JINAN 济南, CHINA 中国, 2023

FEV IUPV TEAM FEV IUPV 团队

PREPARED FOR

11TH INTERNATIONAL CONFERENCE OF ICE RELIABILITY TECHNOLOGY
第11届内燃机可靠性技术国际研讨会

OPTIMIZATION OF OIL CHANGE INTERVALS UNDER ULTRA-LOW EMISSION REQUIREMENTS

超低排放要求下的换油周期优化

AGENDA

INTRODUCTION / EFFECTS OF OIL DETERIORATION

IUPV OVERVIEW

IUPV CYCLES

IUPV CLIENTS

IUPV SIMULATIONS

IUPV OIL DILUTION VALIDATION RESULTS

SUMMARY

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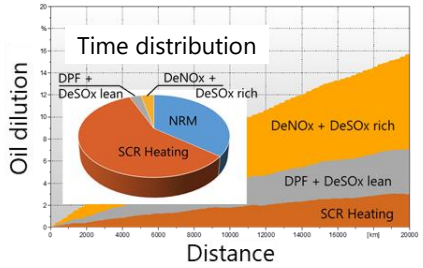
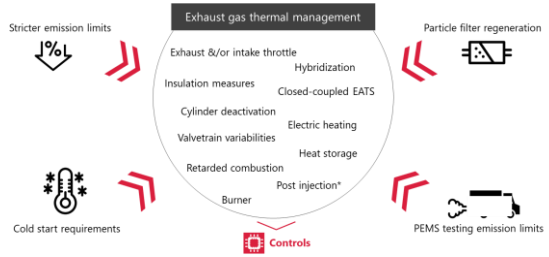
IUPV supports the oil change interval calibration for ultra-low emission requirements of modern combustion engines

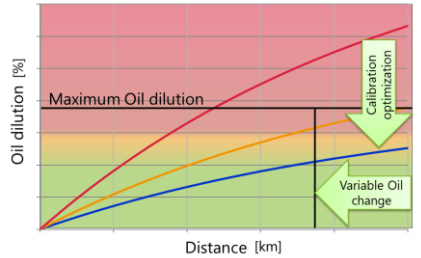
INTRODUCTION / EFFECTS OF OIL DETERIORATION - MOTIVATION



New combustion modes (Heating, richmode,…) increase oil dilution



Emission legislation requires new aftertreatments and heat up concepts



Need for optimization of calibration and variable oil change interval

Lifetime simulation

RDE simulation

FEV IUPV In Use Performance Validation

Oil deterioration simulation

Ki-factor simulation

FEV IUPV supports oil change interval calibration

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IUPV principle uses real driving cycle data for simulation purposes

OVERVIEW OF IUPV PRINCIPLE

Input data	IUPV-Simulation	Output data
IUPV driving cycles	IUPV dashboard	System behavior analysis
Client profiles		Performance statistics

- System characterization with IUPV cycles on chassis dyno/street and/or engine test bench, HiL
- Database with 10.000 worldwide driver profiles of private and commercial clients
- Accelerated, MATLAB based, model in the loop (MiL) simulation with adapted ECU software
- Unlimited combinations of client profiles with IUPV cycles or sections of these cycles can be simulated
- System behavior analysis regarding fleet liftetime performance, oil deterioration, RDE and Ki-factor
- Exemplary results: RDE tailpipe emissions, soot/fuel in oil, RGN statistics, oil change interval etc.

