



Fast track to euro 7 certification

Light-Duty

R.Belleux

Kurzvorstellung:

23 years in vehicle testing

15 years at AVL



Zuständigkeitsbereich:

- Business unit sales support team leader
 - Global accounts support
 - Emission and energy measurement application management
- With focus on light-duty applications.

Rodolph BELLEUX

Teamleader Global Account Support

AVL Analytical Technologies GmbH

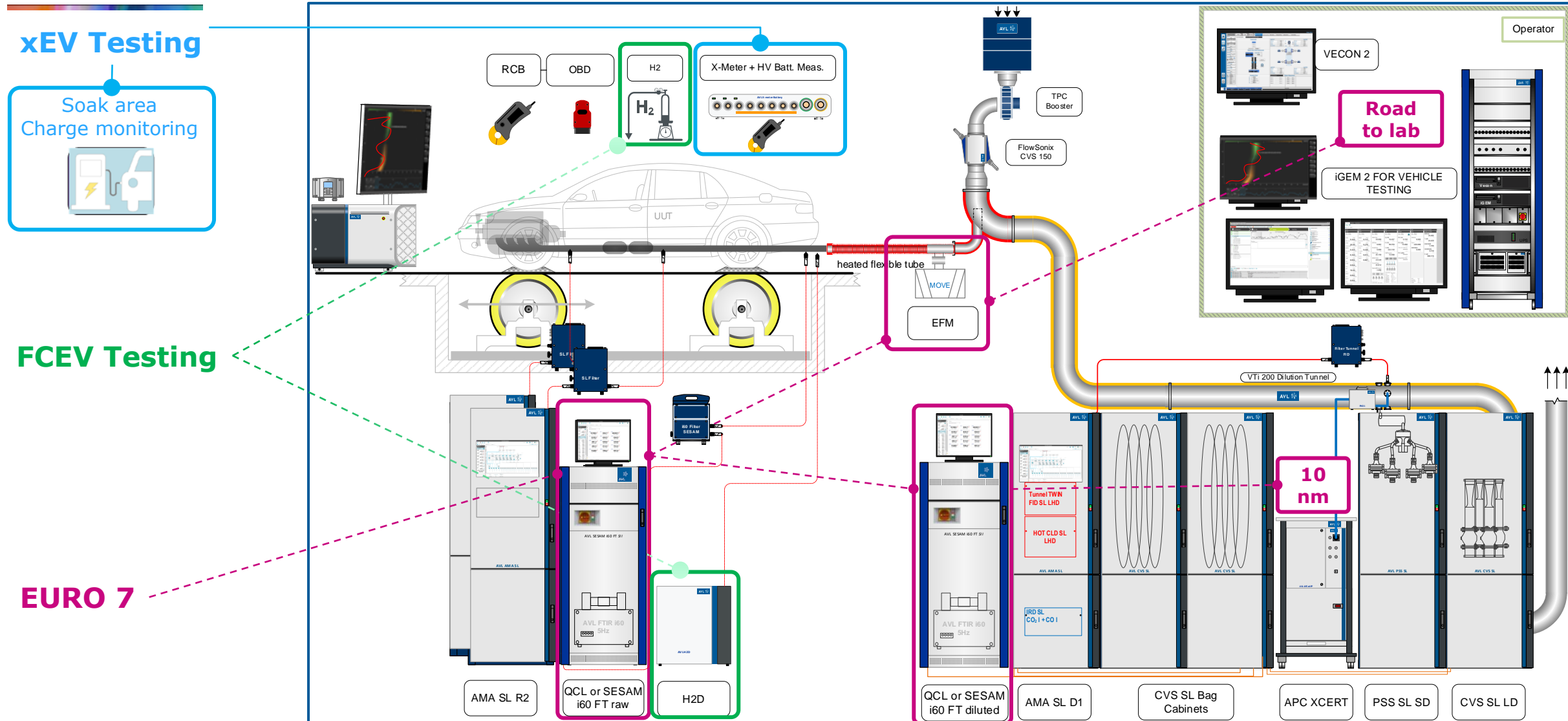
Neuss

rodolph.belleux@avl.com

Our agenda

- 1 The euro 7 test cell**
Emission system and energy consumption for a light-duty test cell
- 2 APC 10 nm**
What about 23 nm?
- 3 NH3 Measurement**
Study, Diluted and raw solutions
- 4 Euro 7 automation**
Road to Lab
- 5 PHEV and BEV Testing**
And automation of soak area
- 6 OEM Declaration**
Data traceability

Euro 7 - Light-Duty Test cell (Chassis dyno example)



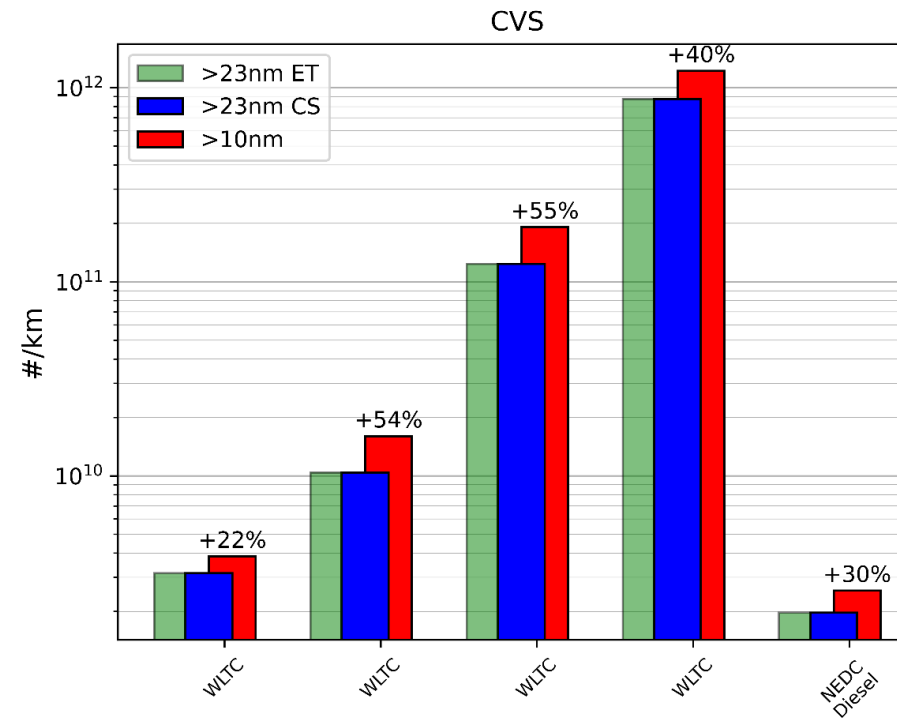
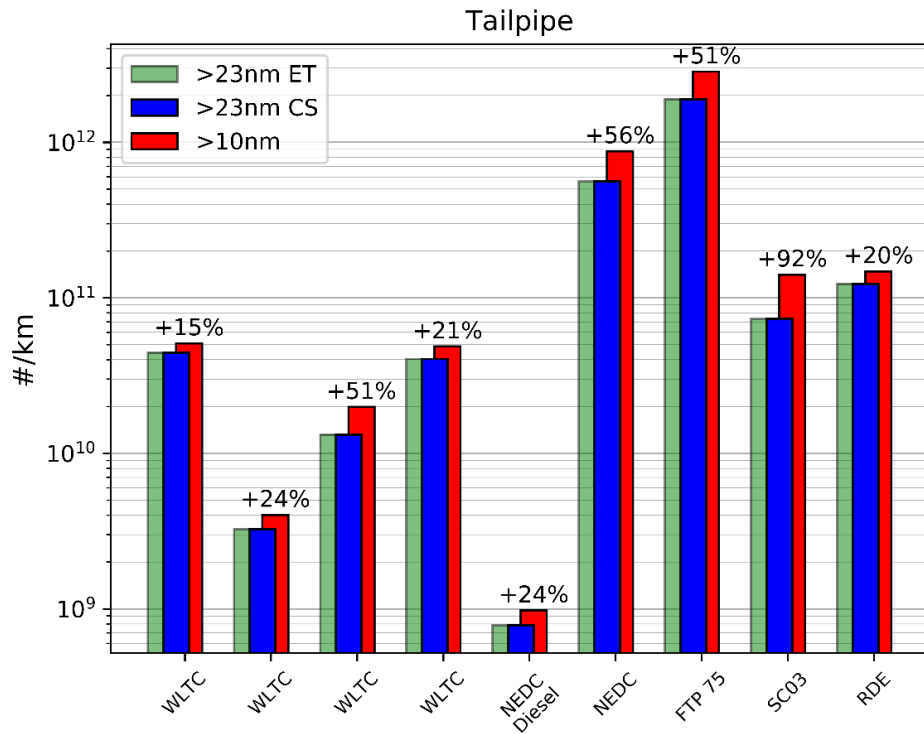


APC 10 nm

Testbed Application

APC xApp 10 Dual: Evaluation at chassis dyno bench

SPN emissions APC plus 23 & APC xApp 10 Dual



The SPN10 emissions are higher than the SPN23, ranging from +15% to +92%

Testbed Application

AVL APC xApp – Advanced Particle Counter

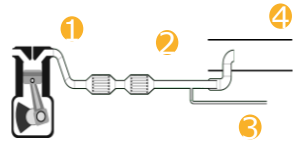
- **Increased Temperature** range from **-30°C - +45°C**
 - Full RDE area (-10°C – +45°C) and beyond supported
 - Cold Start PN measurements
- **Altitude extension from 0 – 3000m**
 - Full RDE area supported (China -2400m)
 - Research measurements in altitude test chambers
- **Best-in-Class Performance on Engine Out Measurements**
 - Duration of Engine Out (EO) measurements can be increased due to easy cleaning procedure, thus reduced down-time during operation
 - Market Leader on engine out applications
- **Measuring** with 2 CPCs in **parallel PN10 & PN23**
 - Simultaneous measurement for PN with actual valid cut-off (23nm) in comparison with next legislation draft (Euro 7 PN cut-off 10nm)



