APL Group

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Holistic Methodology for Generating Customer-Related Testing Profiles for Electrified Powertrains

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EVS30 - Electric Vehicle Symposium 2017

Stuttgart, October 9th - 11th,2017

Agenda

- Motivation
- Transfer of the „Road2Dyno"-Method to Electrified Powertrains
- Summary

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APL Group - Motivation
New Requirements due to RDE Legislation

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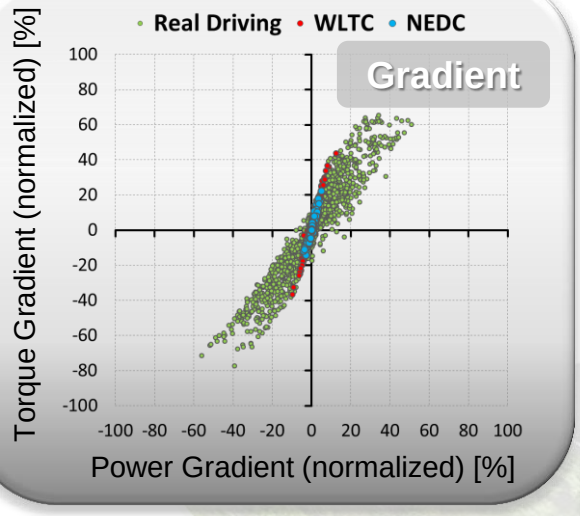

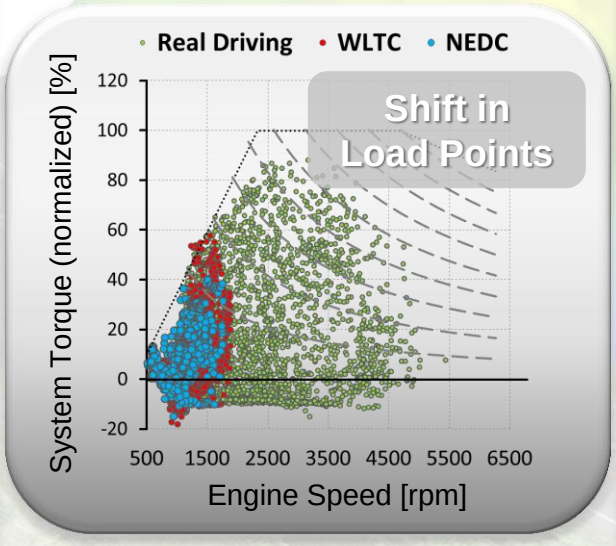

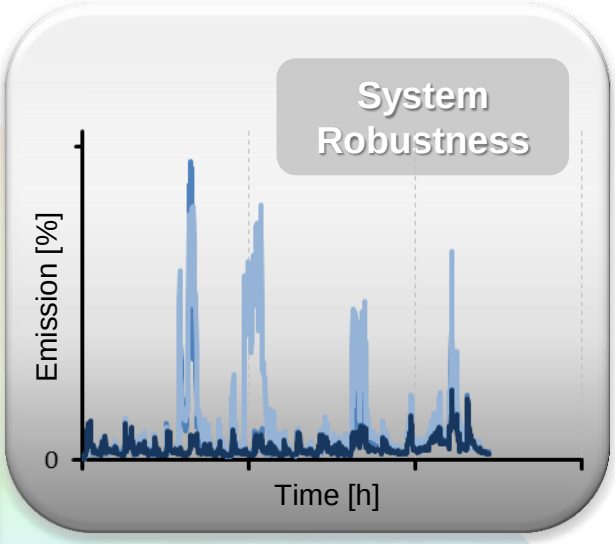

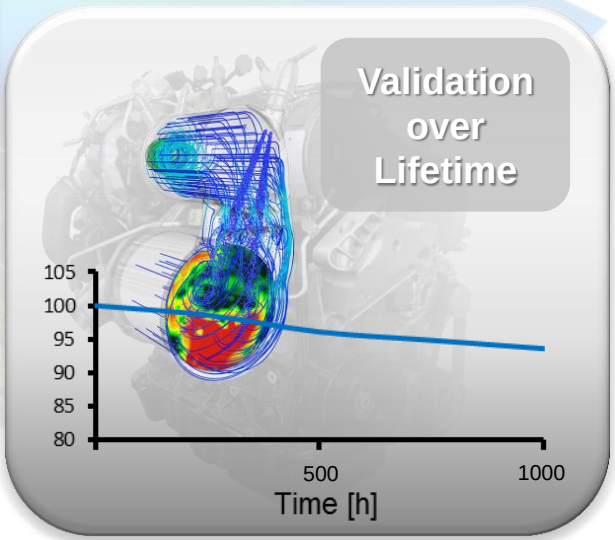

APL Group - Motivation
RDE and the Impact on the Development Process

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REQUIREMENTS SOCIETY/ LEGISLATION