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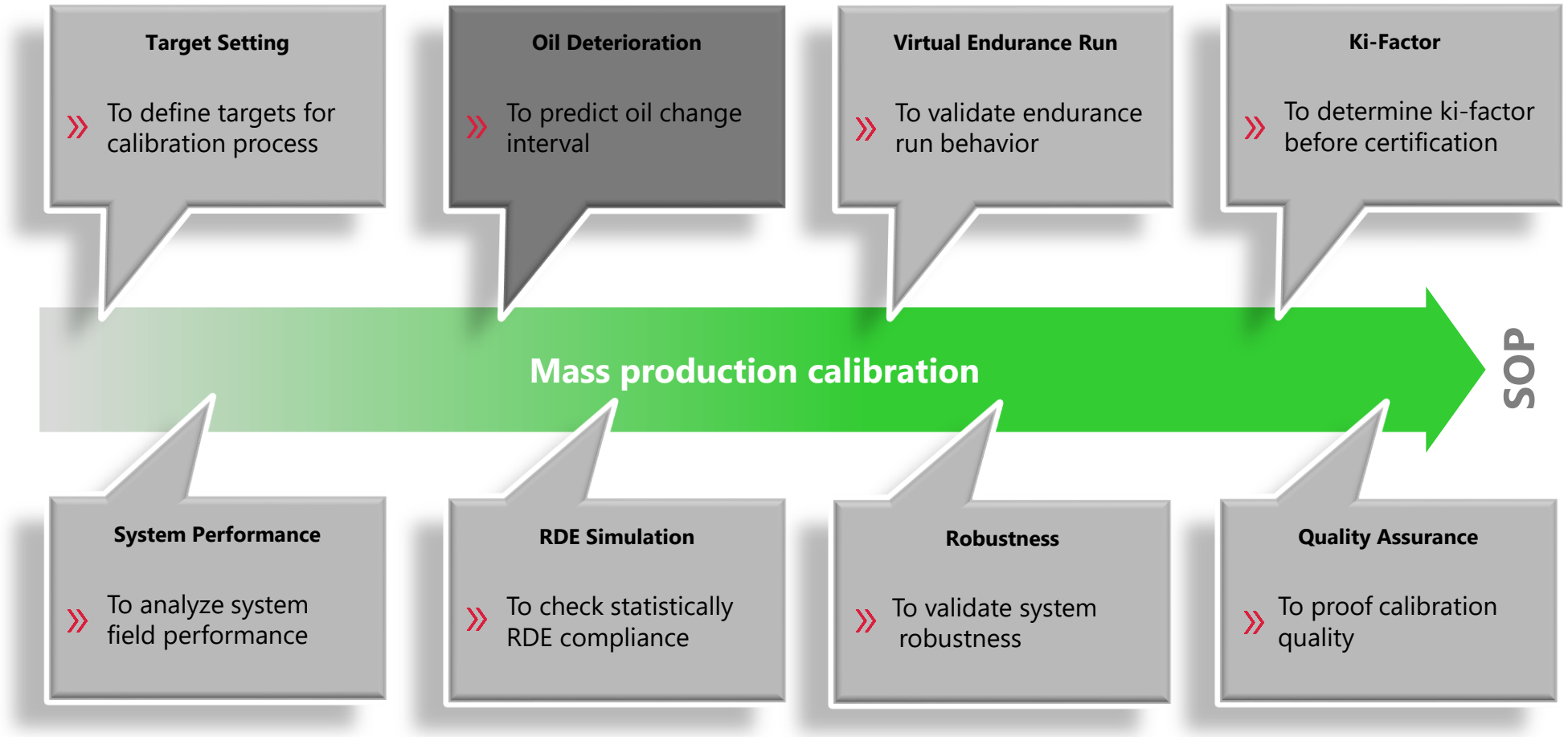
IUPV supports the complete mass production calibration process

