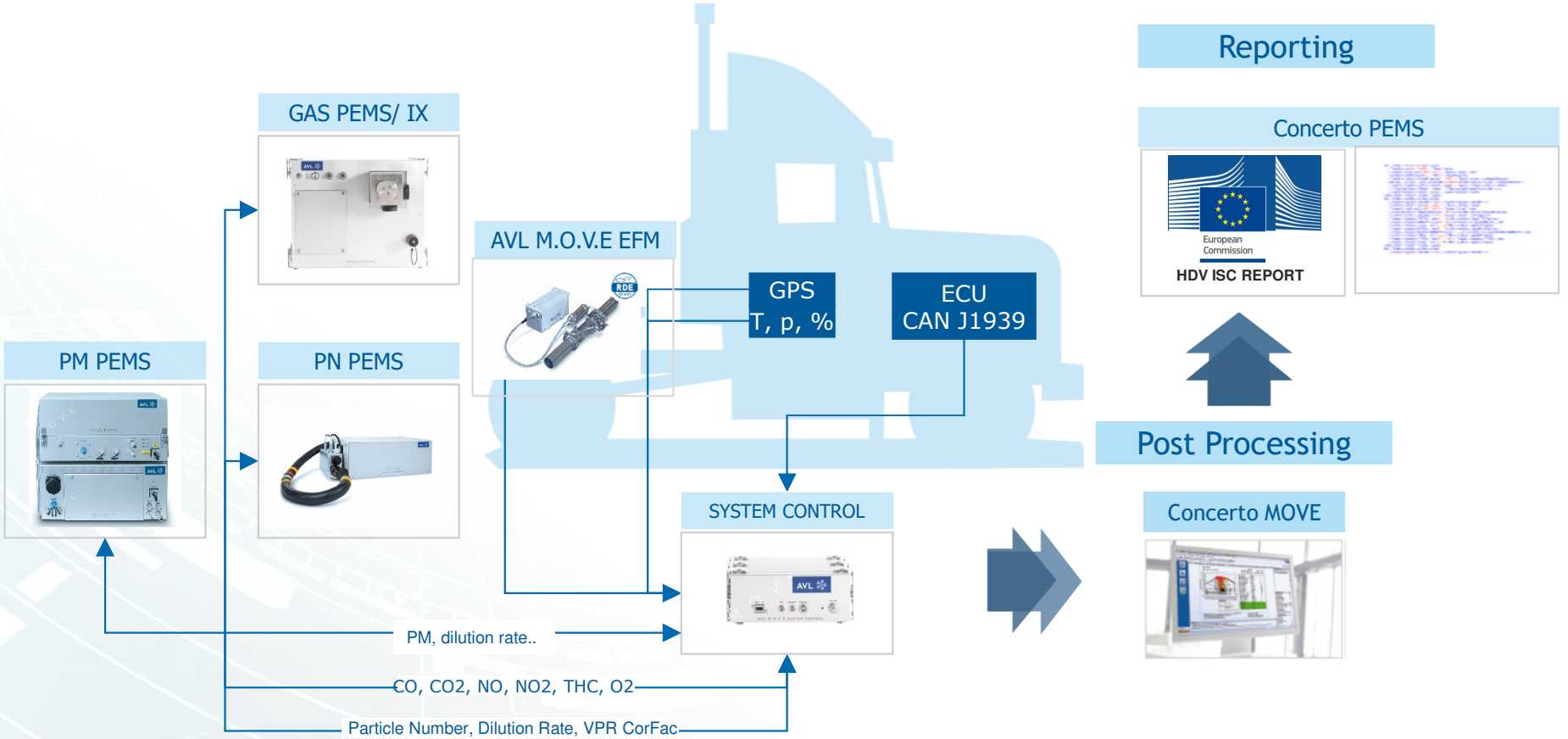


RDE Hardware Architecture for LDV



Automatic Time Alignment Function By Post Processing

RDE Hardware Architecture for HDV

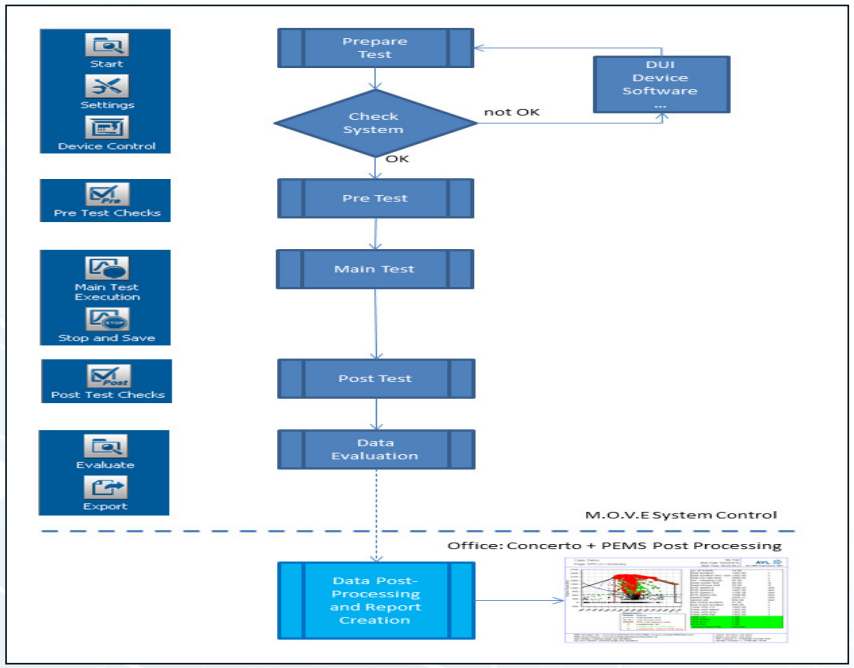


Testing Procedure for On-Road IRDE Test

Correlation requirements:

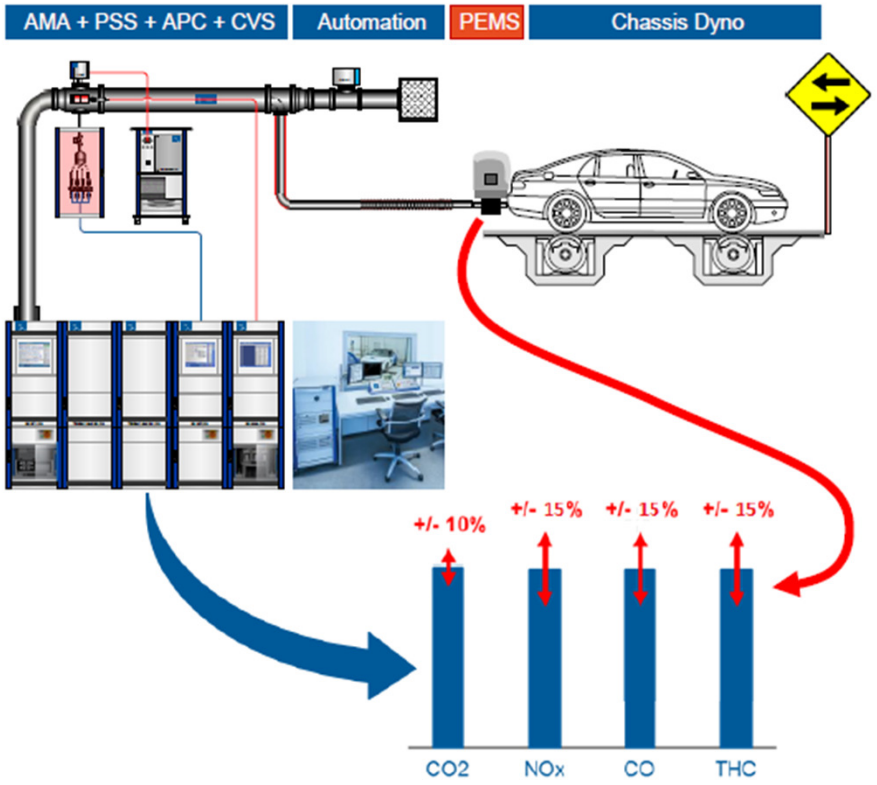
Correlation validation of the total distance-specific mass of pollutants [g/km]

• CO2	+/- 10 mg/km	or +/- 10% of lab. result, whichever is larger
• NOx	+/- 15 mg/km	or +/- 15% of lab. result, whichever is larger
• CO	+/- 150 mg/km	or +/- 15% of lab. result, whichever is larger



- **Test-Sequence**
  - Step 1: Vehicle preparation and PEMS system installation
  - Step 2: PEMS validation with laboratory CVS system (Correlation)
    - To be done before On-road test
    - On a chassis dyno by running MIDC drive cycle for IRDE
  - Step 3: Test Preparation
    - operate devices
    - control device states
  - Step 4: Pre Test Checks
    - Leak Check
    - Zero + Span Adjust
  - Step 5: Main Test Execution
    - Cyclic Zero
  - Step 6: Post Test Checks
    - Zero + Span Check
  - Step 7: Data Evaluation
    - Save/Load/Display/Export Data
  - Step 8: Post-Process Data (using Concerto + PEMS Post Processing)

AVL M.O.V.E System vs CVS System Correlation



RDE recommends correlation to reference laboratory systems

PEMS validation procedure:

- Validation test to be done before the on-road test.
- PEMS installation shall not be changed between validation- and road tests.
- Validation test on a chassis dyno by running a MIDC drive cycle.
- It is recommended to feed the extracted exhaust back to the CVS.
- If not, the CVS results shall be corrected for the extracted exhaust mass.
- NOx humidity correction also applied to the PEMS NO_x result for validation.
- Take care on the type of chassis dyno vehicle restrain systems

Correlation requirements:

Correlation validation of the total distance-specific mass of pollutants [g/km]

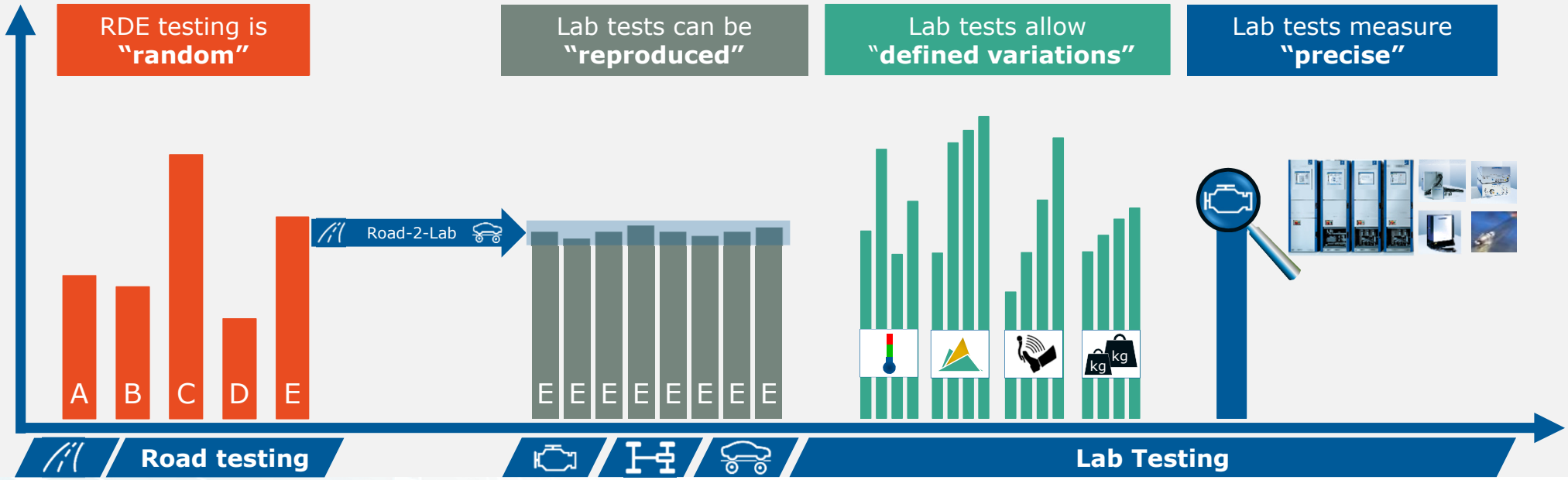
- CO2 +/- 10 mg/km or +/- 10% of lab. result, whichever is larger
- NO_x +/- 15 mg/km or +/- 15% of lab. result, whichever is larger
- CO +/- 150 mg/km or +/- 15% of lab. result, whichever is larger
- THC +/- 15 mg/km or +/- 15% of lab. result, whichever is larger