Testbed Application APC Variants

Section 1:
Particle pre-treatment:
Volatile Particle Remover

Section 2:
Core Sensor: **Condensation
Particle Counter**



- (1) Engine Out
- (2) Tailpipe
- (3) PFDS
- (4) CVS

APC xCert

APC xCert 10

APC xApp

APC xApp 10

APC xApp Dual

NEW

Volatile Particle Remover
Number of PCRF
AVL CPC
EU Legislation

Evaporation Tube (ET)
3
23nm
EU6/VI

Catalytic Stripper (CS)
3
10nm
Euro 7/VII

✓
✓
✓
✓
ET
16
23nm
EU6/VI

✓
✓
✓
✓
CS
16
10nm
Euro 7/VII

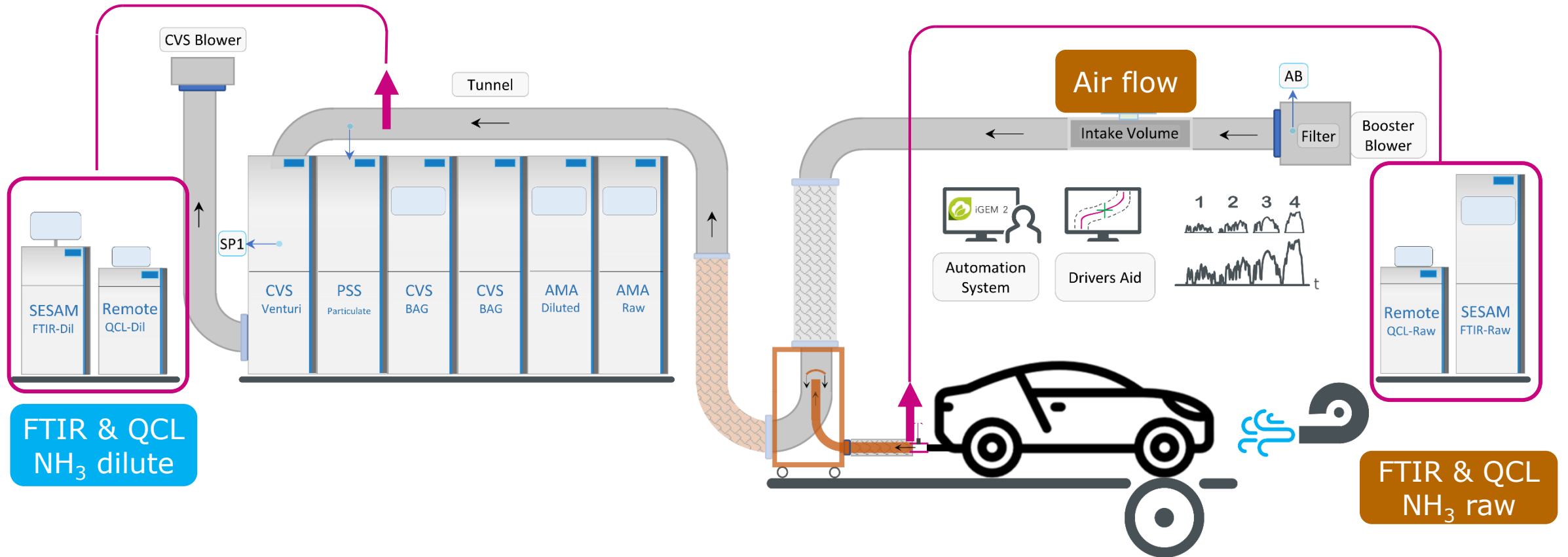
✓
✓
✓
✓
CS (ET)
16
1x 10nm, 1x 23nm
Euro 7/VII (EU6/VI)



NH₃ measurements

Vehicle Test Cell Experimental Setup

Goal: Test **NH₃** mass correlation **Raw to Diluted** and **FTIR to QCL**.

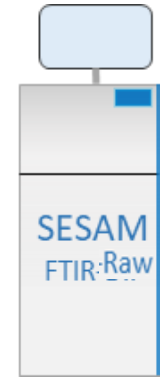


Ammonia Measuring Equipment FTIR and QCL



SESAM FTIR DILUTE (TUNNEL)

- AVL i60 FTIR spectrometer
- Gas cell 3.2m/ **Temp. 50° C**
- Spectral range 4000-650cm⁻¹
- Multi component stable calibration
- **Limit of detection NH₃ 0.03ppm**
- **Apart from NH3 many other components**



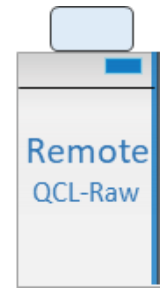
SESAM FTIR RAW (TAILPIPE)

- AVL i60 FTIR spectrometer
- Gas cell 3.2m/ **Temp. 191° C**
- Spectral range 4000-650cm⁻¹
- Multi component stable calibration
- **Limit of detection NH₃ 0.3ppm**
- **Many other components measurable**



AMA QCL DILUTE (TUNNEL)

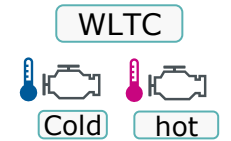
- AVL QCL i60 spectrometer
- Gas cell 9.6m/ **Temp. 60° C**
- Wavelength Modulation 1kHz
- **Limit of detection NH₃ 0.01ppm**



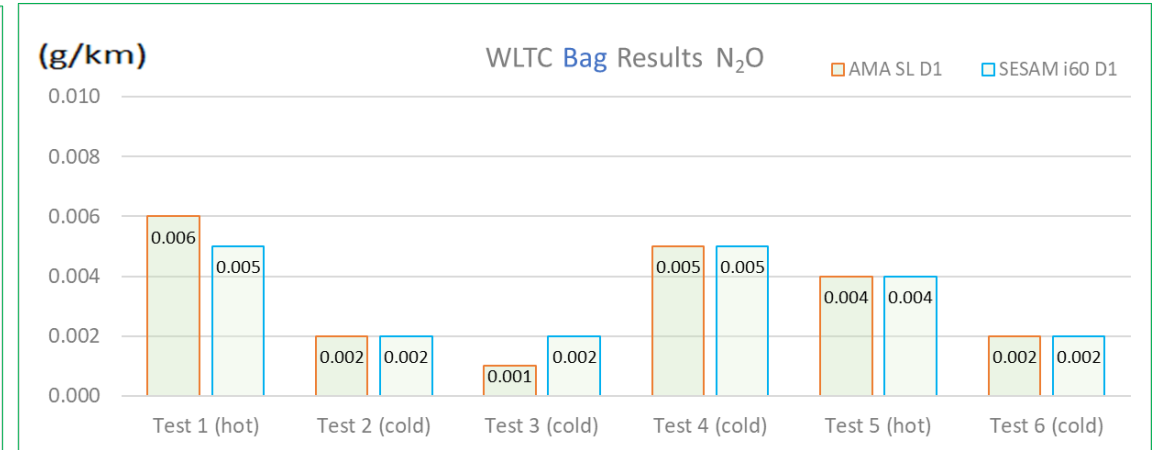
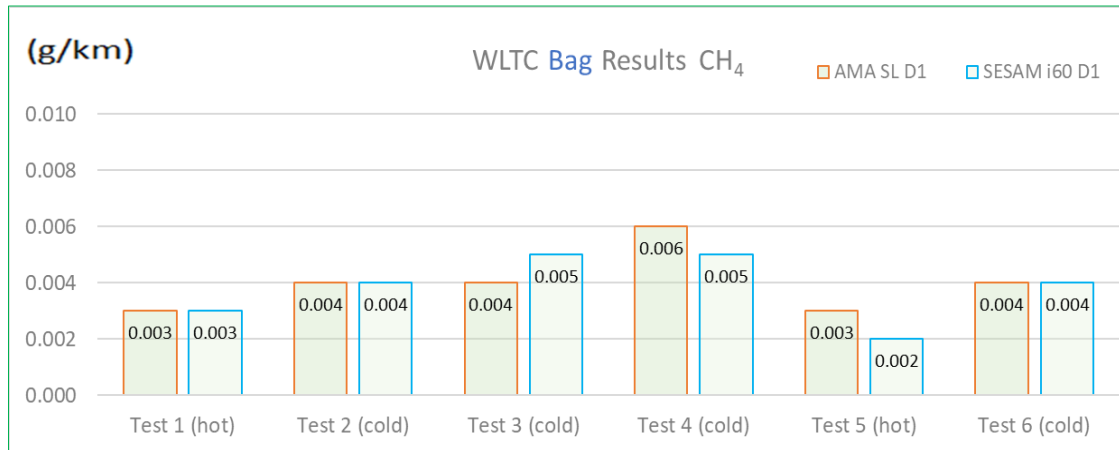
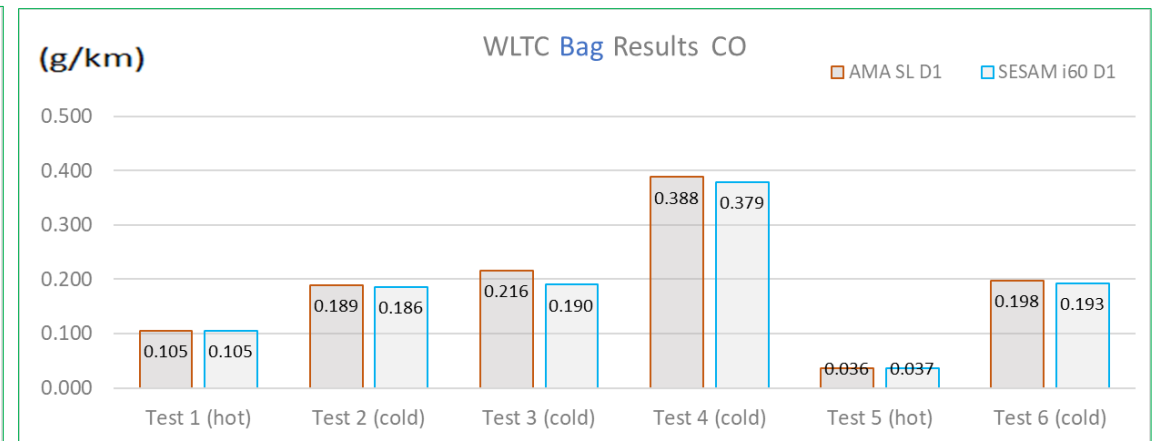
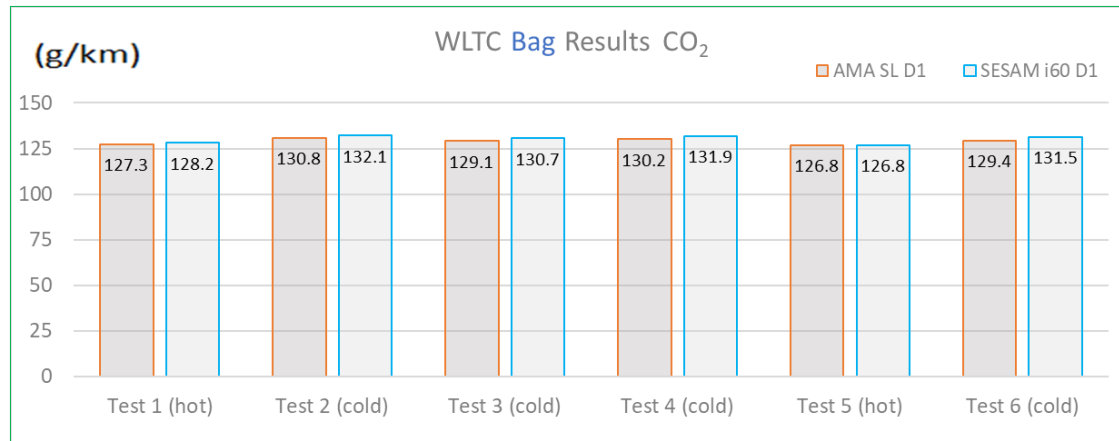
AMA SA QCL RAW (TAILPIPE)

- AVL QCL i60 spectrometer
- Gas cell 5m/ **Temp. 191° C**
- Wavelength Modulation 1kHz
- **Limit of detection NH₃ 0.15ppm**