OVERVIEW OF IUPV SUPPORTING CALIBRATION PROCESS



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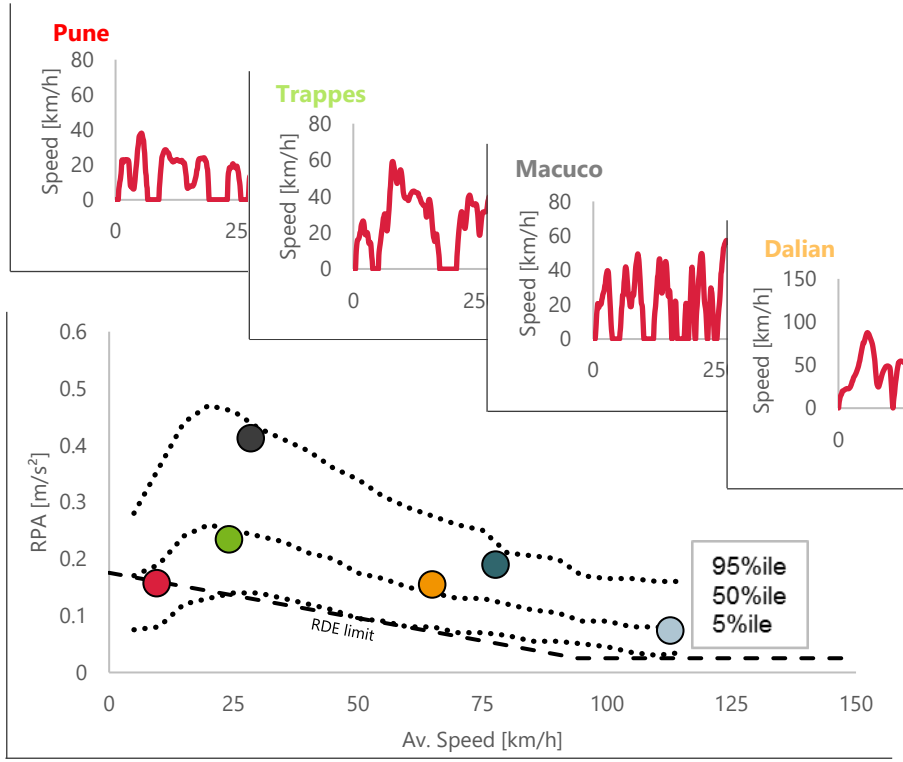
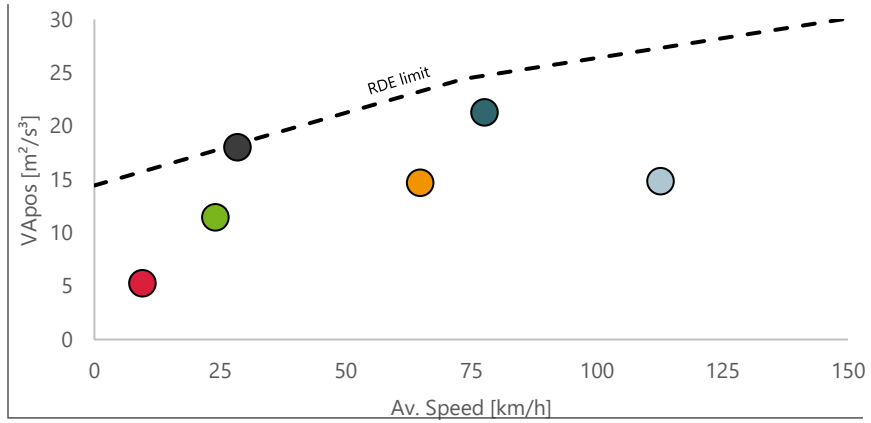
IUPV Standard cycles cover most driving areas for RDE driving

SPECIFICATIONS OF IUPV CYCLES USED FOR SYSTEM PERFORMANCE CHARACTERIZATION

- Representing customer driving behavior, obeying RDE limits
- Exchangeable with comparable OEM specific cycles





Vmean [km/h]	Vmax [km/h]	Dist. [km]	RPA [m/s²]	Vapos [m²/s³]
10	39	2	0.16	2.5
24	67	8	0.23	11.4
29	67	7	0.41	7.0
65	96	7	0.16	14.7
78	121	22	0.19	21.3
113	140	28	0.07	14.8