AVL Solutions

(A comprehensive approach to RDE)


LAB

RDE – R&D in the Lab



AVL M.O.V.E

SMART MOBILE SOLUTION

Interaction between Maneuver & Calibration Assistance

Integration of Road Converter in SMS

Advanced Maneuver Editor

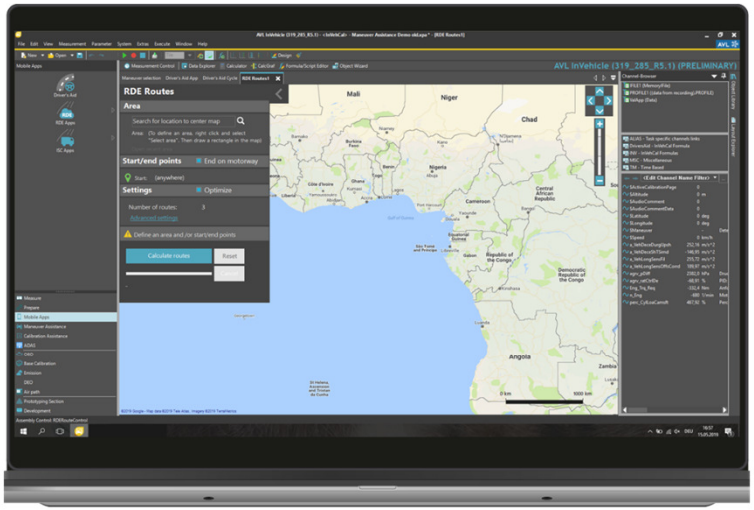
RDE Dynamics

Data Storage

Other Tunings

Smart Mobile Solutions
RDE vehicle package

1. One click route generation

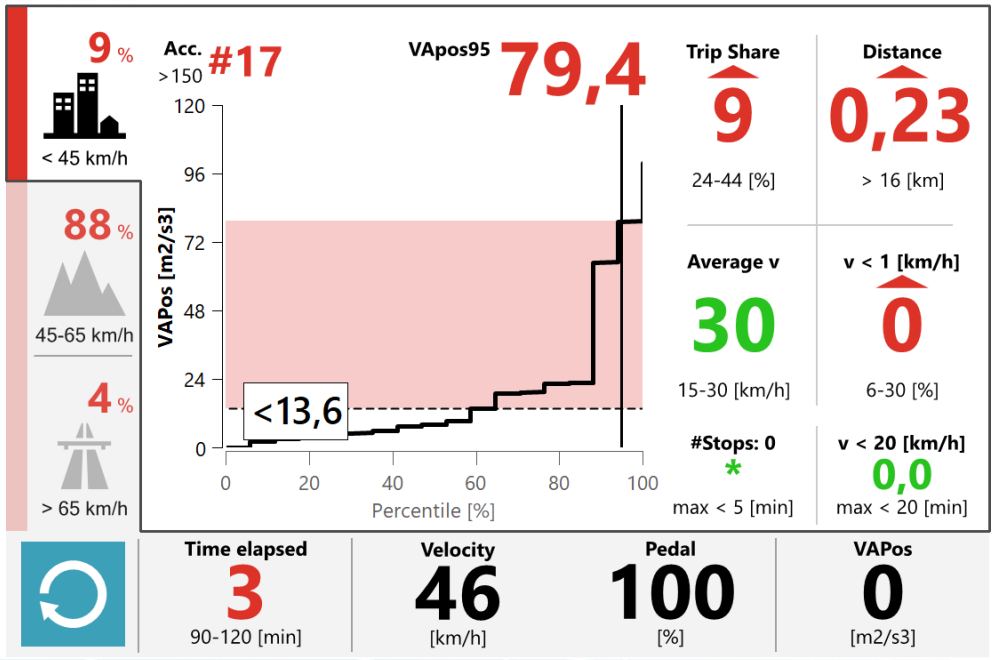


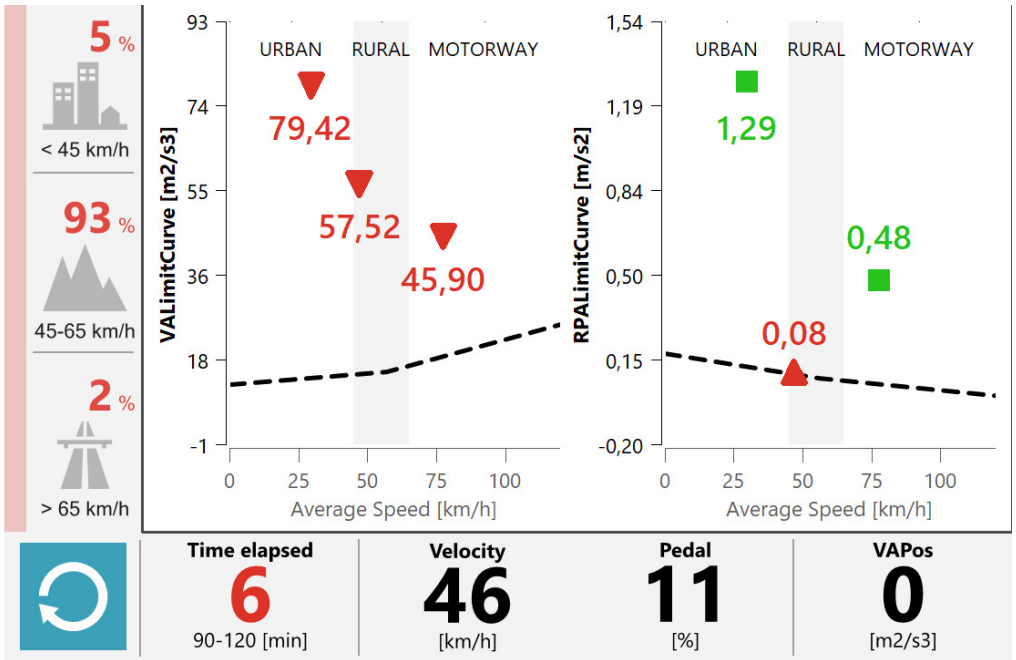
2. Online evaluation and visualization of the RDE test criteria