Series of Six WLTC Test Results

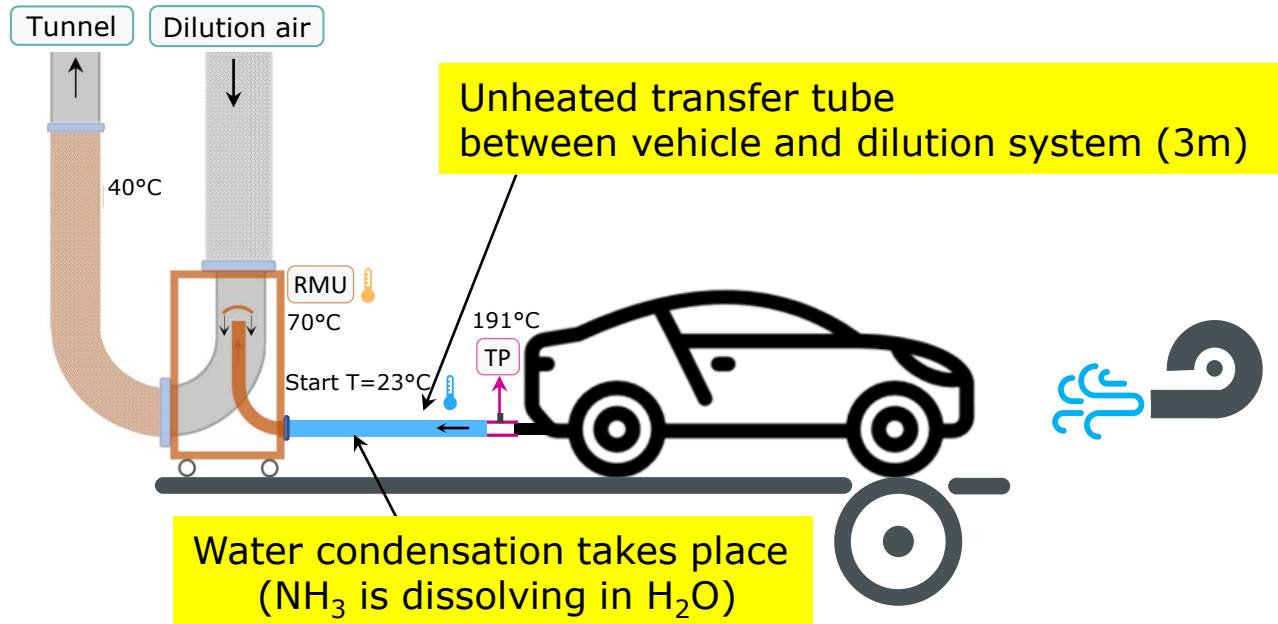


Comparing System Performance between AMA SL D1 vs. SESAM i60 D1 Bag Emission Measurements



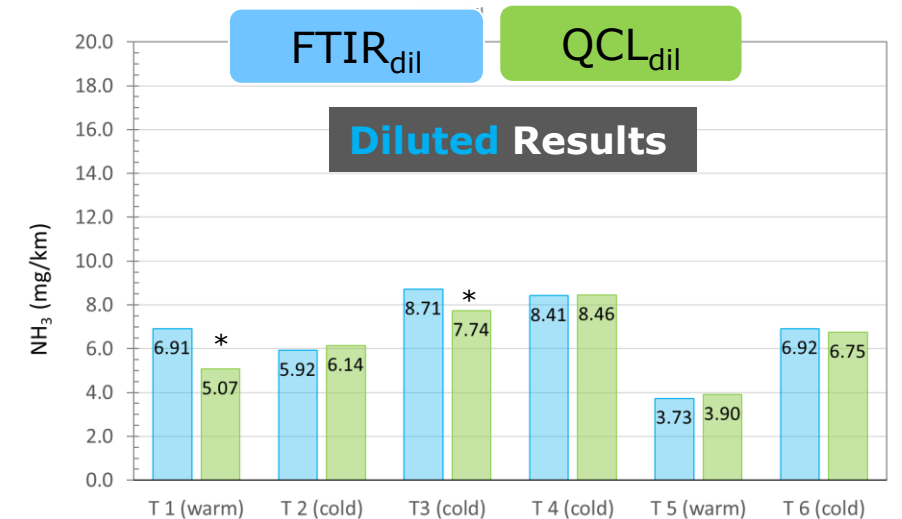
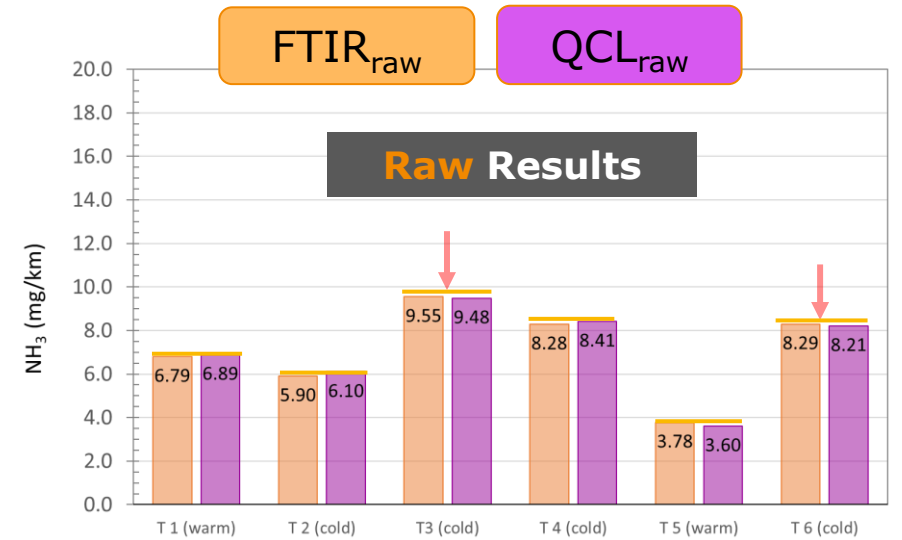
Good performance for standard components

WLTC NH₃ Tests with **unheated** transfer tube



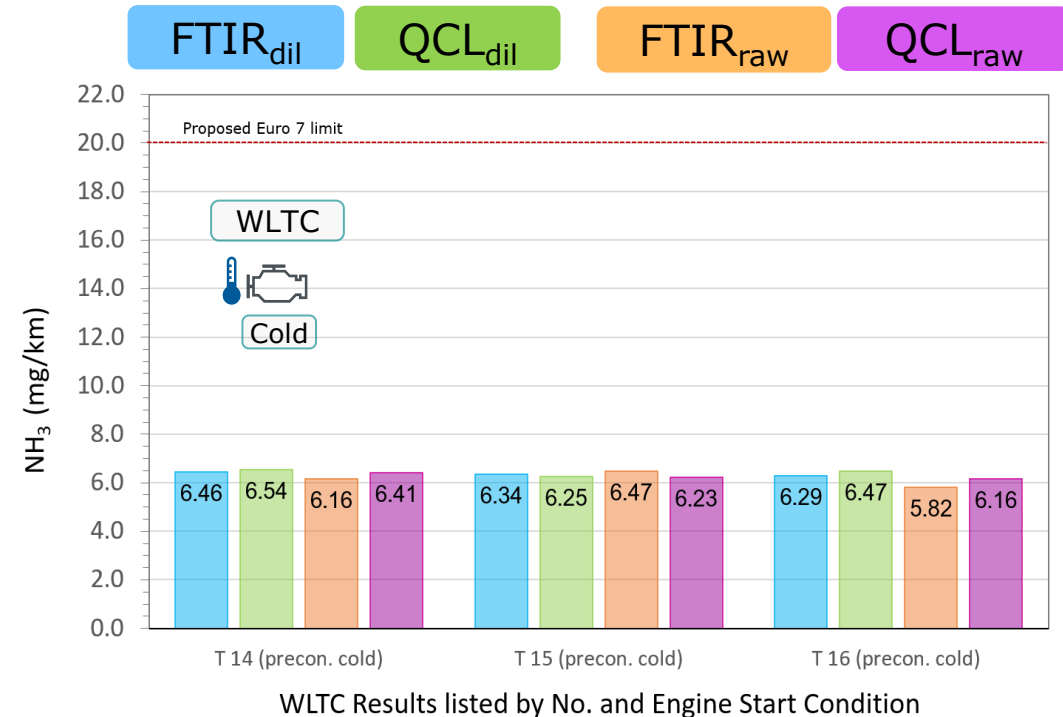
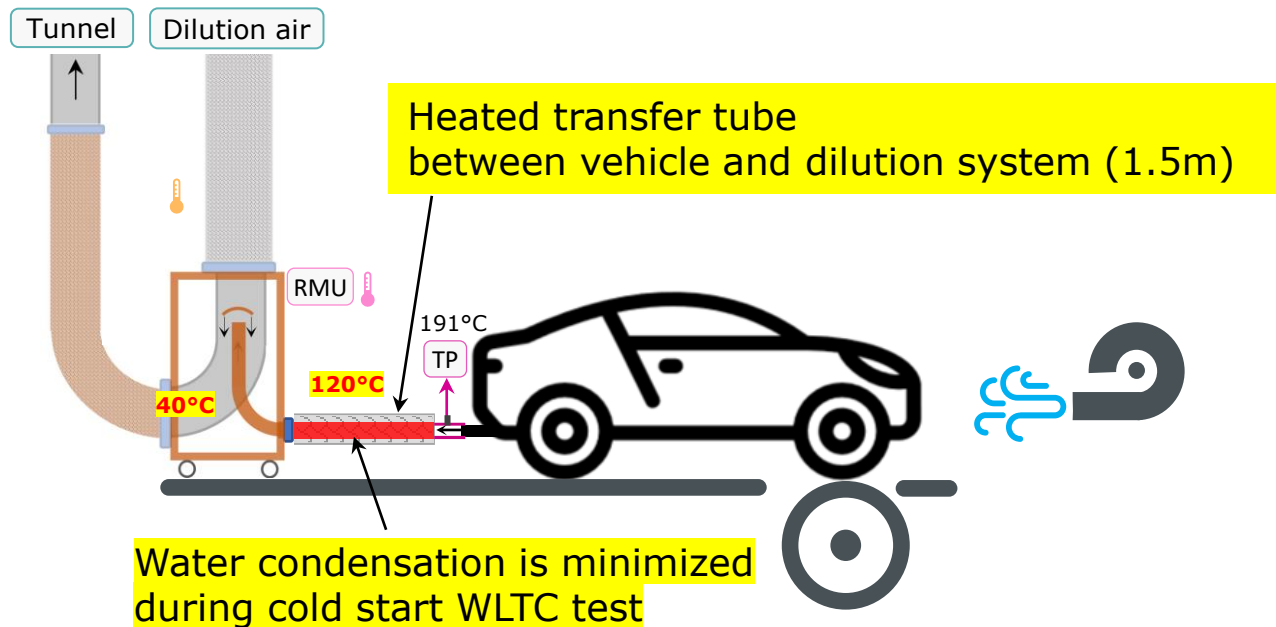
NH₃ + H₂O