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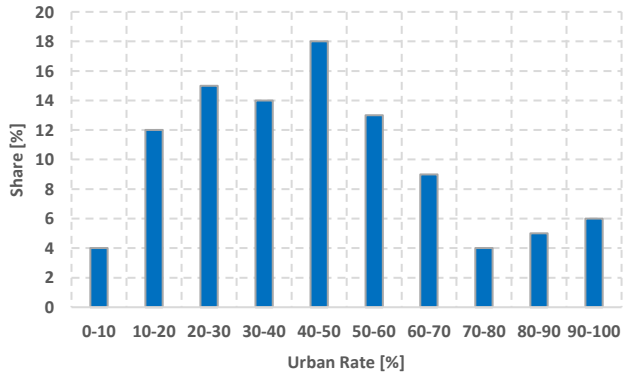
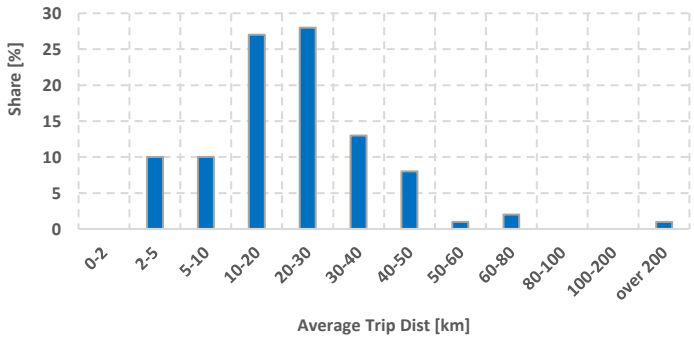
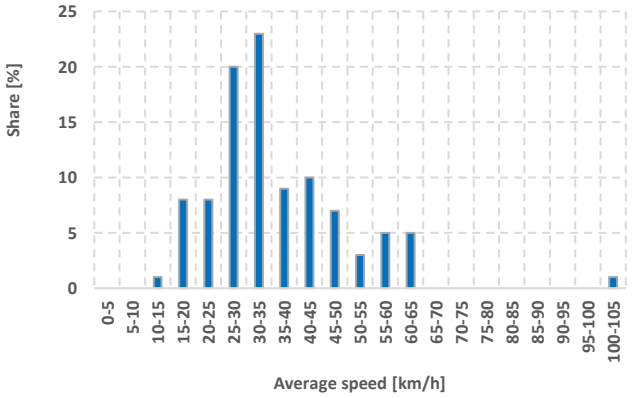
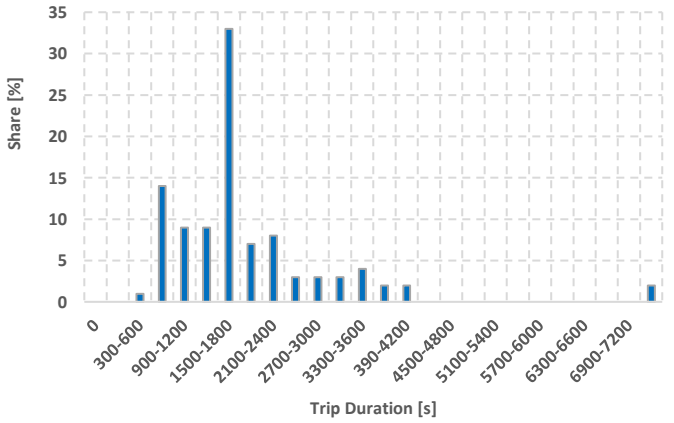
IUPV Client driving behavior is based on mobility survey from European commission

LIFETIME SIMULATION - IUPV CLIENTS DETAILS









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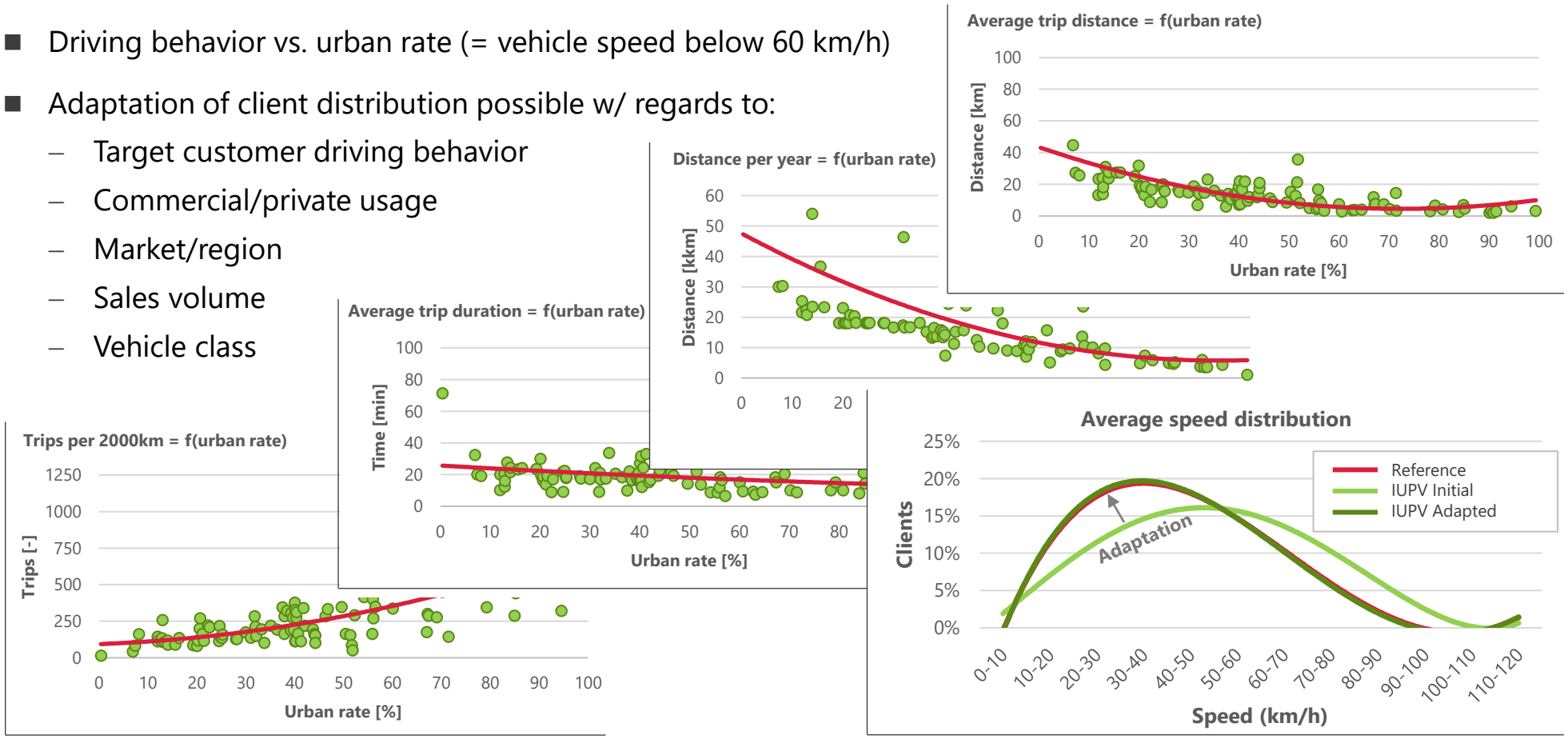
Clients for IUPV can be chosen and adapted based on application needs