3. Re-run an RDE cycle or a part of it

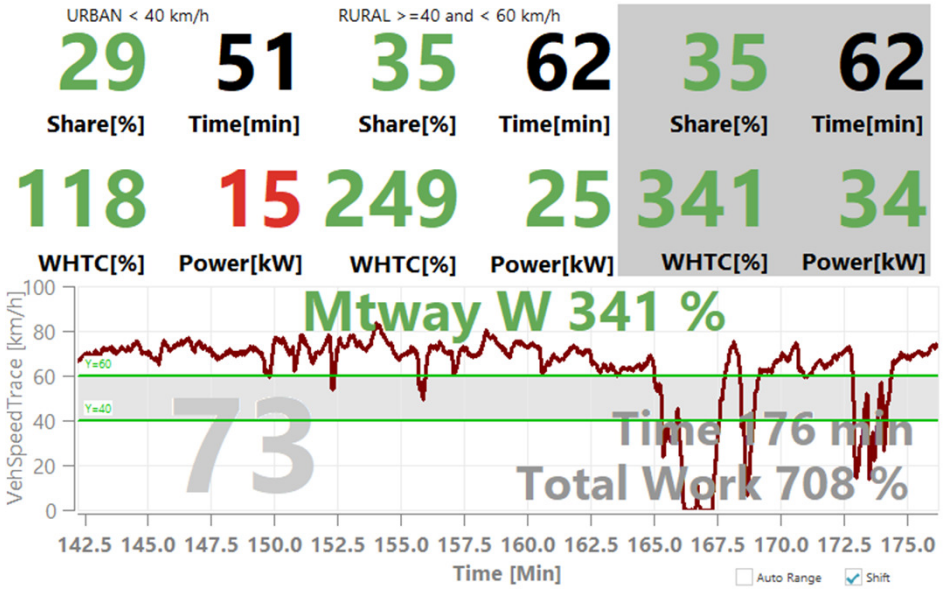
RDE Dynamics

- → User friendly GUI for the RDE Dynamics
- → Clear separation of the trip shares
- → Better visualization of the VAPos
- → VAPos graph with limits-curve





AVL HD RDE with AVL InVehicle



AVL InVehicle

Driver can monitor the trip progress on TAB or mobile phone

- Parameters which are meeting legal requirement during test trip will set to **green**
- Parameters which are not meeting legal requirement during test trip will set to **Red**

Other Tunings

Maneuver Assistance:

- *Maneuver Execution:*

Recorder won't be stopped by Maneuver Assistance if it was already running before. However, if the Maneuver Assistance started the recorder, it still stops it again. The same procedure applies for the data acquisition.

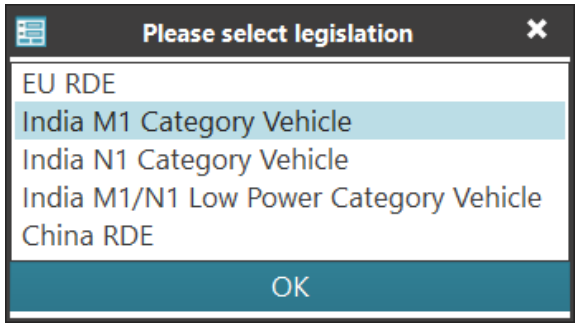
- *Maneuver Changes:*

The changes to a maneuver that is part of a currently running test-run will be updated automatically as soon as the active test run is ended. A manual reload of the maneuvers in the "Maneuver Selection" window is therefore no longer necessary.

RDE Dynamics for India Legislation:

RDE Dynamics have been implemented to match also the India legislations.

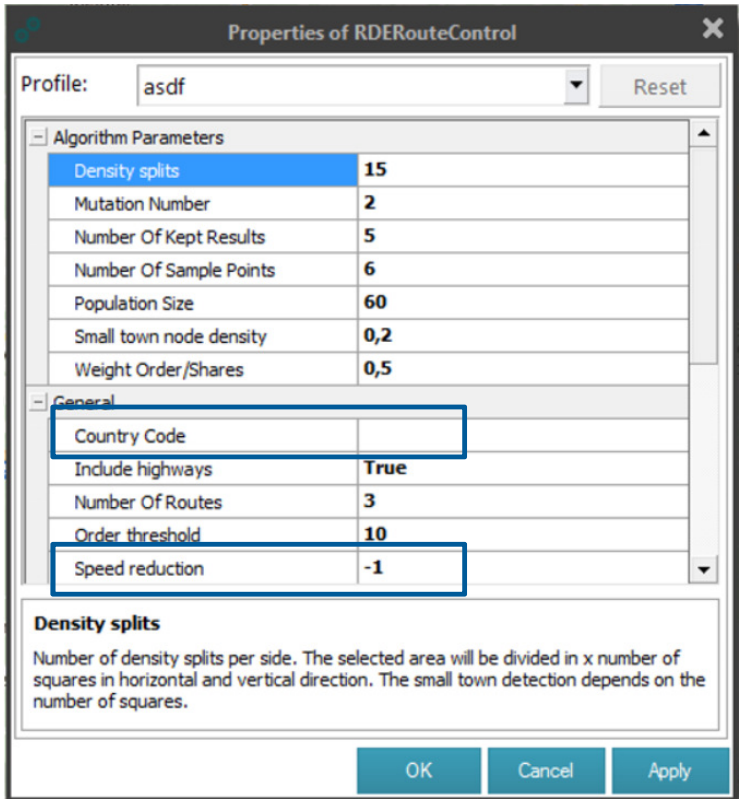
The user can select the legislation he/she wants to use from the drop down menu.