Solubility of NH₃: 90 g per 100 mL at 0 °C
Euro 7 limit: 20 mg / km



WLTC Results listed by No. and Engine Start Condition * Calibration issue

WLTC NH₃ Tests with **heated** transfer tube

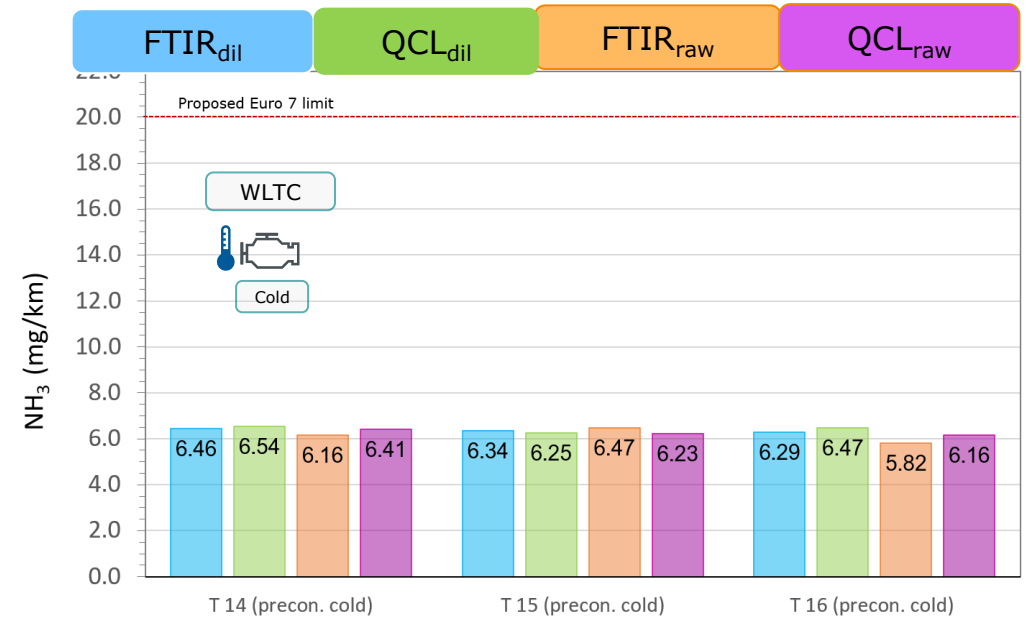
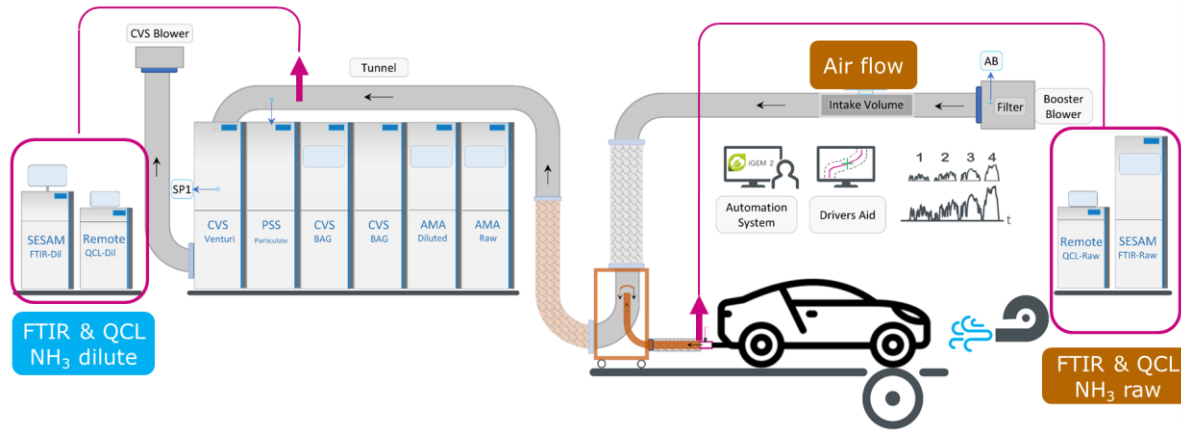


- A series of 3x WLTC were conducted with pre-conditioning and soak-procedure before start of test (cold condition).
- Heating of both transfer tube and Remote Mixing T considerably avoids water condensation in transfer tube and evaporates liquid out of tailpipe

NH₃ diluted measurement works well

Excellent correlation between diluted tunnel and raw tailpipe measurement

Diluted NH₃ measurement: easy handling and best repeatability



WLTC Results listed by No. and Engine Start Condition

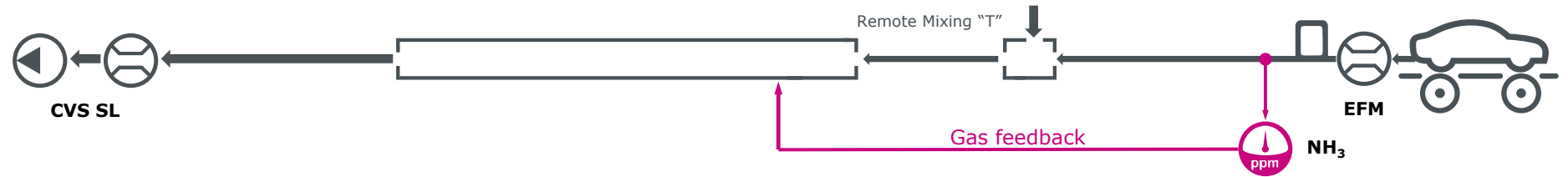
- NH₃ diluted measurement more stable from test to test
- CVS is robust and proven & tested method
- No additional method to measure the exhaust flow necessary
- No bag mass correction or gas feedback
- No delay time management
- No handling efforts for EFM or raw NH₃ sampling

Euro 7_{Light-Duty}: NH₃ Sampling



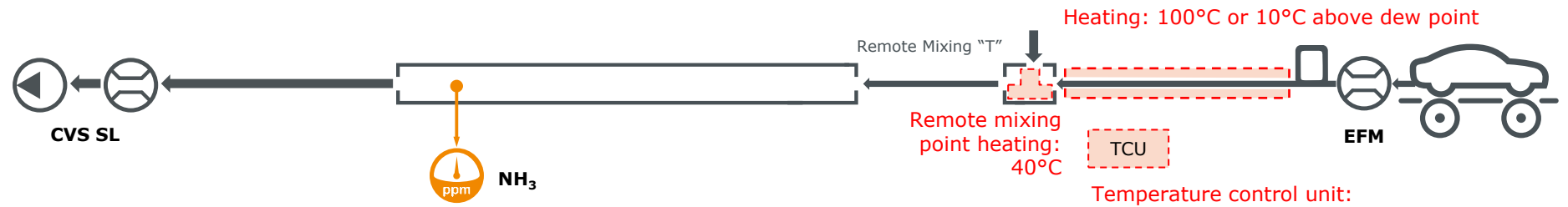
Raw exhaust:

Sampling requirements can be taken from GTR-15



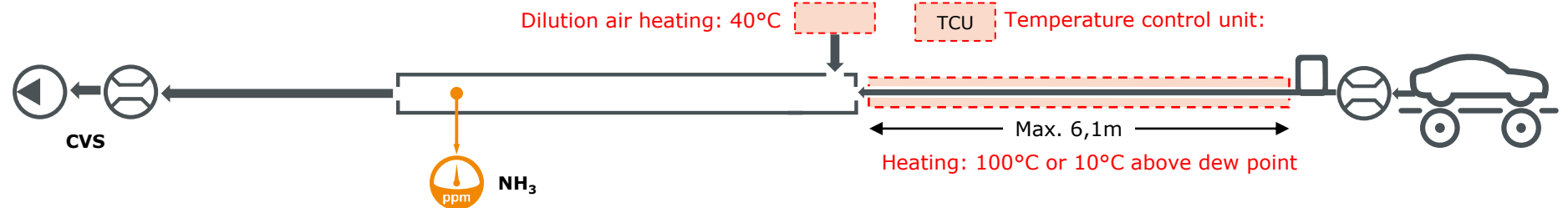
Diluted exhaust with remote Mixing-T:

- Heated transfer line and mixing point needed.



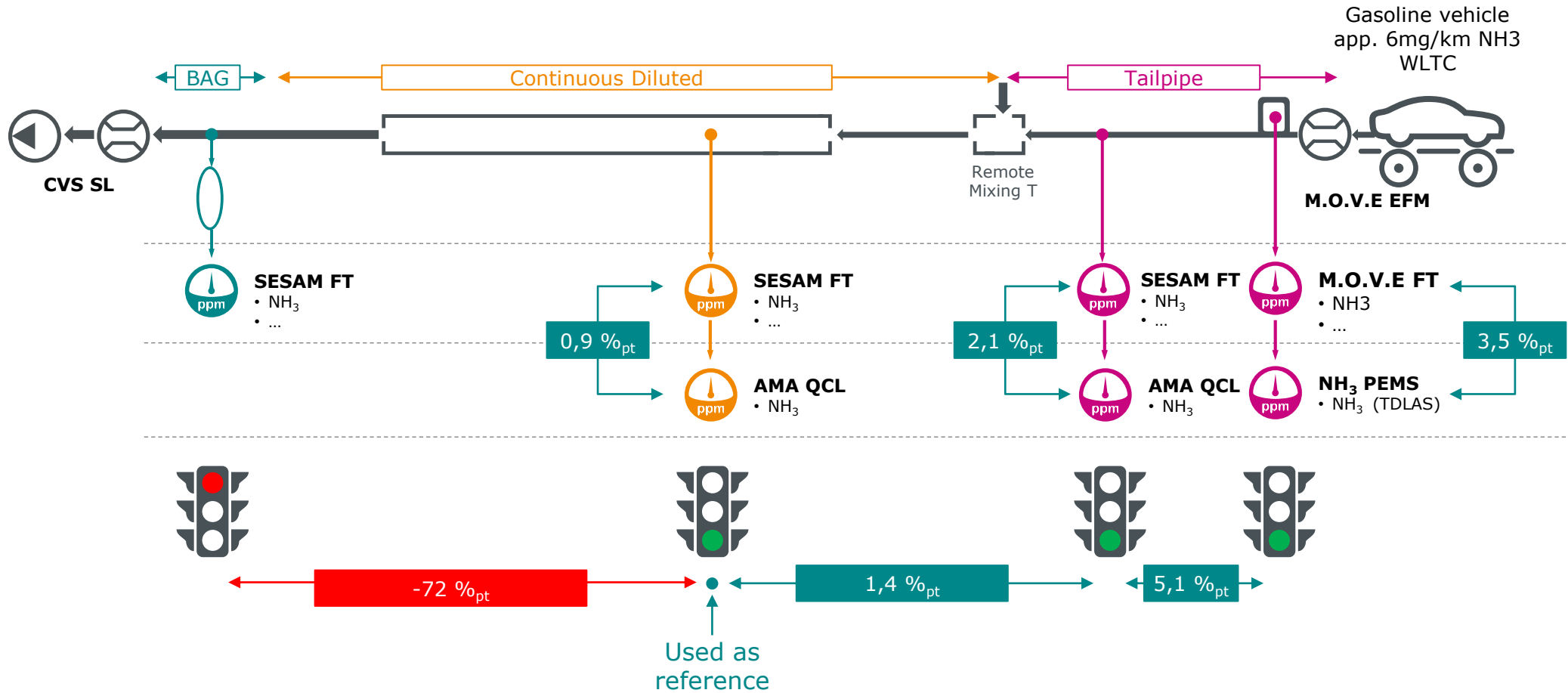
Diluted exhaust with dilution tunnel:

- Heated transfer line and dilution air heating needed.