EXEMPLARY STATISTICS FOR 100 REPRESENTATIVE EUROPEAN CLIENTS

- Driving behavior vs. urban rate (= vehicle speed below 60 km/h)
- Adaptation of client distribution possible w/ regards to:
  - Target customer driving behavior
  - Commercial/private usage
  - Market/region
  - Sales volume
  - Vehicle class



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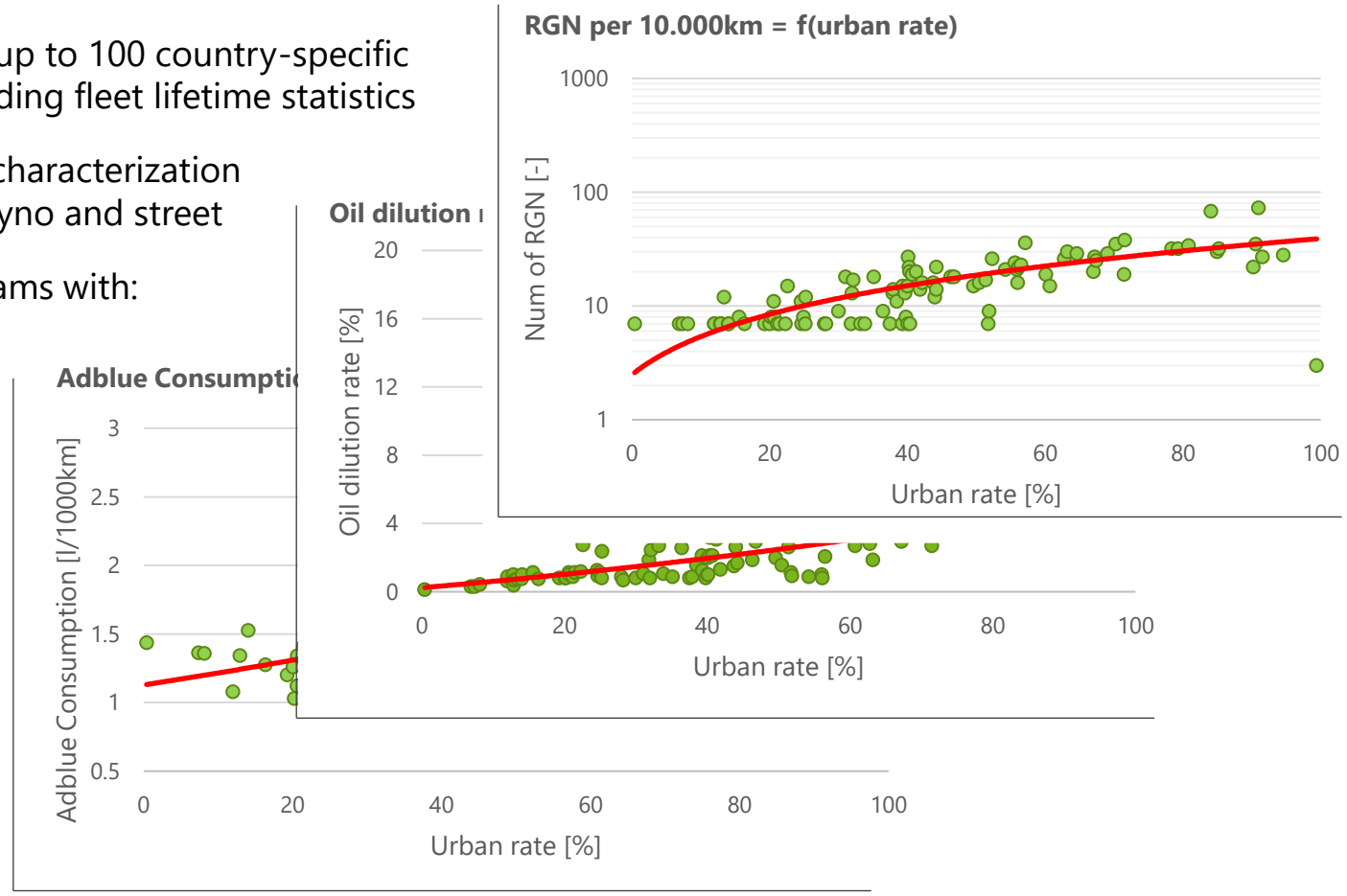
IUPV Lifetime Simulation is developed to validate exhaust system fleet performance over engine lifetime