Other Tunings

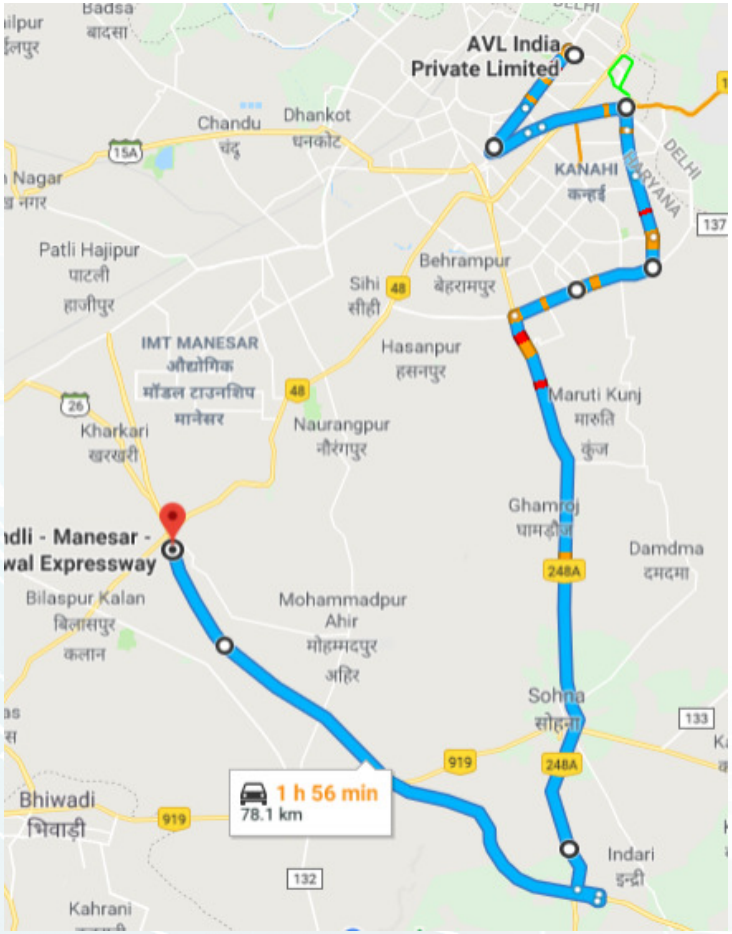
RDE Route Finder:

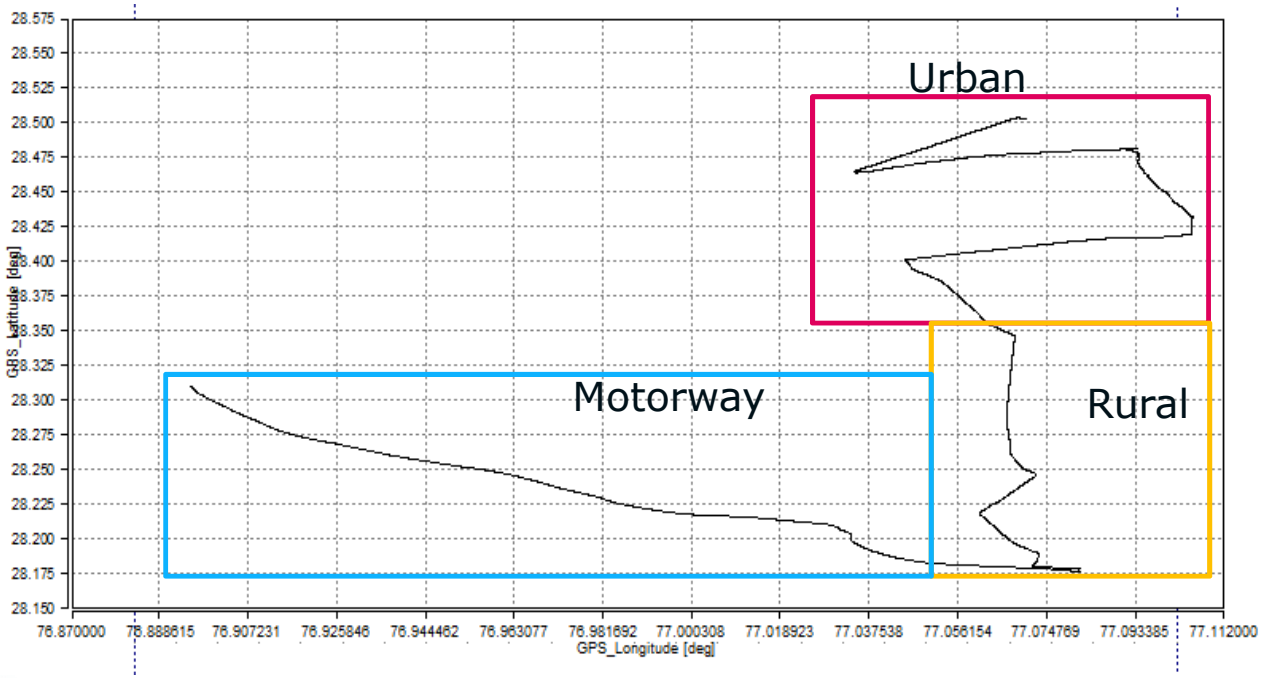
- The settings of the RDE Route finder that are delivered with the SMS version can no longer be overwritten. If the settings are changed, the user always has the possibility to reset the settings to their default values. The user can derive a settings file and make some changes, if desired.
- The property "Country Code" now allows the user to define for which country this settings file is applicable. Therefore it is possible to drive e.g. Indian RDE routes in other countries too by preprocessing map files the same way as it would be preprocessed in India.
- A property in the settings file called *speed reduction factor* can be used to extend or shorten the duration of found routes.