RDE CAPABLE POWERTRAIN

SIMULATION

HARDWARE

OFFICE

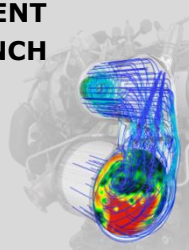
Component MiL

Subsystem MiL

System MiL

REAL DRIVING

COMPONENT TEST BENCH

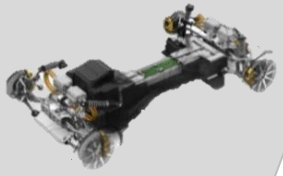


ROLLER TEST BENCH

ENDURANCE TEST BENCH

COMPLEX ENGINE TEST BENCH

POWERTRAIN TEST BENCH



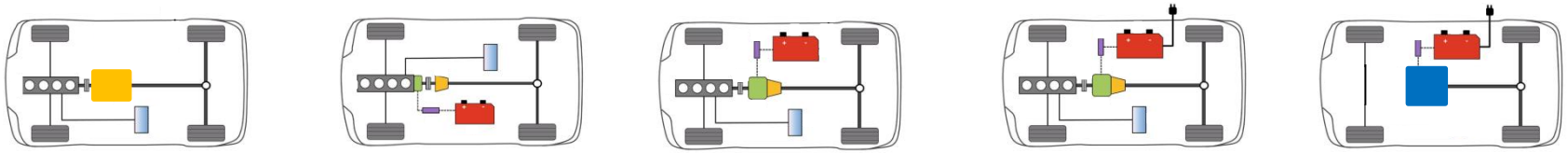
System Coverage

Simulation

Hardware

DEGREE OF ELECTRIFICATION

ICE	MILD-HYBRID	FULL-HYBRID	PLUGIN-HYBRID	BEV

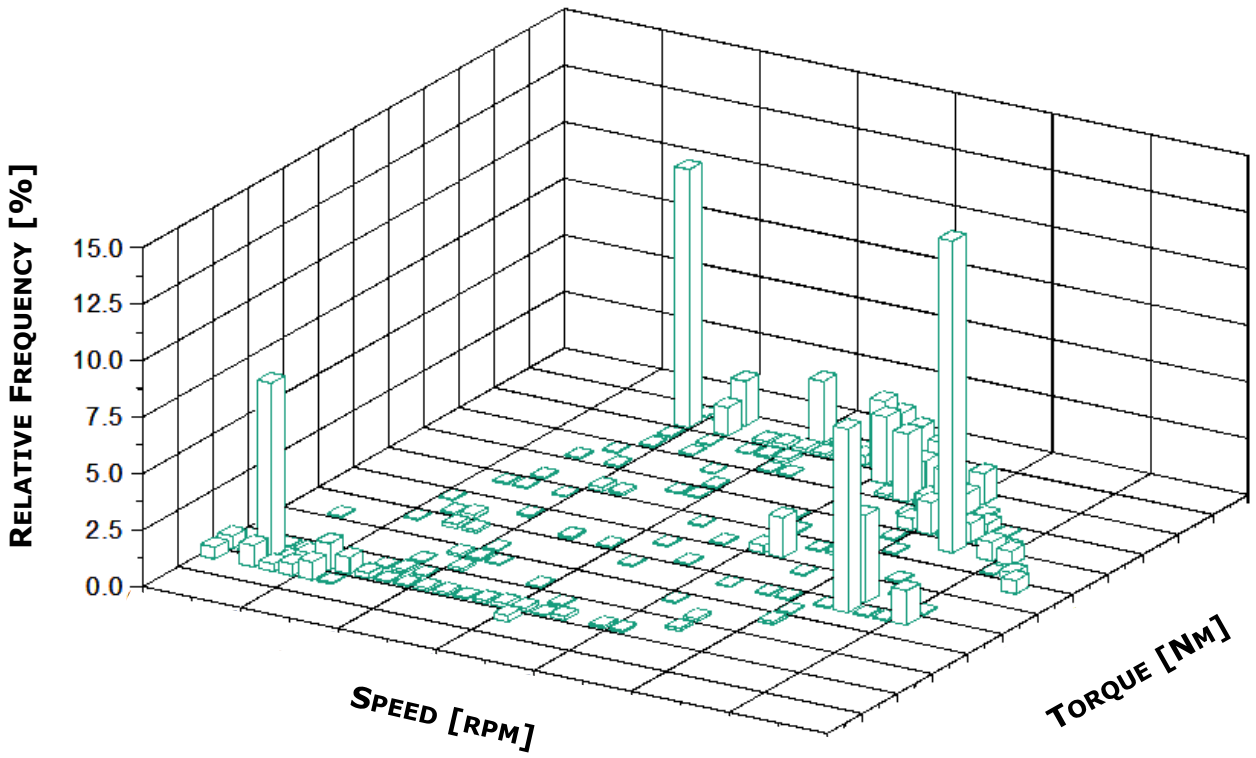


NEW REQUIREMENTS IN REGARD TO MECHANICAL COMPONENTS:
SHIFTING LOAD SPECTRA AS RESULT OF USAGE MARKET, ENVIRONMENTAL CONDITIONS & DRIVING STYLE

VOLTAGE	12 V	48 V	200 V	400 V	800 V

ELECTRIC COMPONENTS — **BATTERY CAPACITY, POWER ELECTRONICS, ...**

APL Group - Motivation
State of Art - Testing



- Driver´s Profile?
- Correct Testing?
- Time and Cost Savings in Testing?