IUPV LIFETIME SIMULATION OVERVIEW

- System behavior analysis for up to 100 country-specific clients, 30.000 km each, including fleet lifetime statistics
- Simulation based on system characterization with IUPV cycles on chassis dyno and street
- Supporting calibration programs with:
  - Robustness validation
  - ECU calibration
  - Signoff testing
  - Target setting
- Evaluation contains:
  - Combustion modes %
  - Raw/tailpipe emissions
  - Adblue consumption
  - Oil change interval
  - Soot/fuel in oil etc.



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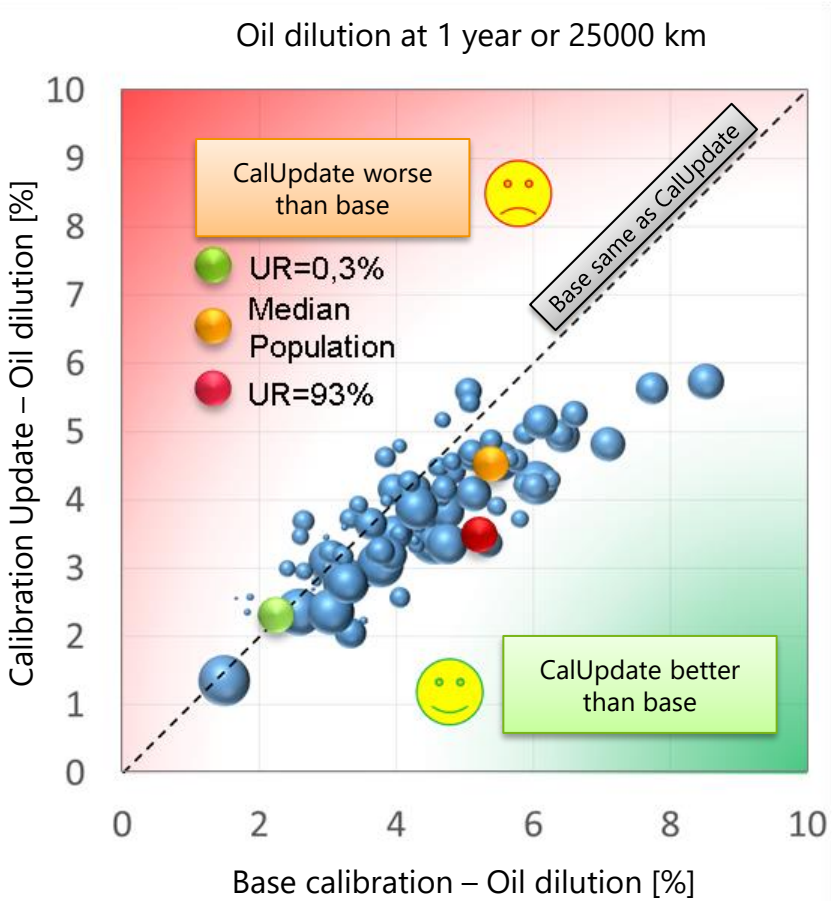
IUPV offers possibilities to simulate impacts of calibration changes regarding oil dilution for different clients