Note: Heated transfer lines will also be needed for engines operated on H2 fuel

Euro 7_{Light-Duty}: NH₃ Results



Data based on AVL Euro 7 testing exercise, Gaggenau, 13.-19.04.2023: Data are average of 3 WLTC tests with a gasoline car app. 6mg/km NH₃

NH3 verifications/Checks

Linearity requirements for FTIR technology

Heavy-Duty - R49-Rev.6

A.7.4.1. Linearity requirements

The analyser shall comply with the linearity requirements specified in Table 7 of this annex. The linearity verification in accordance with paragraph 9.2.1. of this annex, shall be performed at least every 12 months or whenever a system repair or change is made that could influence calibration. With the prior approval of the Type Approval Authority, less than 10 reference points are permitted, if an equivalent accuracy can be demonstrated.

GTR-15

FTIR: **linearity** verification

Within 370 days before testing

See paragraph 7.1. of this annex.

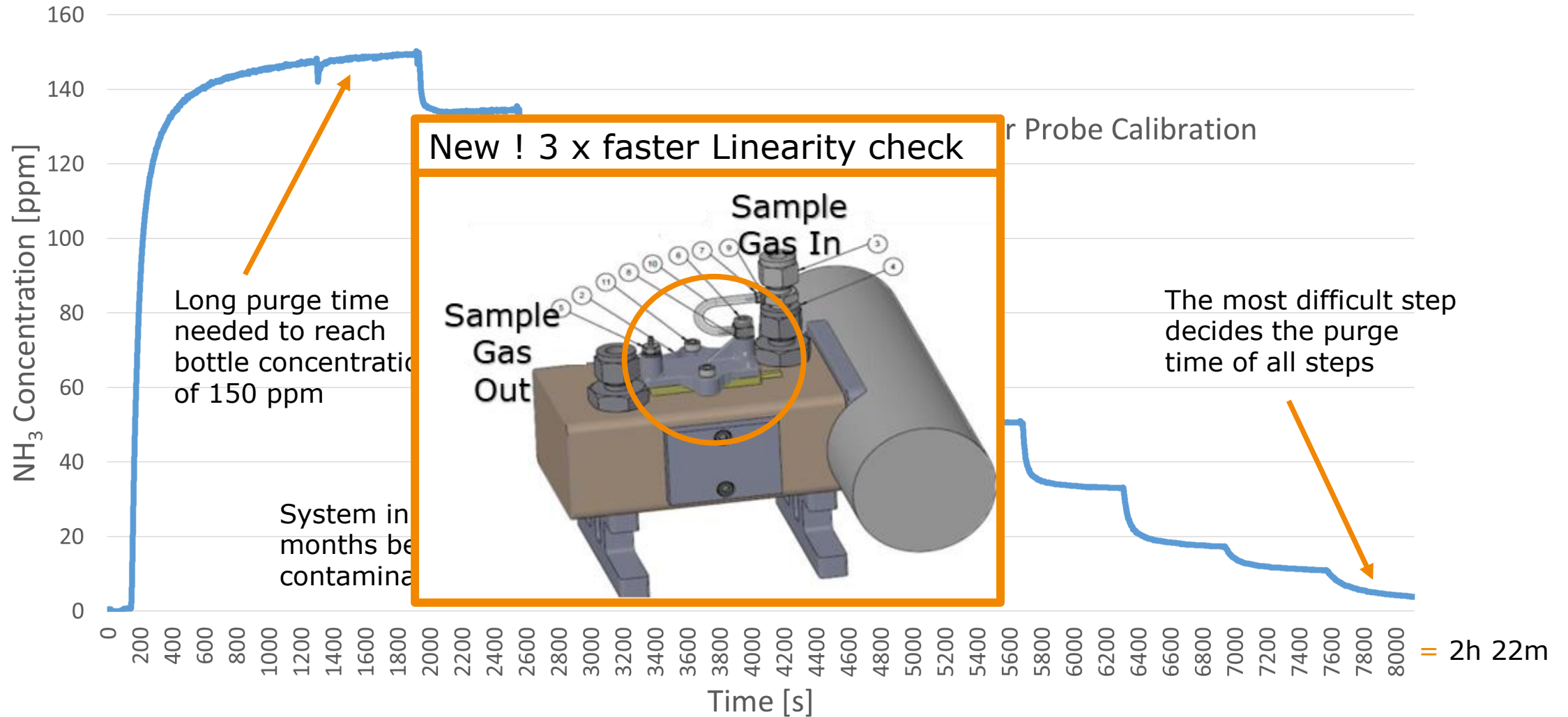
40 CFR 1065

Type of calibration or verification	Minimum frequency ^a
	<i>Gas dividers:</i> Upon initial installation, within 370 days before testing, and after major maintenance.
	<i>Gas analyzers (unless otherwise noted):</i> Upon initial installation, within 35 days before testing and after major maintenance.
	<i>FTIR and photoacoustic analyzers:</i> Upon initial installation, within 370 days before testing and after major maintenance.

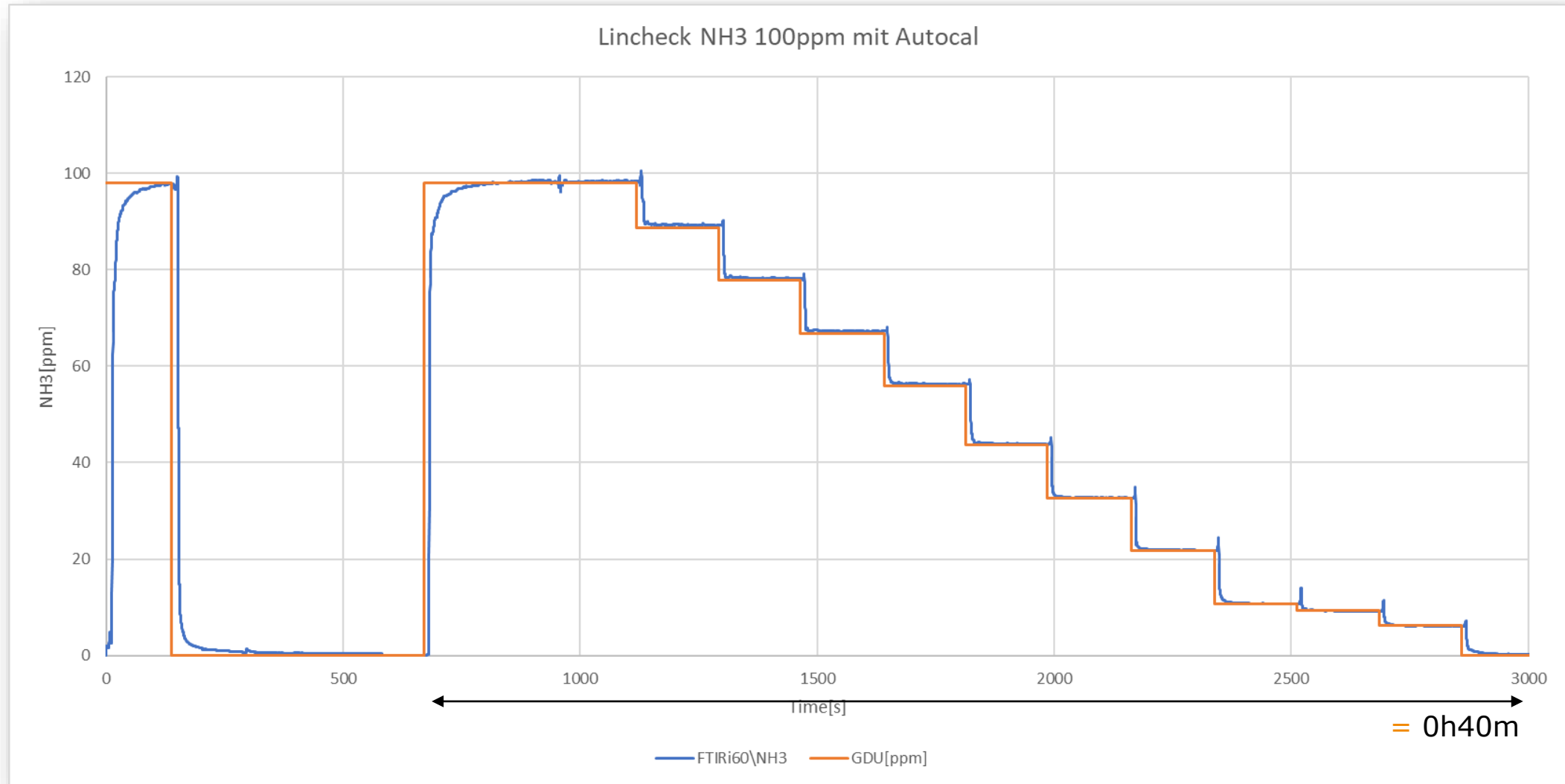
Linearity verification for Quality check for FTIR: every year.

Linearization: never (Only when recalibrating the whole spectrometer. After 5 years, oft 8 years)

NH₃ Linearity Check – via probe system



Lincheck with CalDir





Automation

Road to lab

Euro 7_{Light-Duty} Automation system

iGEM 2 functions:

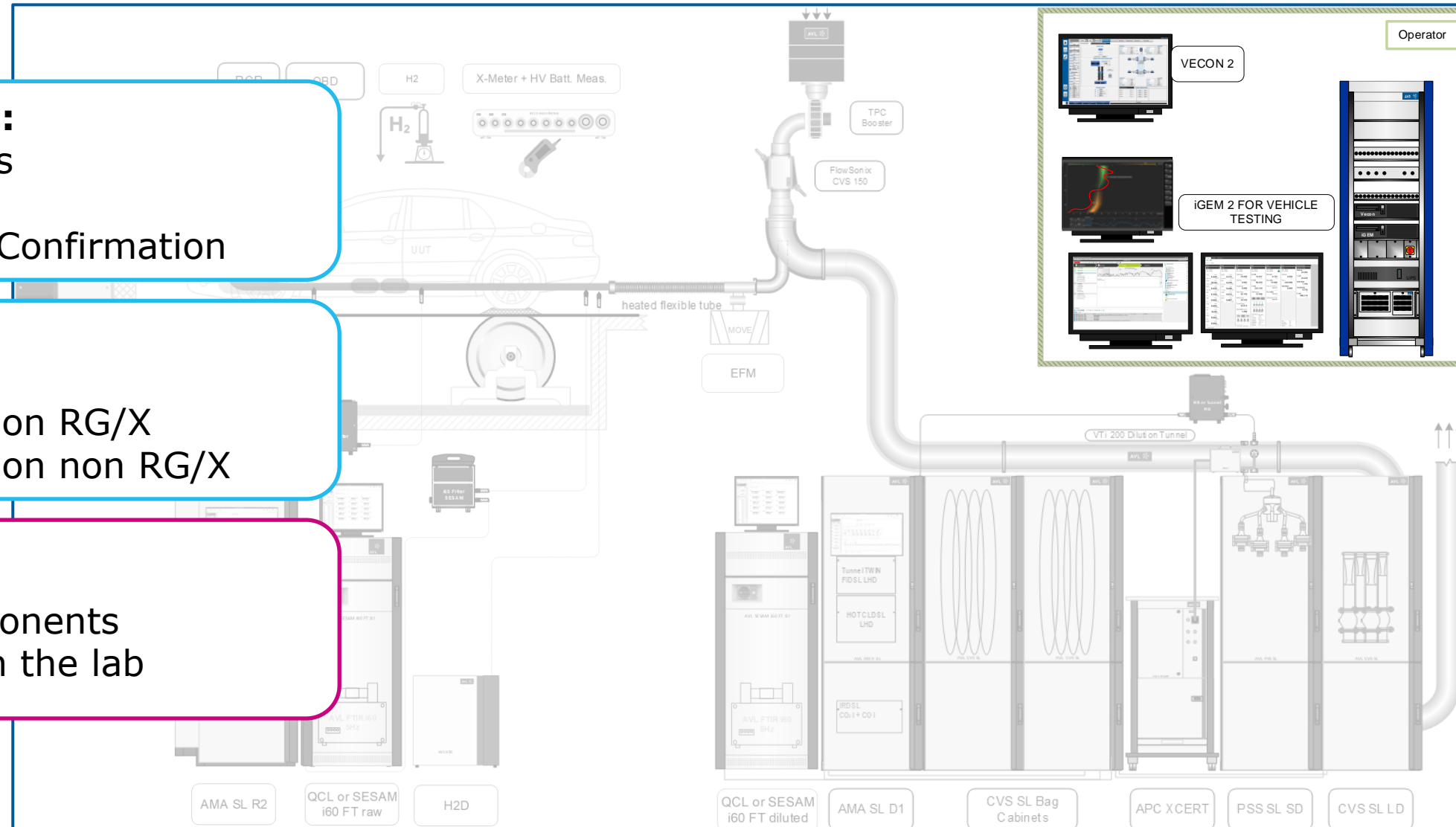
- Road to lab tests
- R&D Tests
- Supports PEMS Confirmation