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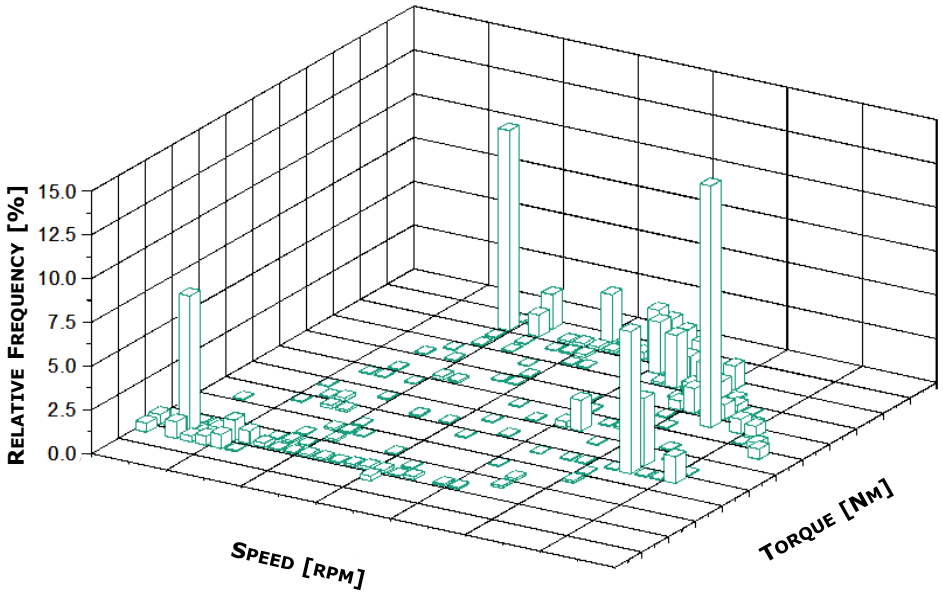
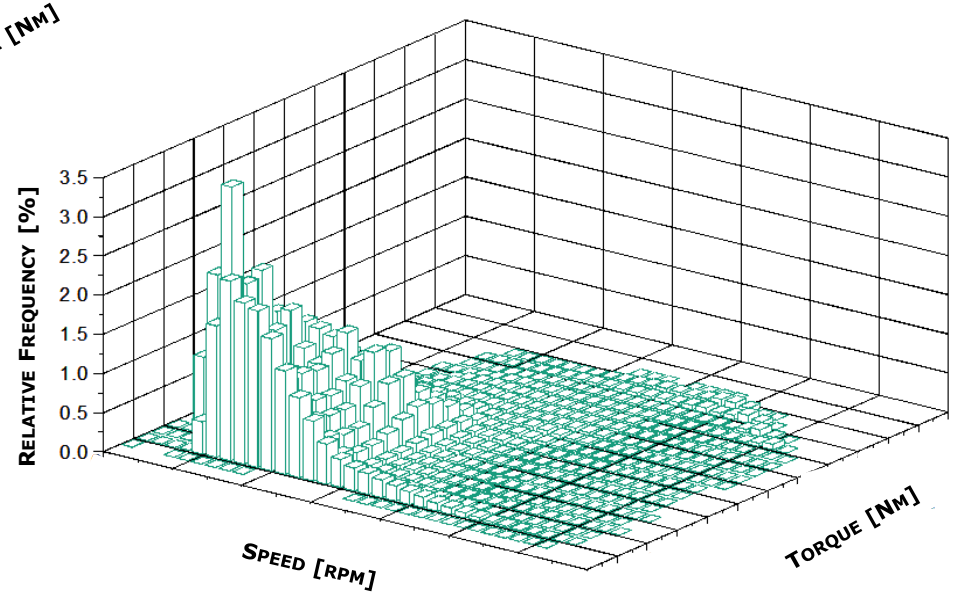
Test Bench vs. Vehicle



Endurance Test on Engine Test Bench

Load Spectra Real Driving



Agenda

- Motivation
- Transfer of „Road2Dyno"-Method to Electrified Powertrains
- Summary

Method „Road2Dyno“

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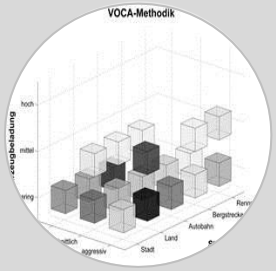
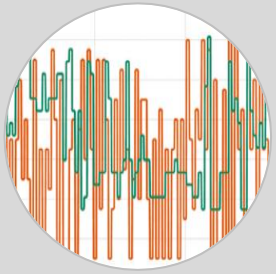
Enquiry of
Real Driving Data



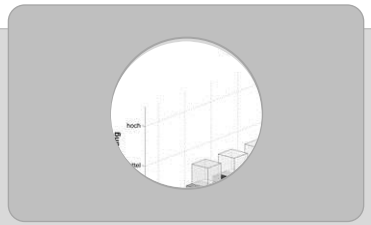
Determination of
representative
Load Spectra
by VOCA

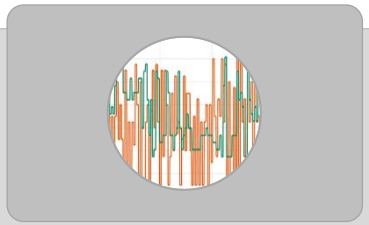


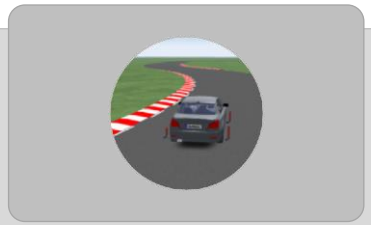
Derivation of
Testing Profiles
with SDC-Tool

Integration of
Acceleration Factors
with GenETeC

Database
Management





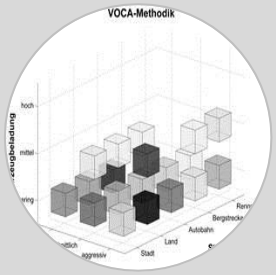


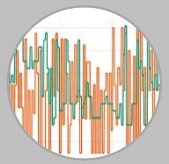
Enquiry of Real Driving Data:

Usage of a CAN-Datalogger:

- Access to Vehicle-CANBus
- Datatransmission via UMTS
- Automated Data Validation & Analysis

Signal	Frequency (Hz)
Engine Speed (ICE)	2
Engine Torque (ICE)	2
Engine Speed (E-Motor)	2
Engine Torque (E-Motor)	2
State of Charge (SOC)	2
Vehicle Speed	2
Accelerator Pedal Position	2
Gear	2
Steering Angle	2
GPS Altitude	2
Longitudinal Acceleration	10
Lateral Acceleration	10