SIMULATION EXAMPLE: BASE AND CALIBRATION UPDATE IMPACT ON OIL DILUTION



Note: Bubble size indicates urban rate (small bubble = low urban rate, large bubble = high urban rate)

- In this example oil dilution level increased for some clients, for some other clients the level decreased
- Overall total oil dilution level decreased with updated calibration

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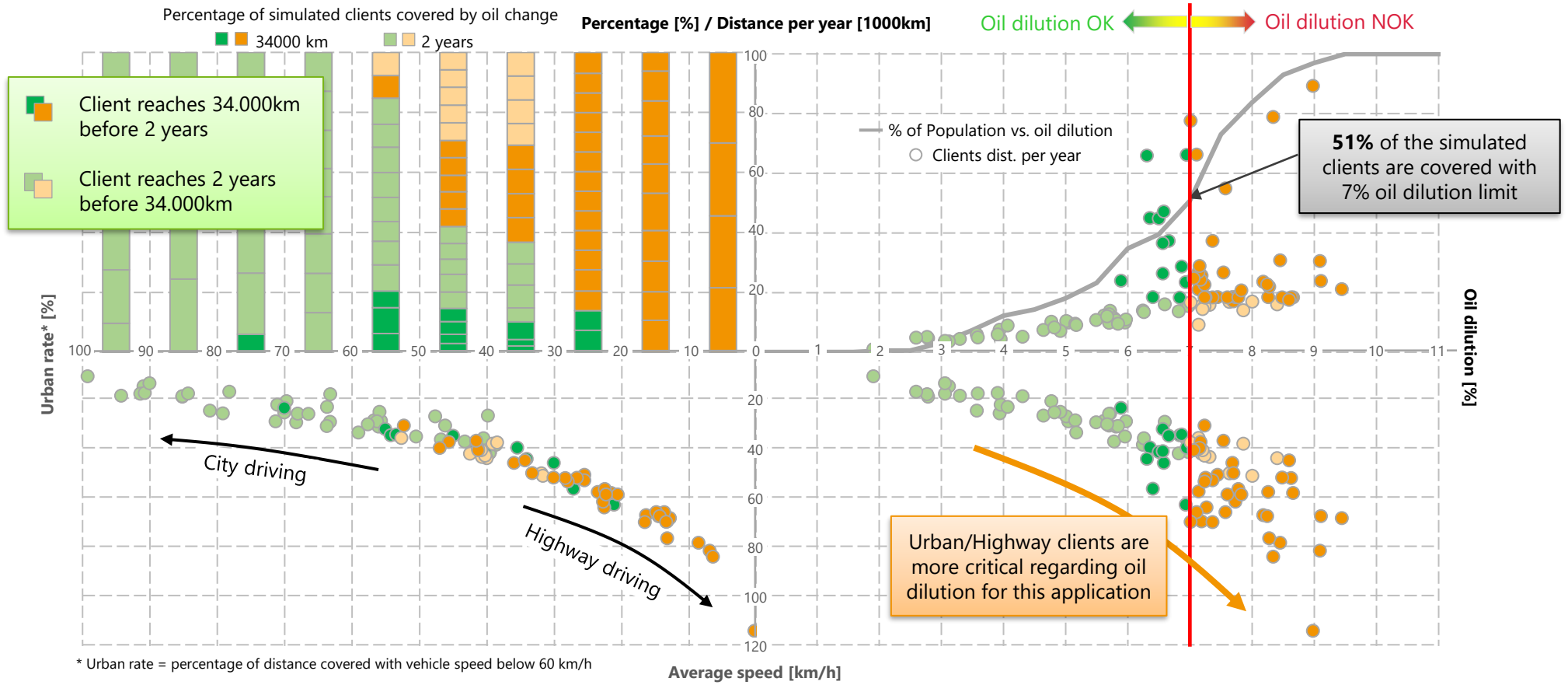
IUPV offers statistical evaluations how many clients will meet specific oil dilution limits