AVL ITC’s experience with RDE Testing

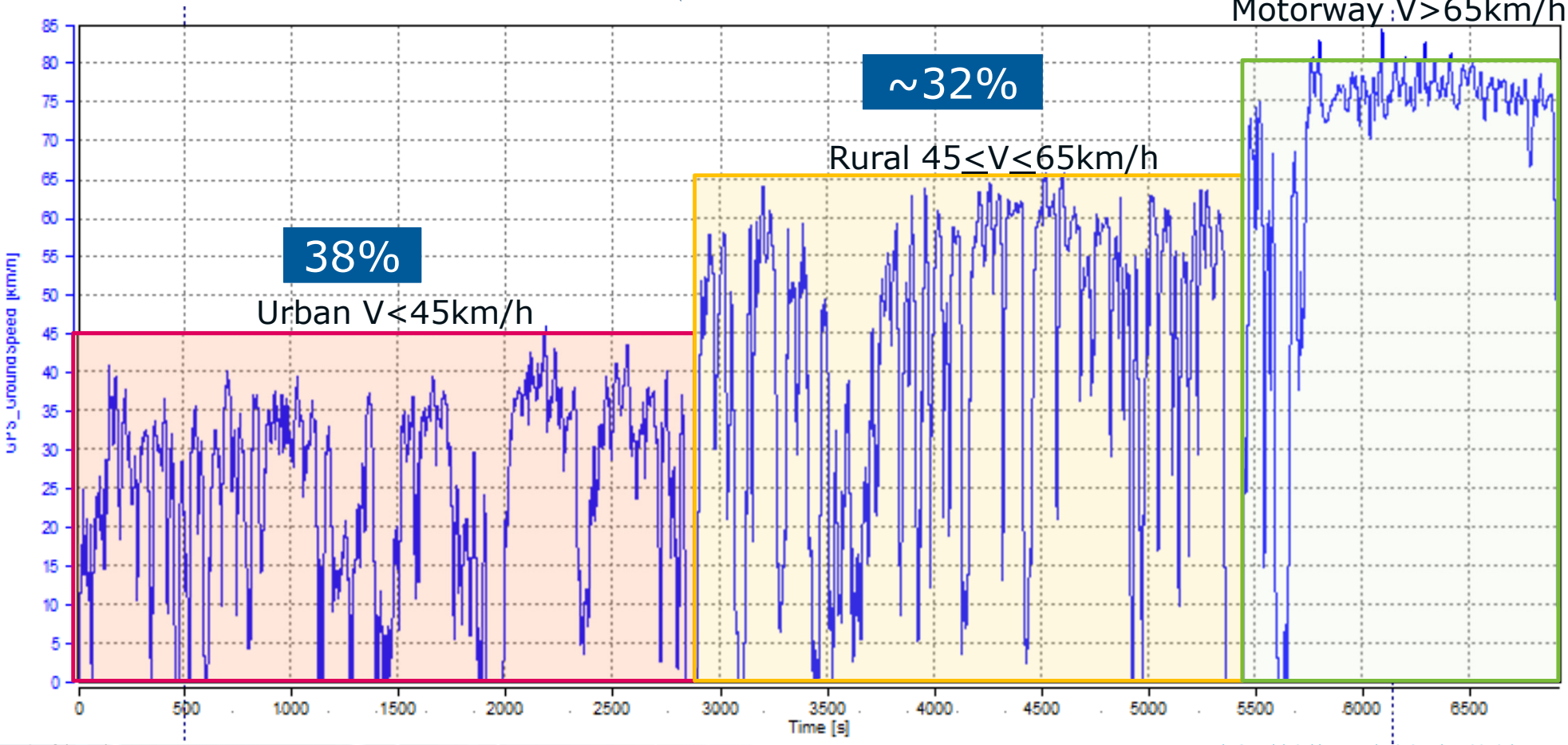
AVL Identified Routes for IRDE-LDV



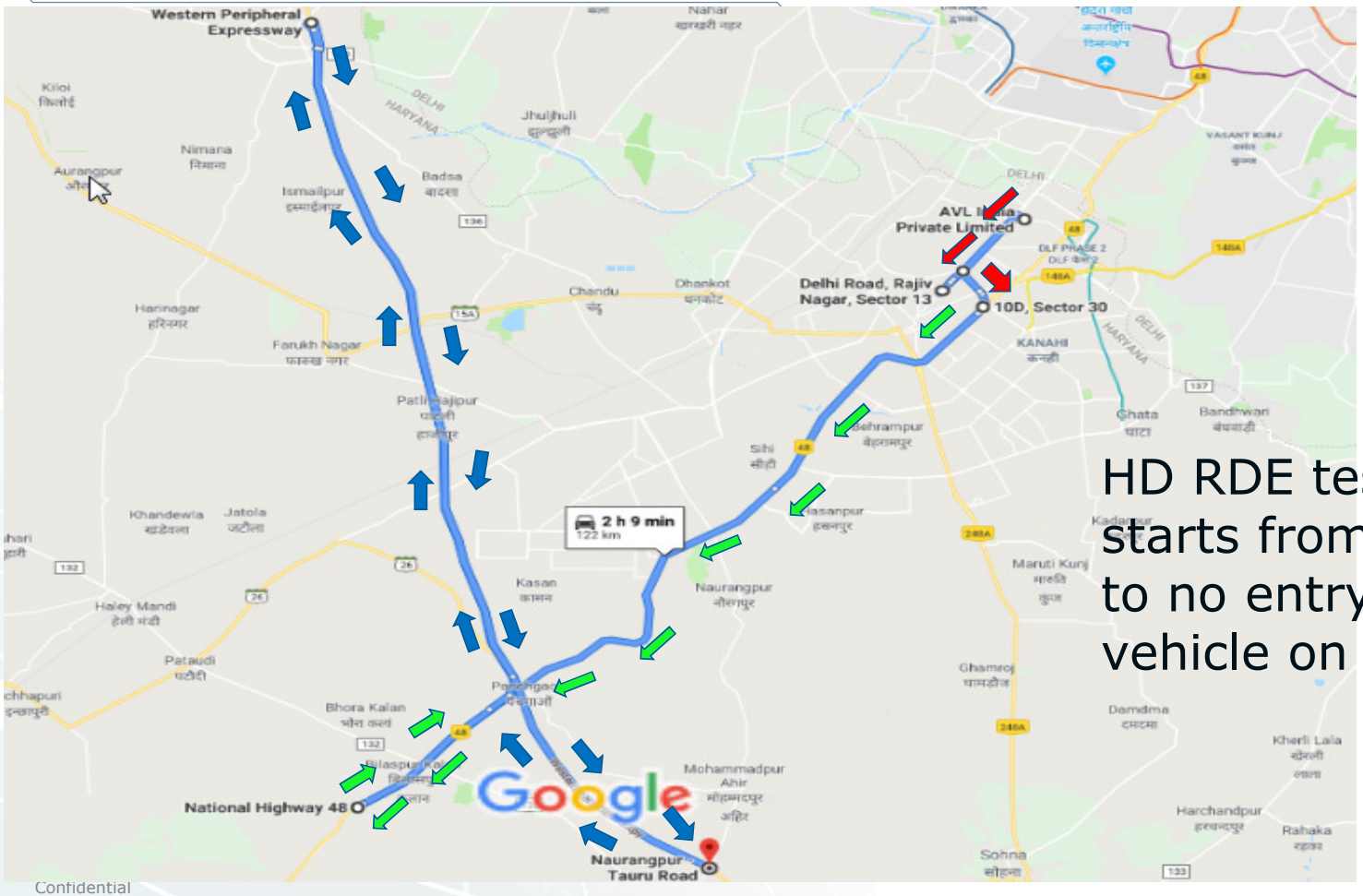


Distance covered approx. 80km in less than 120min

Trip Shares on Identified Routes for IRDE-LDV



AVL Identified Routes for IRDE-HDV



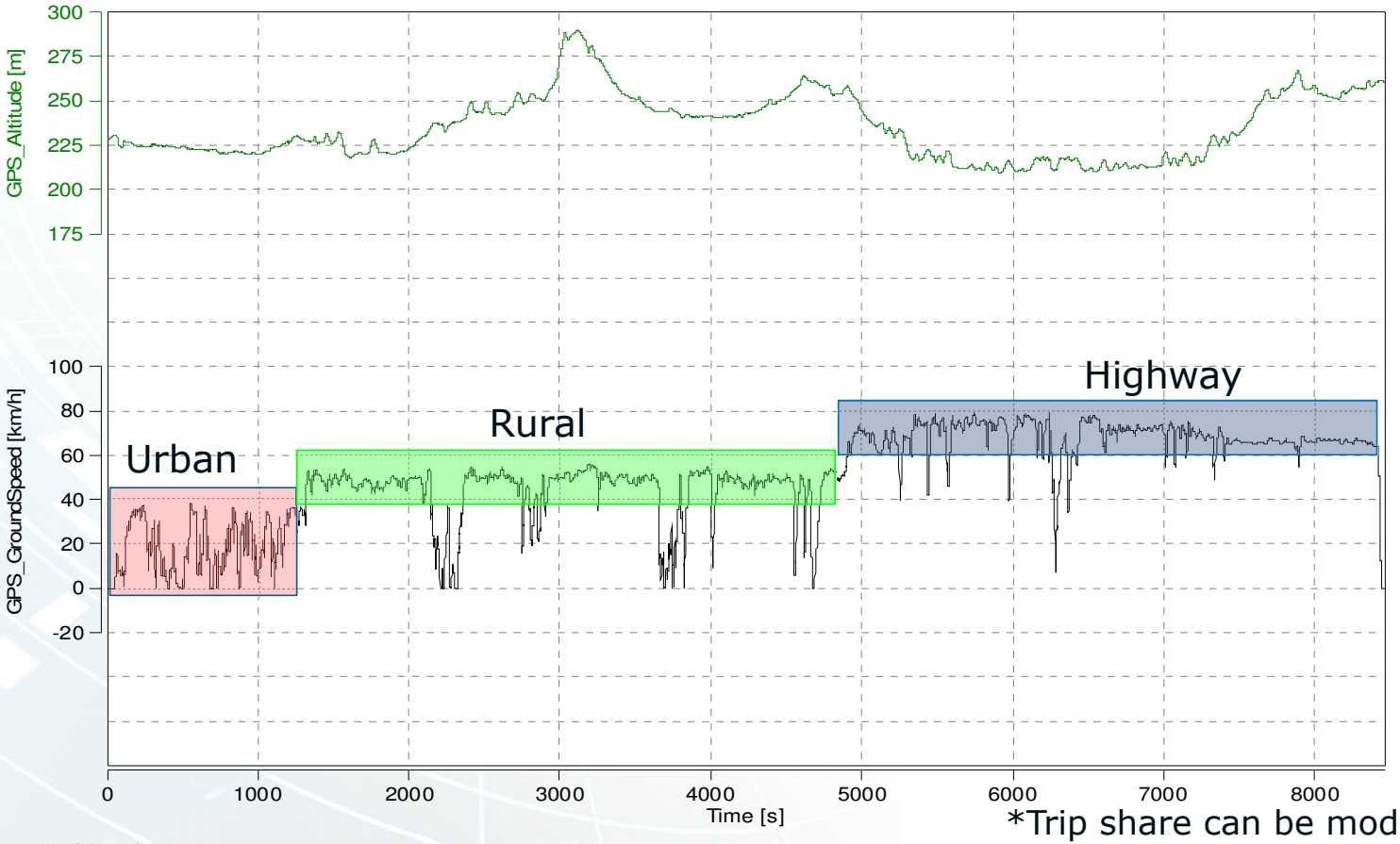
Urban