Determination of representative Load Spectra with VOCA – Vehicle Operating Condition´s Analysis:

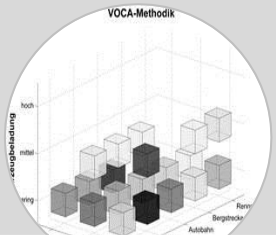
Definition of Customer Usage Condition:

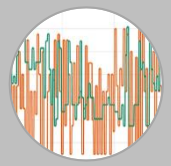
- Virtual Space which contains all statistically relevant Types of Customers
- Based on 3F-Parameterraum (TU Braunschweig)

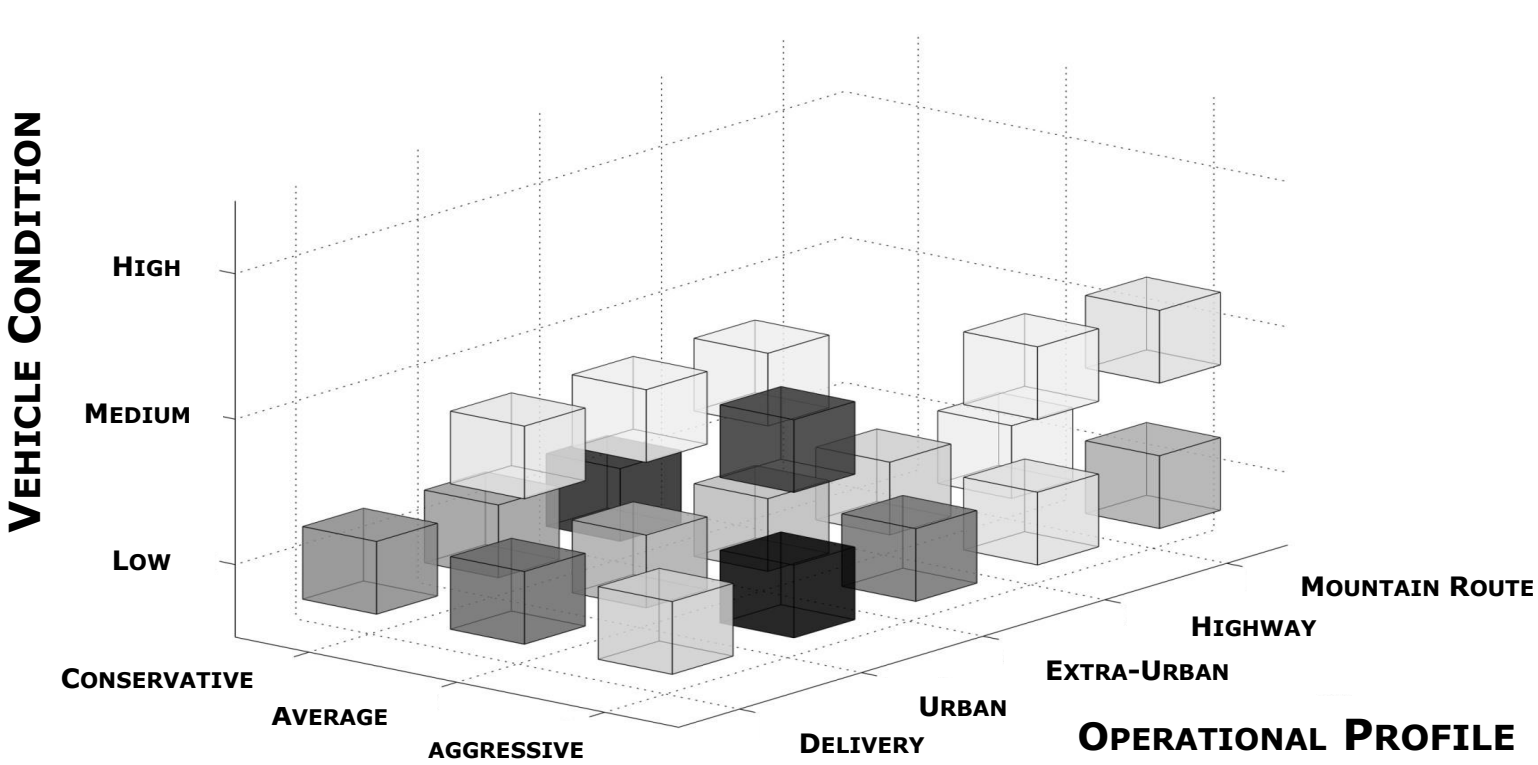
Determination of the Load on all components to be considered:

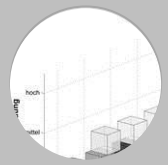
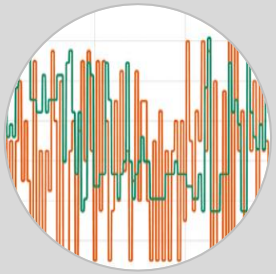
- Systematic Analysis of Customer Usage
- Algorithm for Detection of all Customer Types
- Derivation of representative Load Spectra for each Component by Using Damage Accumulation Hypothesis

Method „Road2Dyno“
Step 2 - Determination of representative Load Spectra





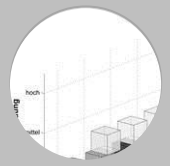
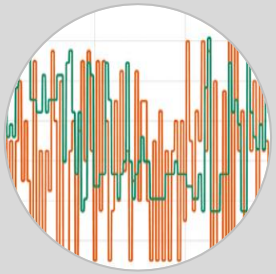




Determination of Testing Profiles with the SDC-Tool – Synthetic Driving Cycle - Tool:

Consideration of the following Parameters:

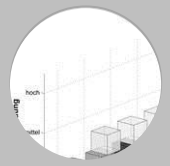
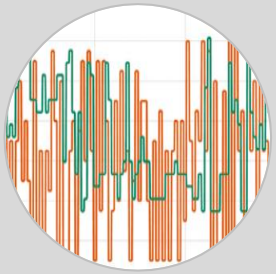
- Vehicle Speed
- current vehicle longitudinal acceleration
- following Vehicle longitudinal acceleration
- Operational Profile
- Driving Style
- Vehicle Condition
- Vehicle lateral acceleration
- Stop Duration
- etc.