iGEM 2 Cycle:

- RTS 95
- Cycle reproduction RG/X
- Cycle reproduction non RG/X

Post-processing

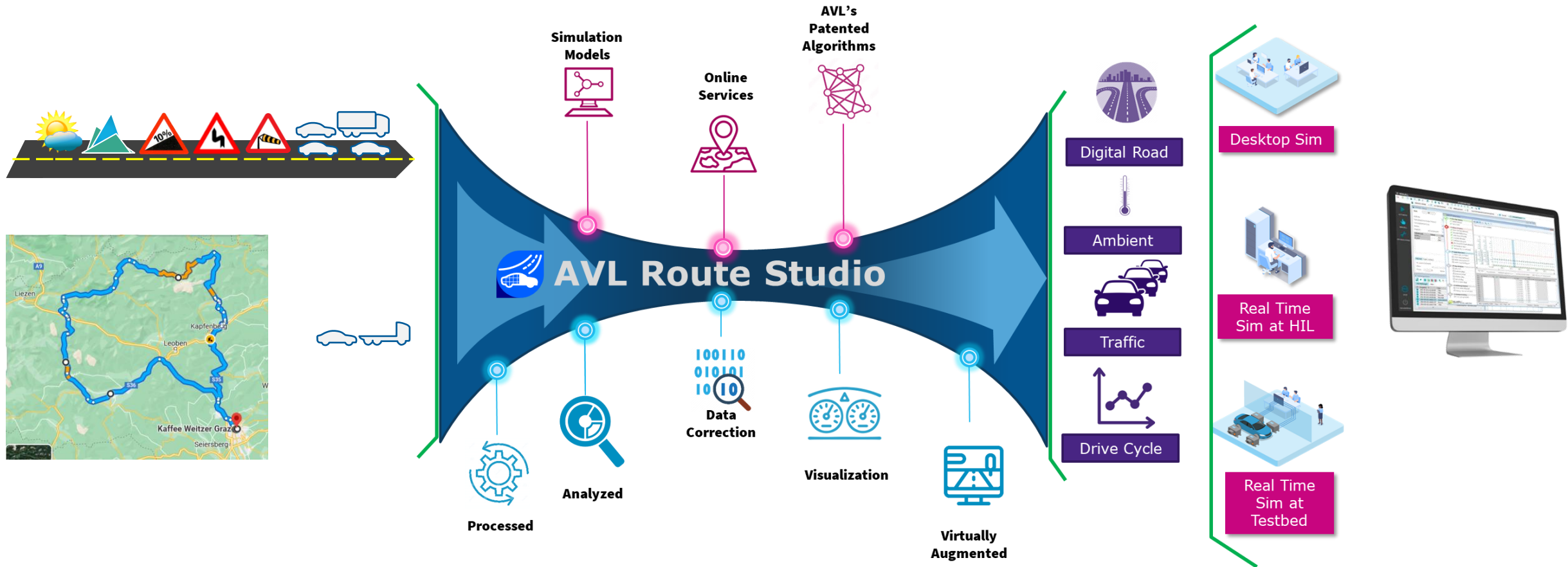
- Additional components
- RDE reporting in the lab



Route Studio

Enabler of road to lab solutions

From road or from online maps: create/reproduce at the testbed.
Enrich with additional variations (weather, driver, traffic, etc...)





BEV solutions for euro 7

Euro 7^{Light-Duty} BEV Chassis Dyno

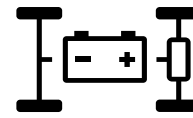
Already supports SMCT+ testing !

BEV (and xHEVs) specific products

- iGEM Charge Monitoring 

- iGEM 2 for BEV 

- X-Meter 



Hybrid Soak Area

X-Meter + current clamp
(for soak area measurements)



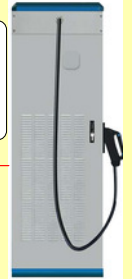
OPTION

iGEM Charge
Monitor

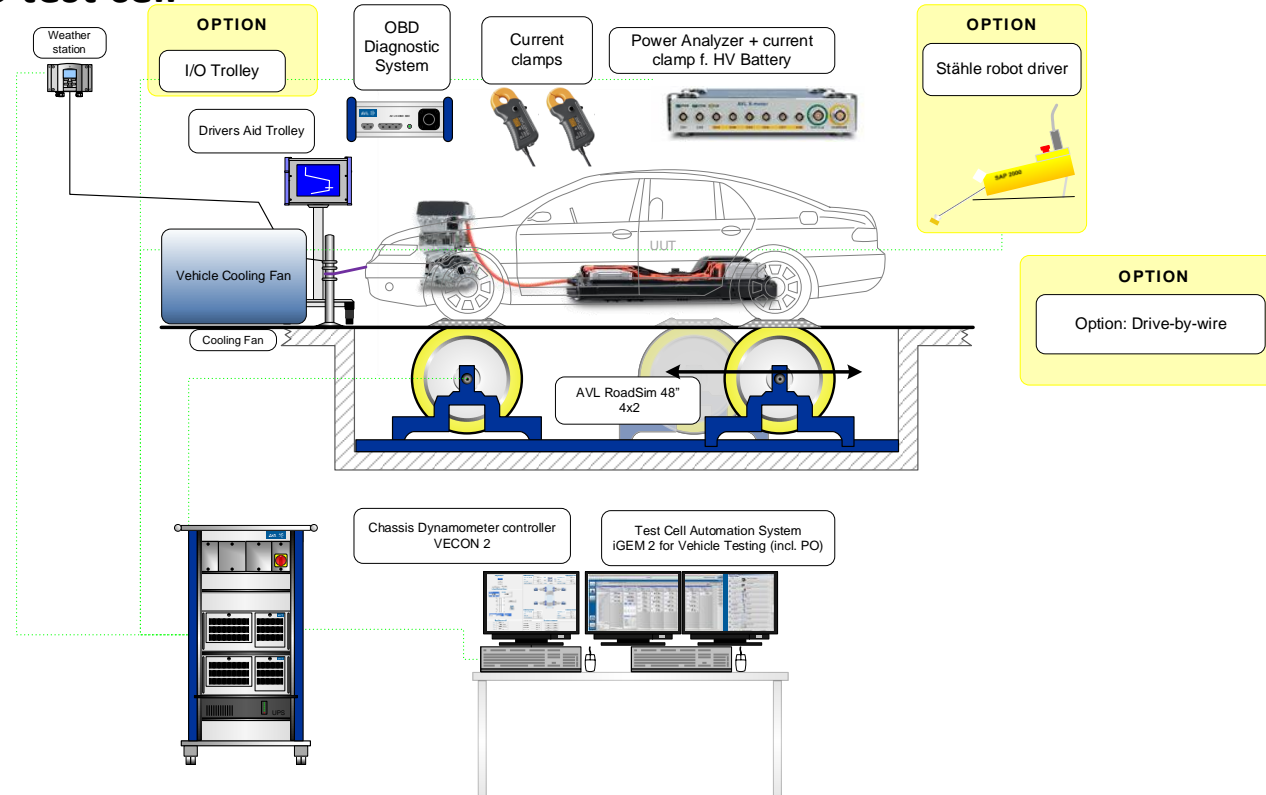


OPTION

Charger
- Fast Charger (DC)
- AC Charger
(mandatory by legislation)