EXAMPLE: 34000 KM / 2 YEARS OIL CHANGE INTERVAL – 7% OIL DILUTION LIMIT



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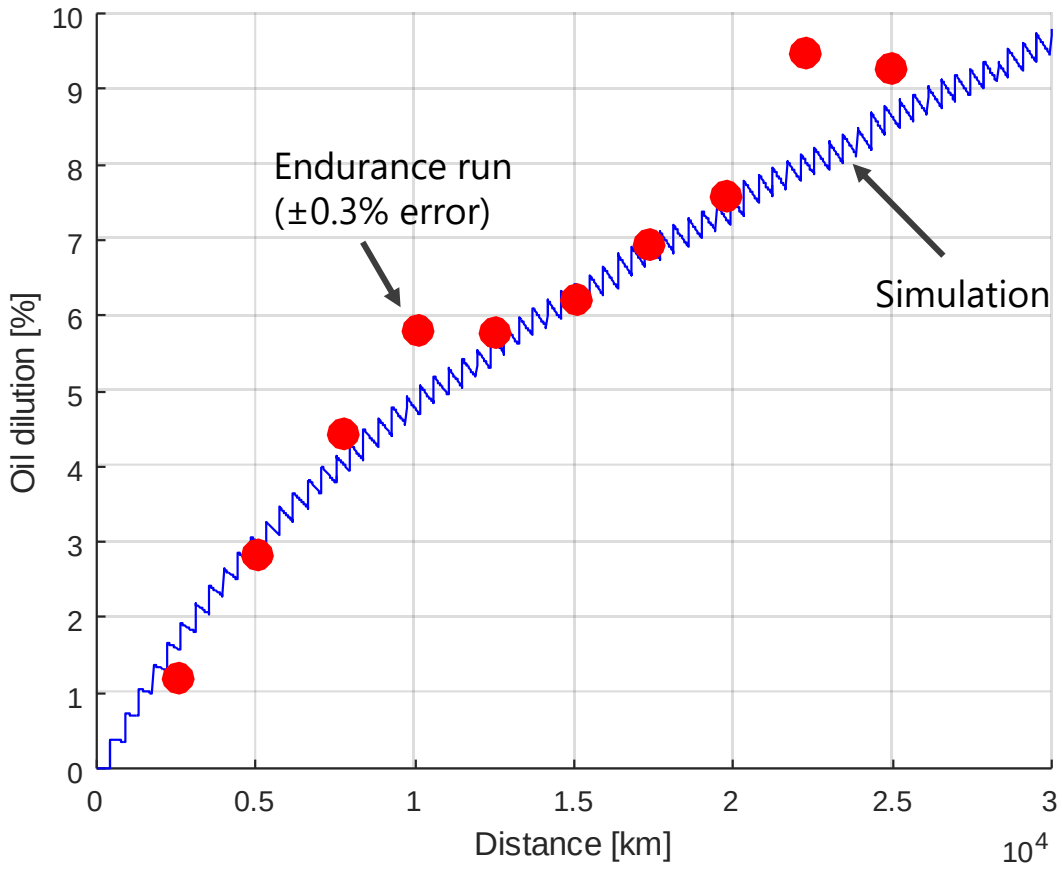
IUPV oil dilution models deliver accurate results compared to oil samples from endurance run data

ENDURANCE RUN DATA VS. IUPV SIMULATION



- For validation purposes an endurance run was simulated in IUPV
- Red dots represent oil dilution samples from endurance run
- Blue line shows the oil dilution level for a virtual endurance run with similar specifications (max. speed, avrg. vehicle speed, torque and engine speed)

→ Oil dilution level and simulation have good accuracy

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IUPV is developed to support calibration process from project start till SOP

- The patented IUPV tool with its algorithms and simulations is used for the entire calibration process, beginning at target setting, over to ECU calibration till robustness testing
- IUPV consists out of 4 individual components, which fulfill separate requirements
  - Lifetime simulation: Exhaust system fleet performance analysis over engine lifetime
  - RDE simulation: System performance analysis regarding real(istic) driving emissions
  - Oil deterioration simulation: Statistical oil deterioration and oil change interval prediction
  - Ki-factor simulation: Ki-factor based supervisor strategy optimization
- Advantages of IUPV:
  - Database with worldwide, partly in field acquired, client driving profiles
  - Defined characterization cycles, covering large driving behavior area
  - Flexibility to adapt to customer needs, like OEM specific cycles and/or clients
  - Many years of experience with ECU software and models simulating physics
  - Simulation based on real testing combined with back-to-back tests

→ With IUPV it is possible to predict system mass production behavior during all project calibration phases

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