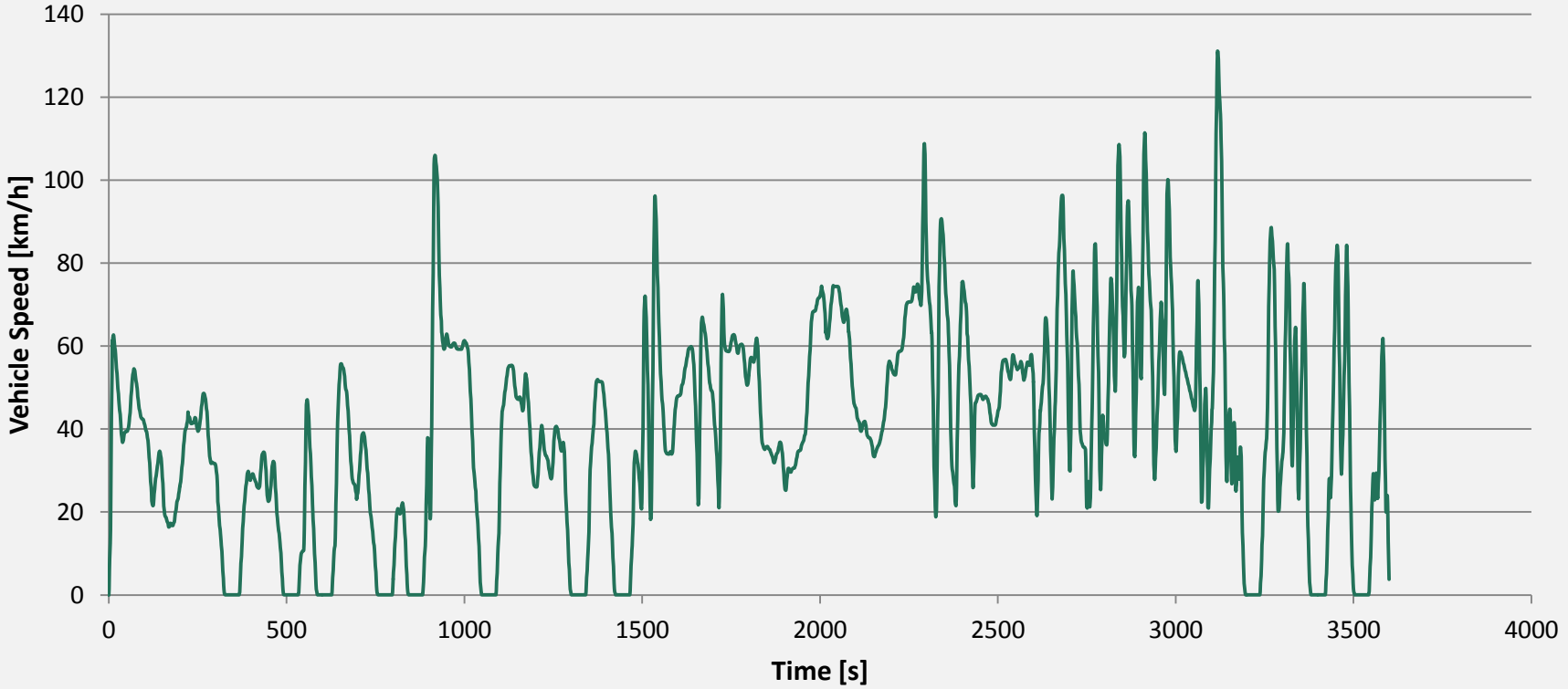
Method „Road2Dyno“
Step 3 - Derivation of Testing Profiles

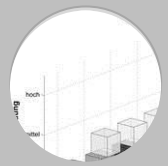
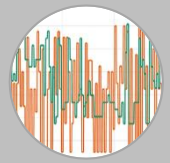




Time [s]	Vehicle Speed [km/h]	Operational Profile	Driving Style	Vehicle Condition	longitudinal acceleration [m/s²]	folll. longitudinal acceleration [m/s²]	Max. Vehicle Speed [km/h]	Selection Criterion
0	0	3	3	1	0	0	300	0
1	…	…	…	…	…	…	…	…
2	…	…	…	…	…	…	…	…

Method „Road2Dyno“
Step 3 - Derivation of Testing Profiles



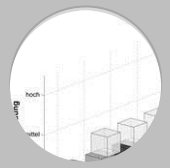
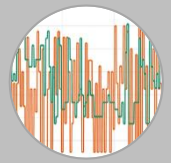




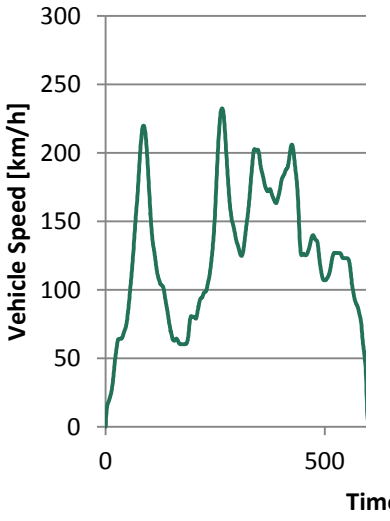
Integration of Acceleration Factors:

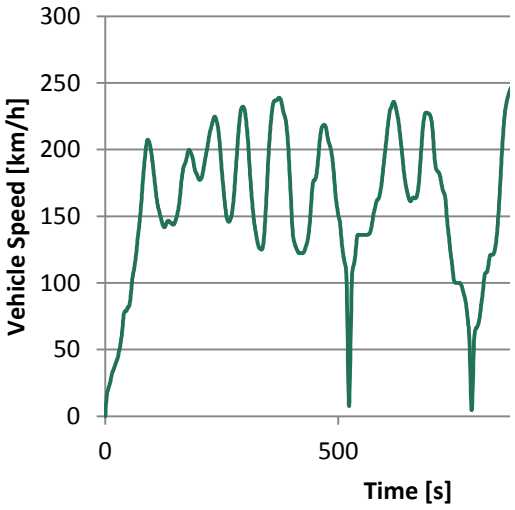
Generating virtual Load Spectra from synthetic Driving Cycles:

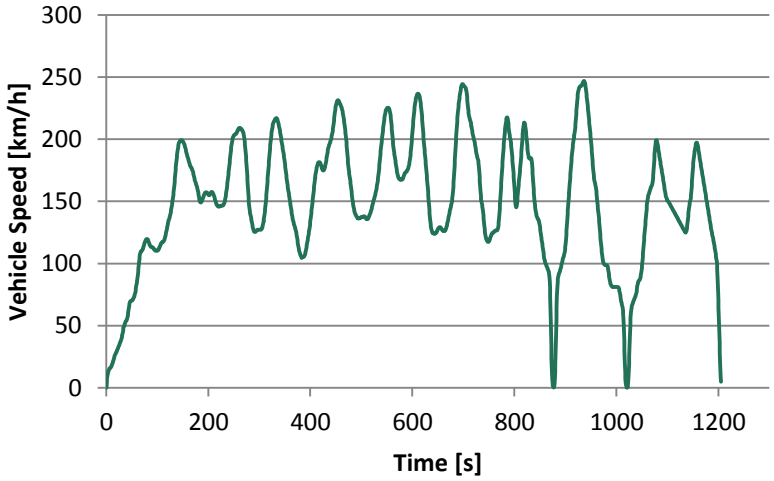
- Usage of a Full Vehicle Simulation Environment => IPG Carmaker
- Installation and Validation of a Vehicle and Driver Modell
- Alternative Usage: Parameter Variation for Effects Analysis on Real Driving Load Spectra
    - Powertrain Parameters
    - Engine Parameters
    - Degree of Electrification
    - Driving Style
    - Operational Profile
    - Vehicle Condition

Method „Road2Dyno“
Step 4 - Integration of Acceleration Factors





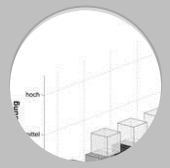
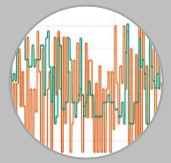