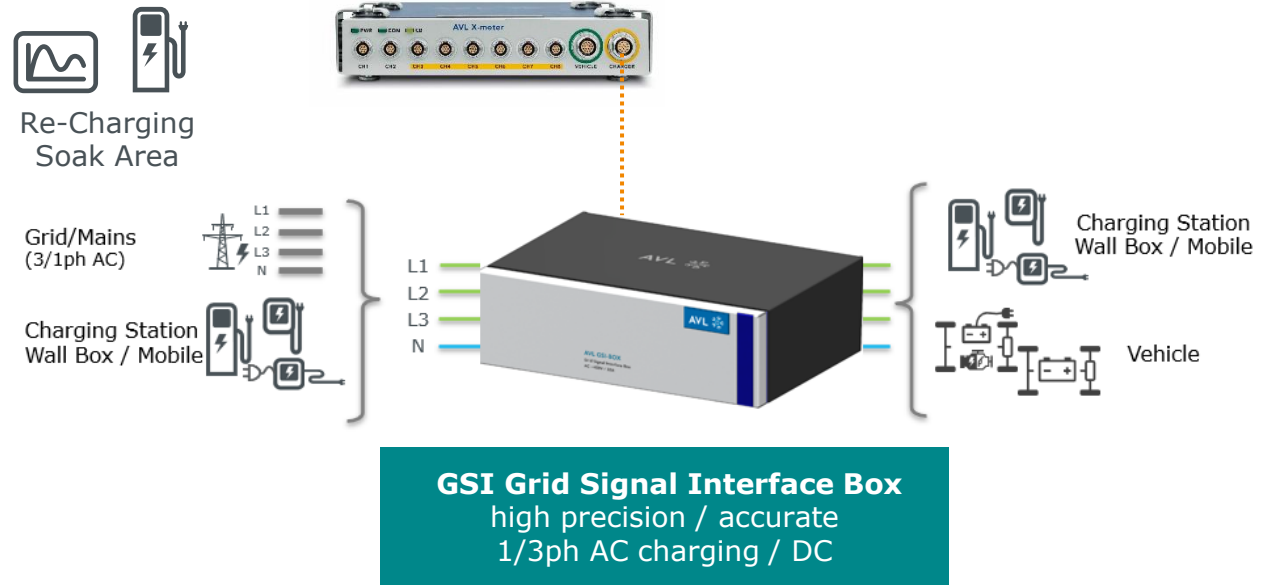
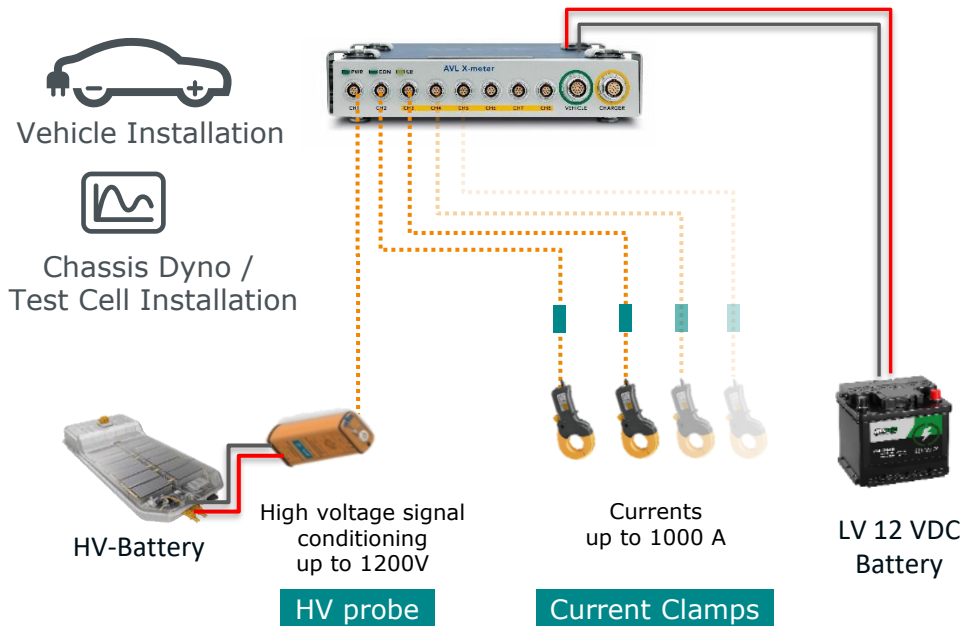


Chassis dyno test cell



Euro 7 Light-Duty BEV AVL X-meter

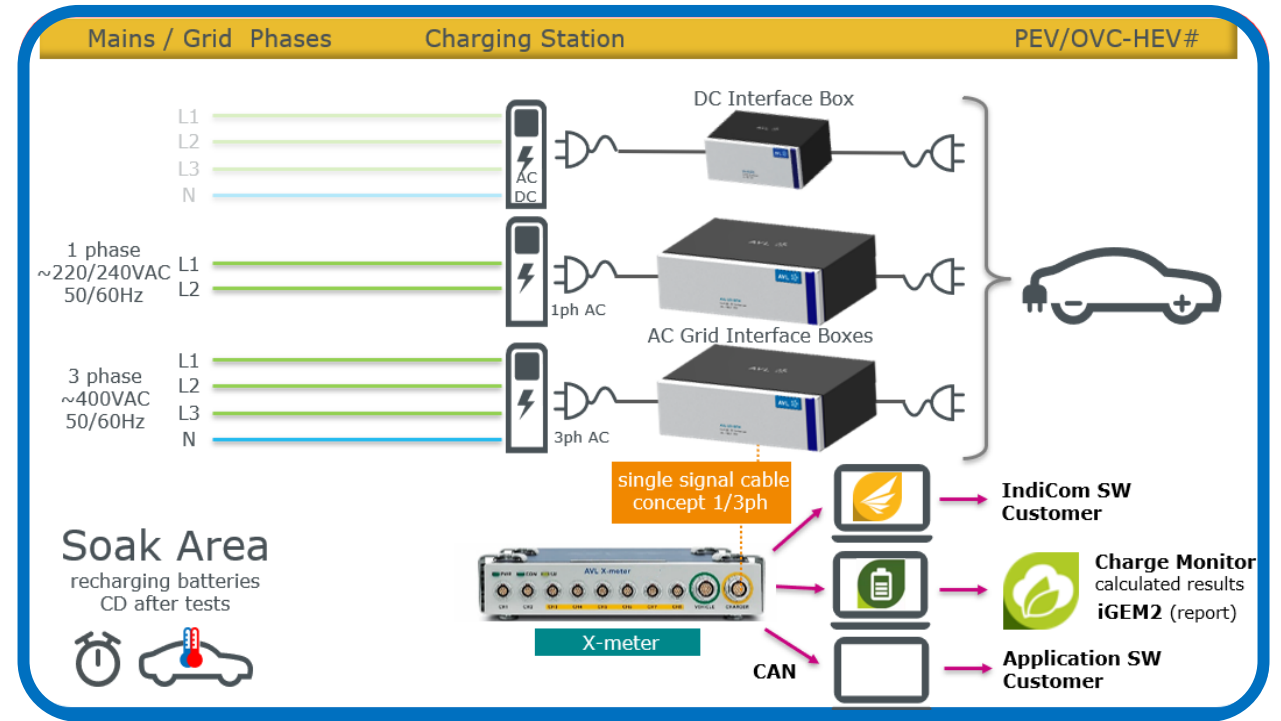
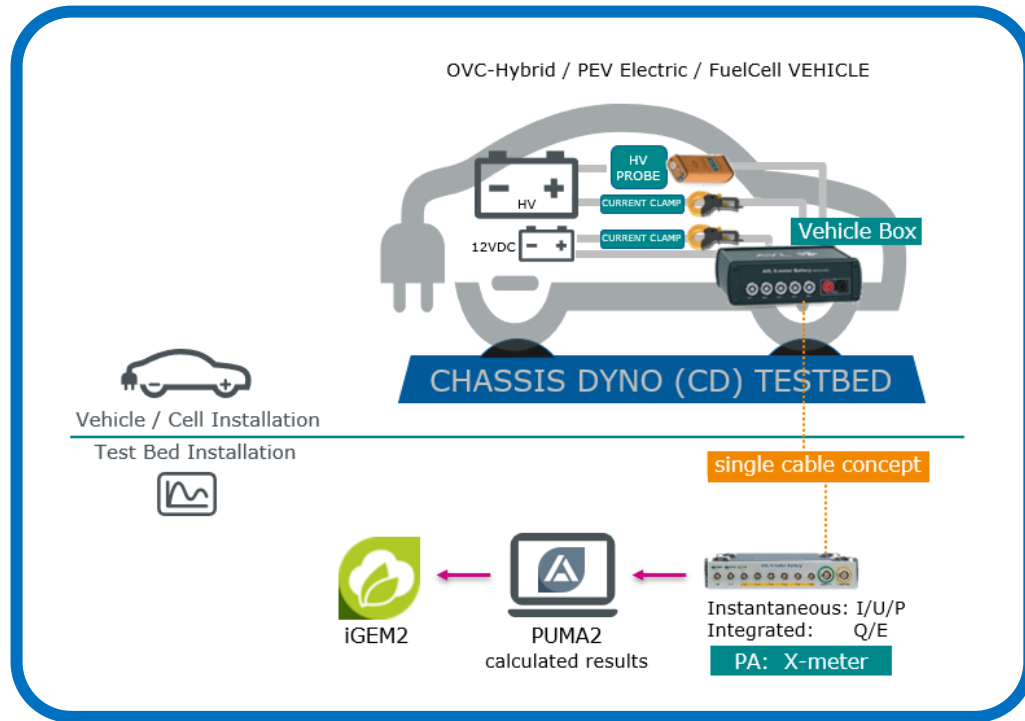
X-meter System



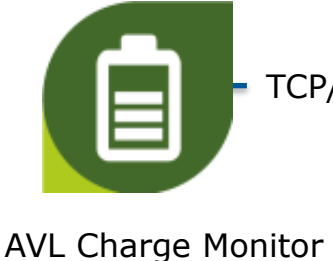
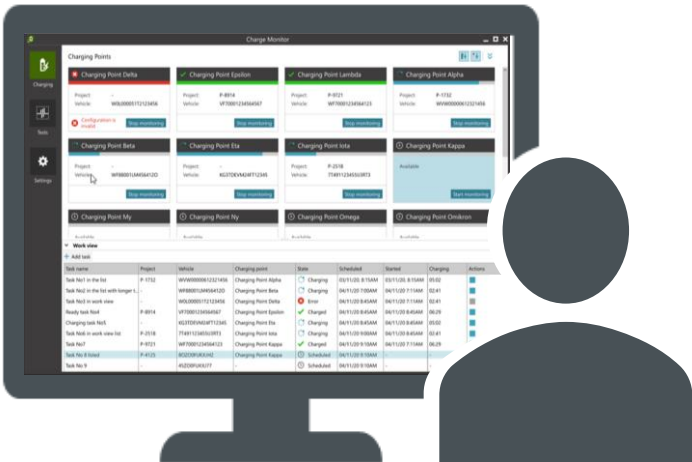
Euro 7_{Light-Duty} BEV