Rural

Highway

HD RDE test in NCR starts from 11 am due to no entry of HD vehicle on city road.

Trip Shares on the Routes for IRDE-HDV



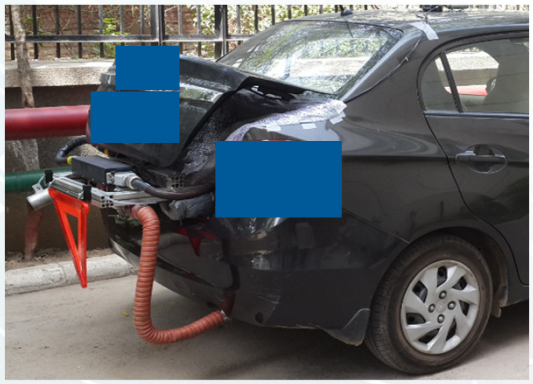
Cycle Share(TimeBased):-

Trip Share on AVL HD Route:-

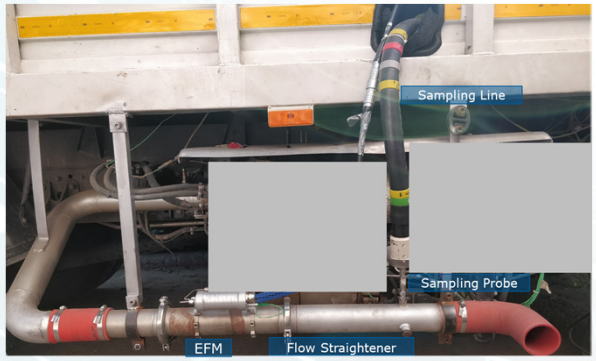
- Urban ~ 25%
- Rural ~ 36%
- Highway ~ 39%
- WHTC Work=~7-8 times