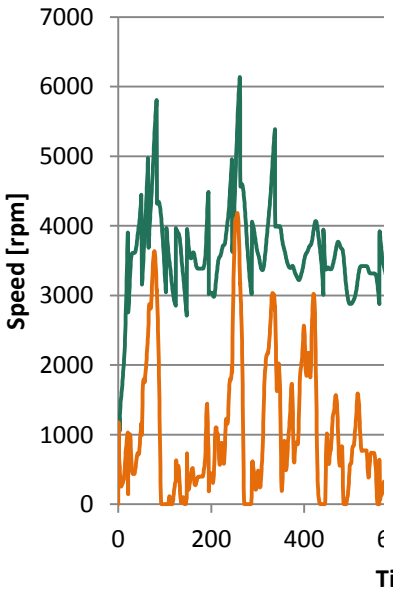
Damage Mechanism 1

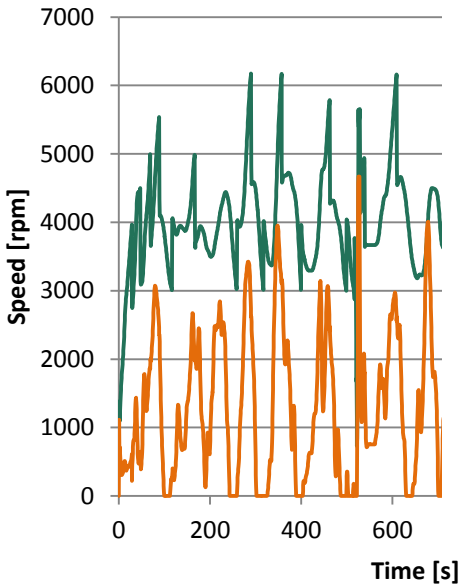
Damage Mechanism 2

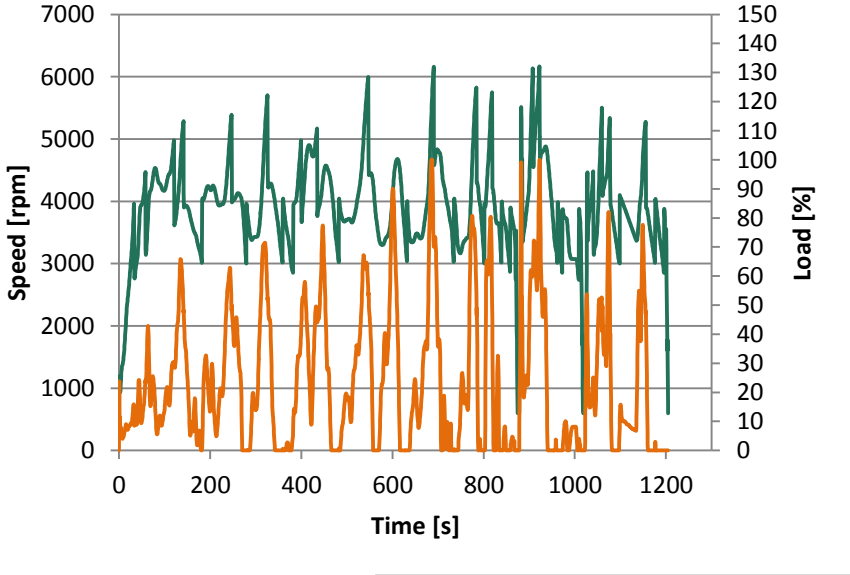
Damage Mechanism 3

Method „Road2Dyno“
Step 4 - Integration of Acceleration Factors





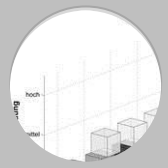
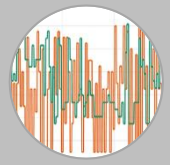


Damage Mechanism 1

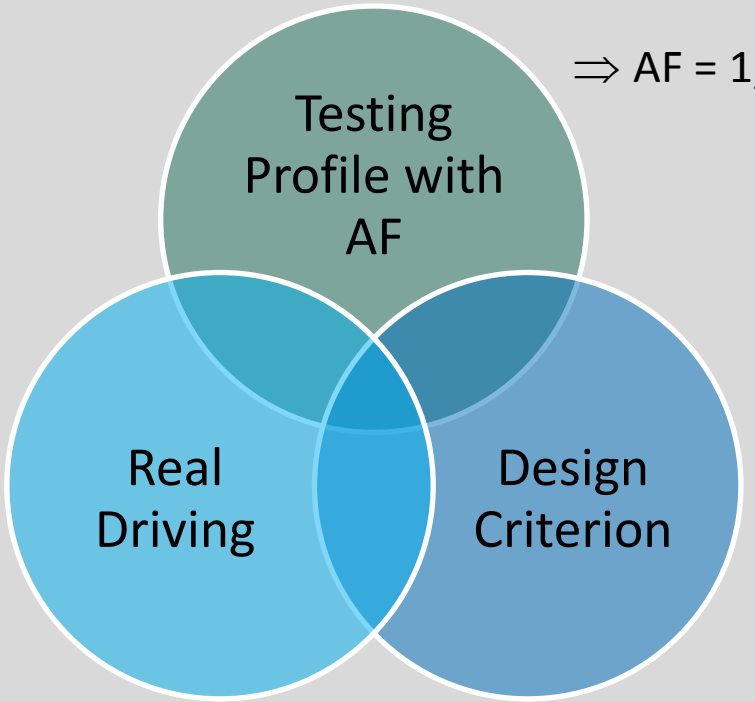
Damage Mechanism 2

Damage Mechanism 3

Method „Road2Dyno“
Step 4 - Integration of Acceleration Factors

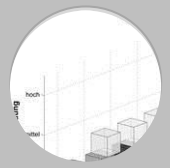
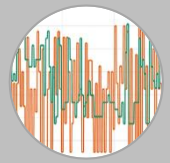
Derivation of the precise test specification using the following criteria:



⇒ AF = 1,8

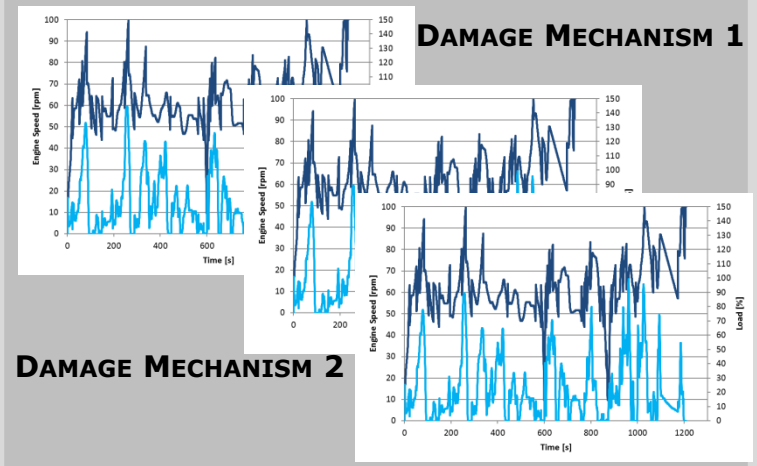
⇒ e.g. $1,5*10^7$ Load Cycles @ 95% Customer

⇒ e.g. $2*10^7$ Load Cycles

GENETEC – GENERATOR FOR ENDURANCE TESTING CYCLES

BASIS

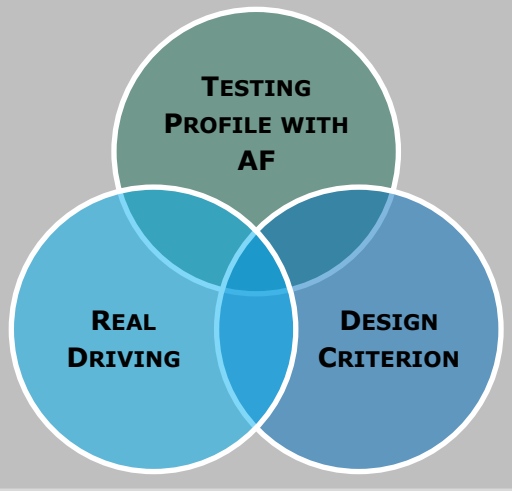


DAMAGE MECHANISM 1

DAMAGE MECHANISM 2

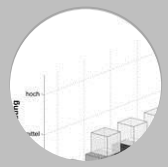
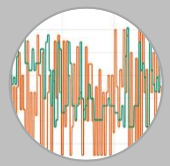
DAMAGE MECHANISM 3