Electric energy consumption of all REESS

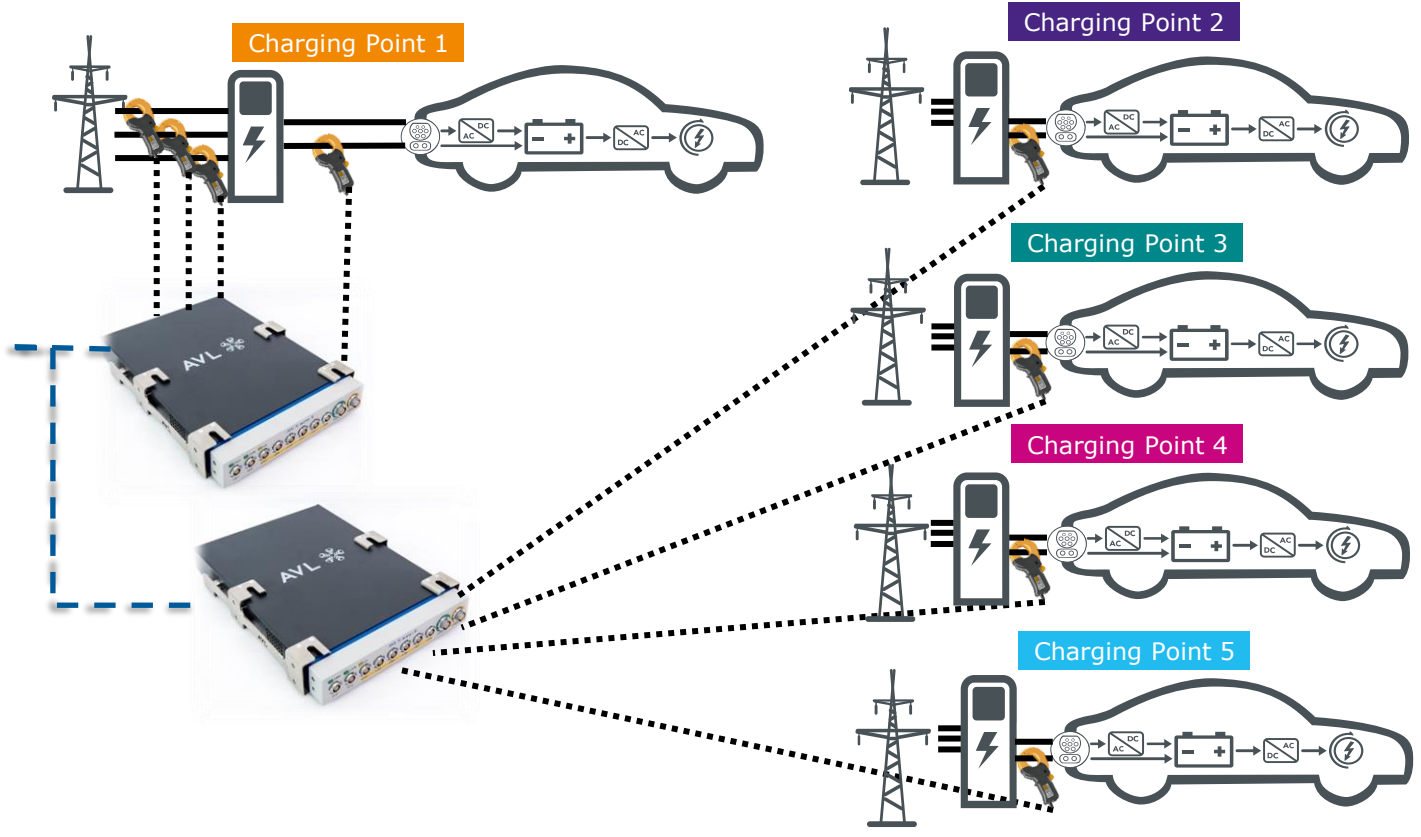
High mobility thanks to interface boxes



Euro 7 Light-Duty BEV AVL CHARGE MONITOR



TCP/IP





OEM Declaration

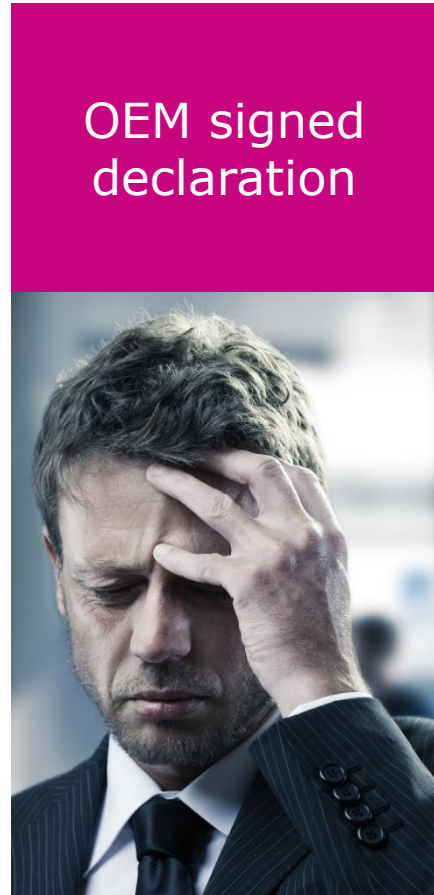
OEM (signed) Declaration text for EU7

2. The manufacturer shall provide the type-approval authority with a signed declaration of conformity as regards the RDE, CO₂ ambient temperature correction, OBD, OBM, emission and battery durability, continuous or periodic regeneration, anti-tampering and crankcase requirements as specified in Annex V. The manufacturer shall provide to the type-approval authority a signed declaration of conformity on the use of adaptive controls and geofencing options when the manufacturer selects these options.

Regulatory Compliance – Workflows -



NEW

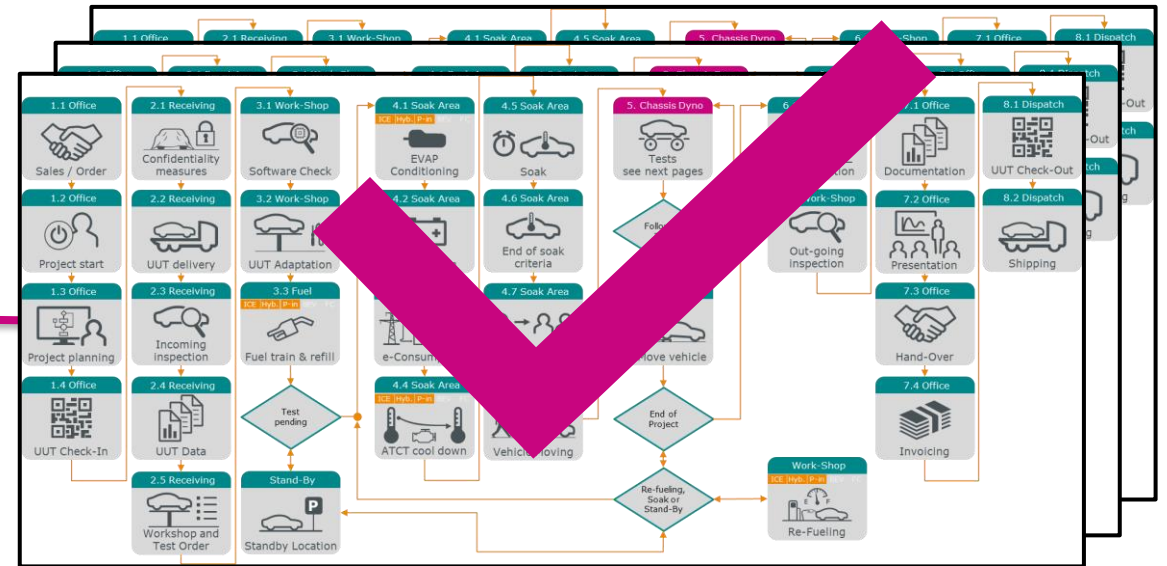


* From Kurt Engeljehringer

CERTIFIED TRUE COPY

This ___ day of _____ 20__

Head of Product Development



OEM representative must sign declaration for type approval process and vehicle compliance, with legal implications!

Comparison of certification over time and regions



Euro 6

Precisely defined conditions

Defined cycle

Precisely defined RDE

Technical service responsible



Precisely defined conditions

5 x defined cycles

On-road as defeat device search

Self-certification



Euro 7

Very large conditions

No defined cycle

RDE

Signed declaration

Powertrain Development Process

NEW

OEM Declaration

Type Approval

In-Service

Concept

Development

Concept

Simulation

Powertrain Elements

Elements Testing

Road testing

Chassis Dyno testing

Powertrain Testing

Propulsion Testing

HiL Testing

Simulation Level 4

Simulation Level 3

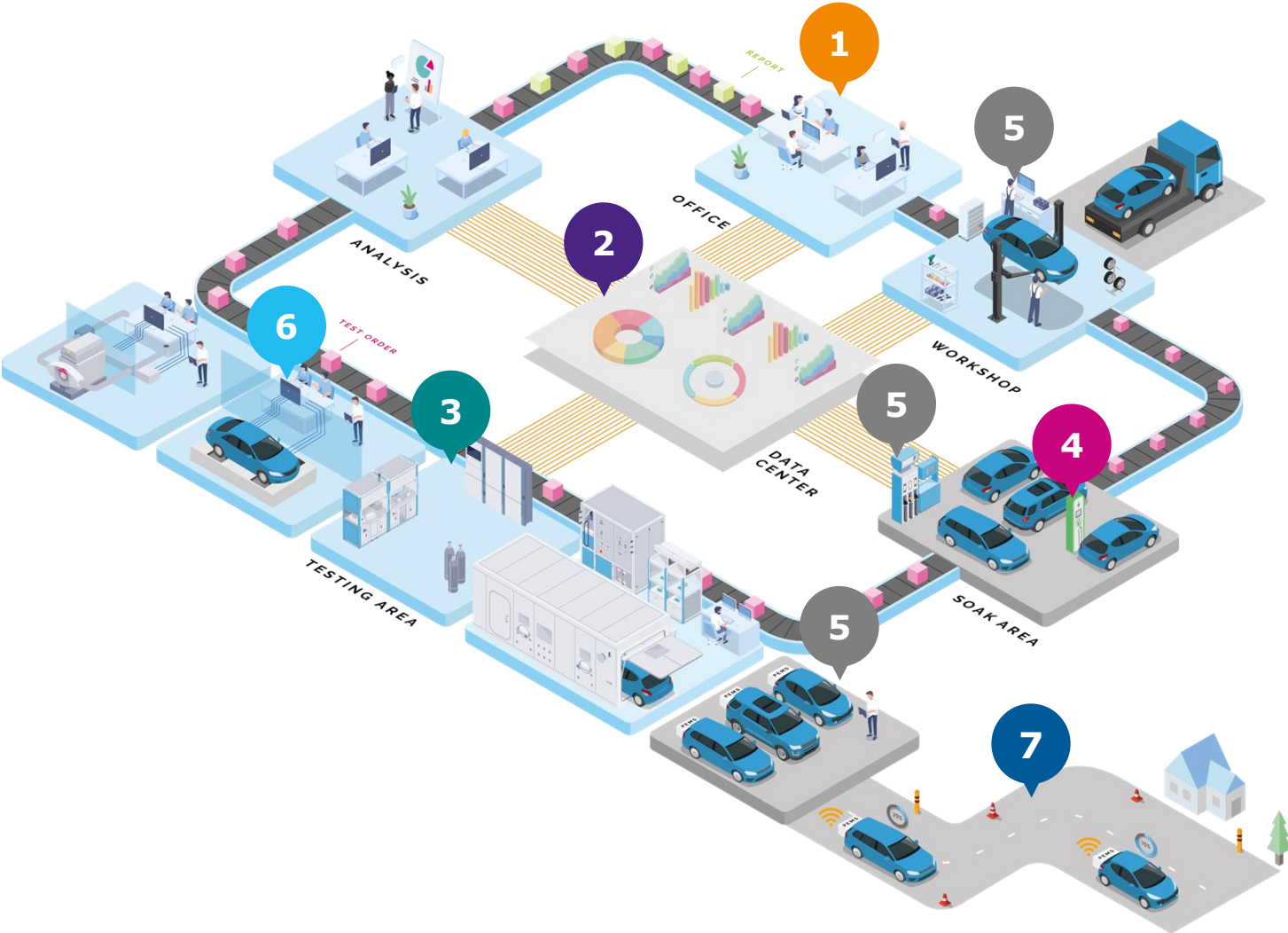
Simulation Level 2

Simulation Level 1



Not all cases can be covered on the road, need to use all simulation levels to prepare OEM declaration

AVL Lab Management™ – Vehicle Testing



AVL Lab Management™ for Vehicle

1	ASSET & PROCESS CONTROL	MONITORING
2	DATA MANAGEMENT	DATA INTELLIGENCE

Process Control Modules

3	CAL. GAS MANAGEMENT	PARTICULATE MATTER MANAGEMENT	
4	CHARGE MONITORING	SOAK AREA MONITORING	VEHICLE TRACKING

- 5** Manual Workstations
- 6** Test Automation
- 7** Road Testing

AVL – Euro 7 ready



AVL exhaust gas measuring equipment – product portfolio

Thank you



www.avl.com