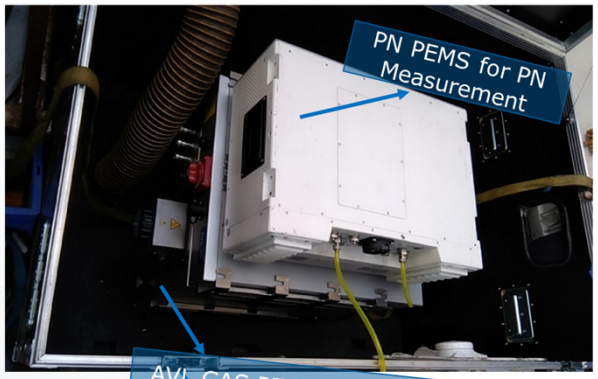
*Trip share can be modified based on vehicle category

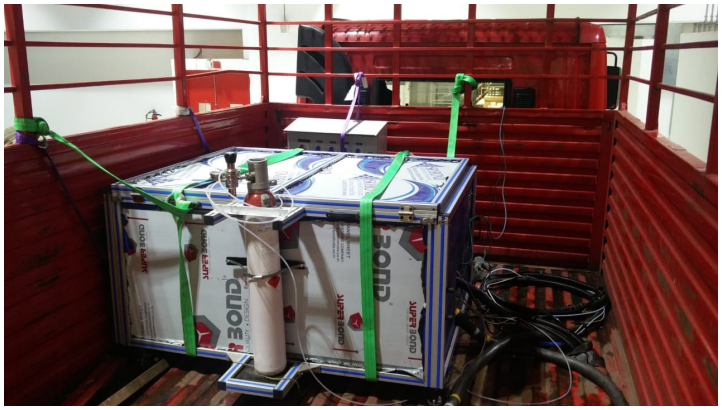
AVL ITC Experience on RDE - PC



AVL ITC Experience on RDE – HDV







REAL DRIVING EMISSIONS (RDE)
A REAL CHALLENGE FOR ON ROAD TESTING

RANDOMNESS

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

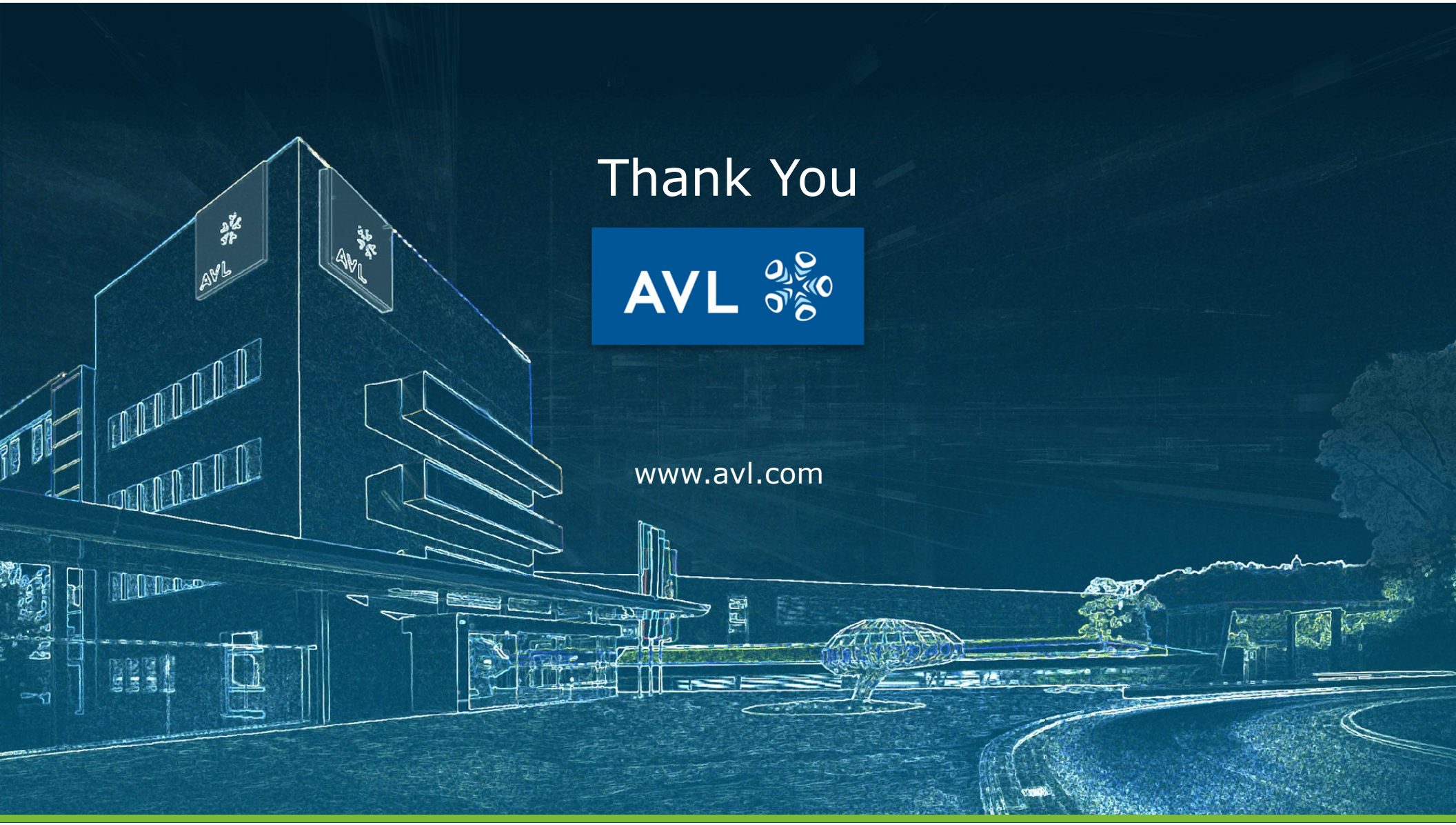
AMBIENT TEMPERATURE

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..

RDE READY


Thank You
AVL
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