BOUNDARY CONDITIONS



CONVENTIONAL TESTING PROFILE: 300 H
NEW TESTING PROFILE: 210 H

TIME SAVING OF 30 %

Database Management:

Utilization of enquired Real Driving Data:

- Integration of Real Driving Load Spectra in a Holistic Development Process
- Detailed automated Evaluation and Conjunction Algorithms as Basis for Component Design
- Access for all Development Engineers
- Transfer of enquired Driving Style and Customer Driving Behaviour Data to Future Vehicle Concepts

Method „Road2Dyno“
Step 5 – Database Management

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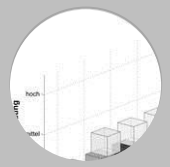
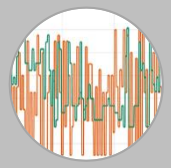
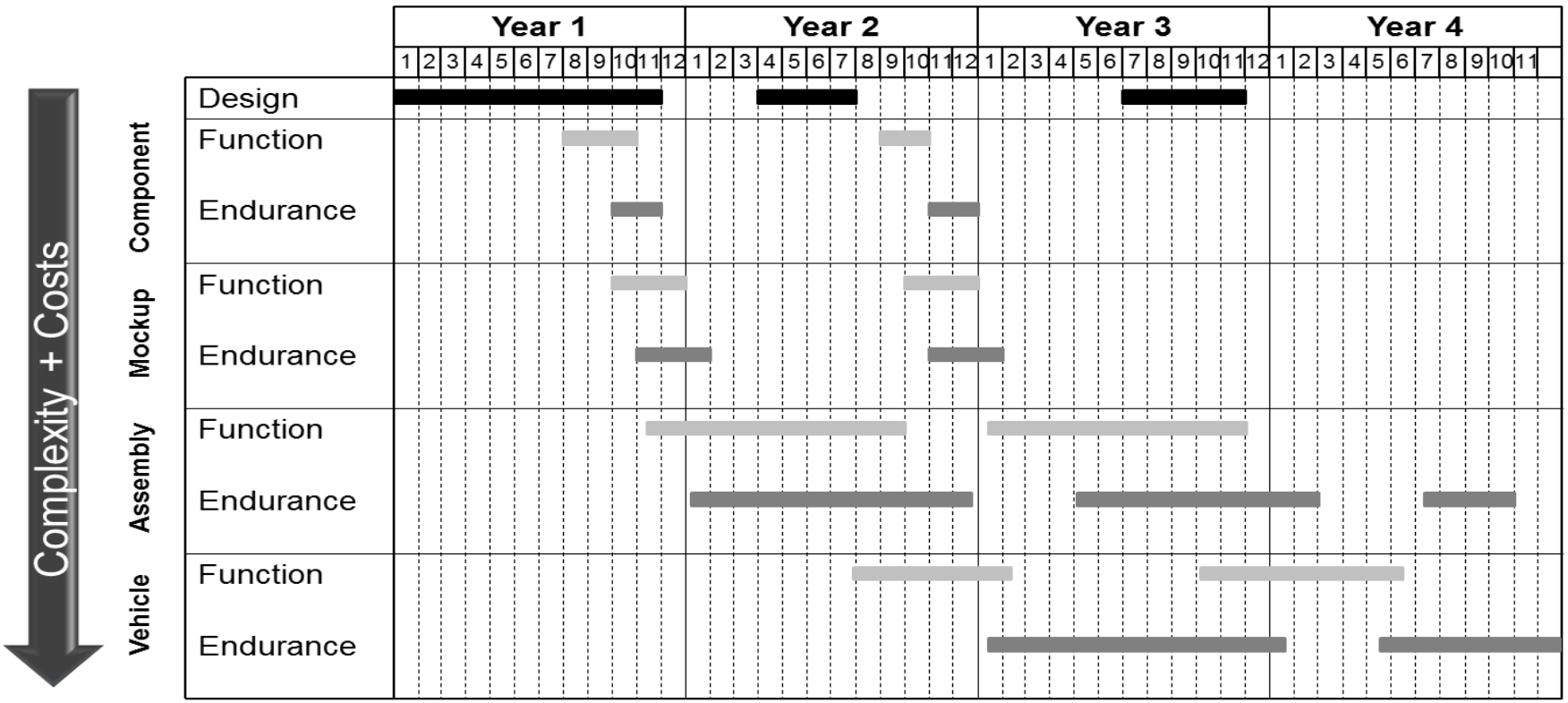
AIP IAVF APS IVP MOT



Agenda

- Motivation
- Transfer of the „Road2Dyno"-Method to Electrified Powertrains
- Summary

Summary

- Presentation of a methodology for the integration of customer representative load spectra into the testing process by generating well-defined as well as time- and thus cost-optimal testing profiles

- Indication of the reduction potential with regard to test time and test costs

- Implementation of the methodology even in the early stages of the development process promises reliable information about system robustness concerning performance, emission behaviour or reliability

- Ensuring customer-usage-related conditions by performing reproducible testing procedures for comparison of different component suppliers, development stages or product layouts

Vielen Dank !