MAGNA
Forward. For all.

Matlab Environment in Automotive Development

Engineering Center Steyr

Agenda

- **11:15 – 12:45 Uhr**
  - Begrüßung und Vorstellung
  - Überblick MAGNA Powertrain Engineering Center Steyr
  - Automotive Development Process
  - Use-Cases
  - Diskussion

Magna

By the numbers.

$37.8B	in sales
343	manufacturing assembling facilities
168,500+	entrepreneurial employees
#1	north america market position
#4	global market position

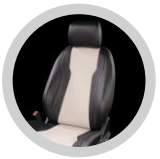
AS OF Q4 2022

Swamy Kotagiri	CHIEF EXECUTIVE OFFICER
Vince Galifi	PRESIDENT
Pat McCann	CHIEF FINANCIAL OFFICER
Eric Wilds	CHIEF SALES & MARKETING OFFICER
Aaron McCarthy	CHIEF HUMAN RESOURCES OFFICER
Boris Shulkin	CHIEF DIGITAL AND INFORMATION OFFICER
Anton Mayer	CHIEF TECHNOLOGY OFFICER
Bruce Cluney	CHIEF LEGAL OFFICER
Guenther Apfalter	PRESIDENT MAGNA EUROPE AND ASIA
Uwe Geissinger	EXECUTIVE VICE PRESIDENT OPERATIONAL EFFICIENCY

Magna leadership.

John Farrell | President

Tom Rucker | President

BODY EXTERIORS & STRUCTURES		SEATING SYSTEMS	POWER & VISION			COMPLETE VEHICLES	NEW MOBILITY
BODY & CHASSIS	EXTERIORS	SEATING	POWERTRAIN	ELECTRONICS	MECHATRONICS, MIRRORS, LIGHTING	COMPLETE VEHICLES	NEW MOBILITY
							
John O'Hara PRESIDENT	Grahame Burrow PRESIDENT	John Wyskiel PRESIDENT	Diba Ilunga PRESIDENT	Sharath Reddy EXECUTIVE VICE PRESIDENT	Jeff Hunt PRESIDENT	Roland Prettner INTERIM PRESIDENT	Matteo DelSorbo EXECUTIVE VICE PRESIDENT

Magna Powertrain
Product Groups and Services

TRANSMISSION SYSTEMS

DRIVELINE SYSTEMS

ENGINEERING SERVICES

METAL-FORMING SOLUTIONS

Our combined product groups and services deliver **highly efficient, modular** and **scalable powertrain solutions.**

Key Figures

- Founded: 1995 (ECS) < 1864 (Steyr)
- Employees: 800
- Facility size (m²): 54.800
- Test circuit for on-and off-road testing

- **Certificates**
  - EN ISO 45001: 2018
  - EN ISO 9001: 2015
  - IATF 16949
  - EN ISO 14001: 2015
  - TISAX: 2018
  - ISO/IEC 17025

Location St. Valentin - History

1899 — **J. PUCH Erste Steiermärkische Fahrrad-Fabriks AG Graz**

1914 — **PUCHWERKE AG**

1899 — **Österr. DAIMLER Motorenges. Wr. Neustadt**

1928 — **AUSTRO DAIMLER-PUCHWERKE AG**

STEYR-DAIMLER-PUCH AG

1864 — **J. & F. Werndl & Comp. STEYR**

1926 — **STEYR-WERKE AG**

1934

1957 — **MAGNA TORONTO CANADA**

1989 — **Truck Division of SDP acquired by MAN**

1995 — **Engineering Center Steyr**

1998 — **STEYR-DAIMLER-PUCH ENGINEERING CENTER STEYR** A COMPANY OF MAGNA

2001 — **MAGNA STEYR** ENGINEERING CENTER STEYR

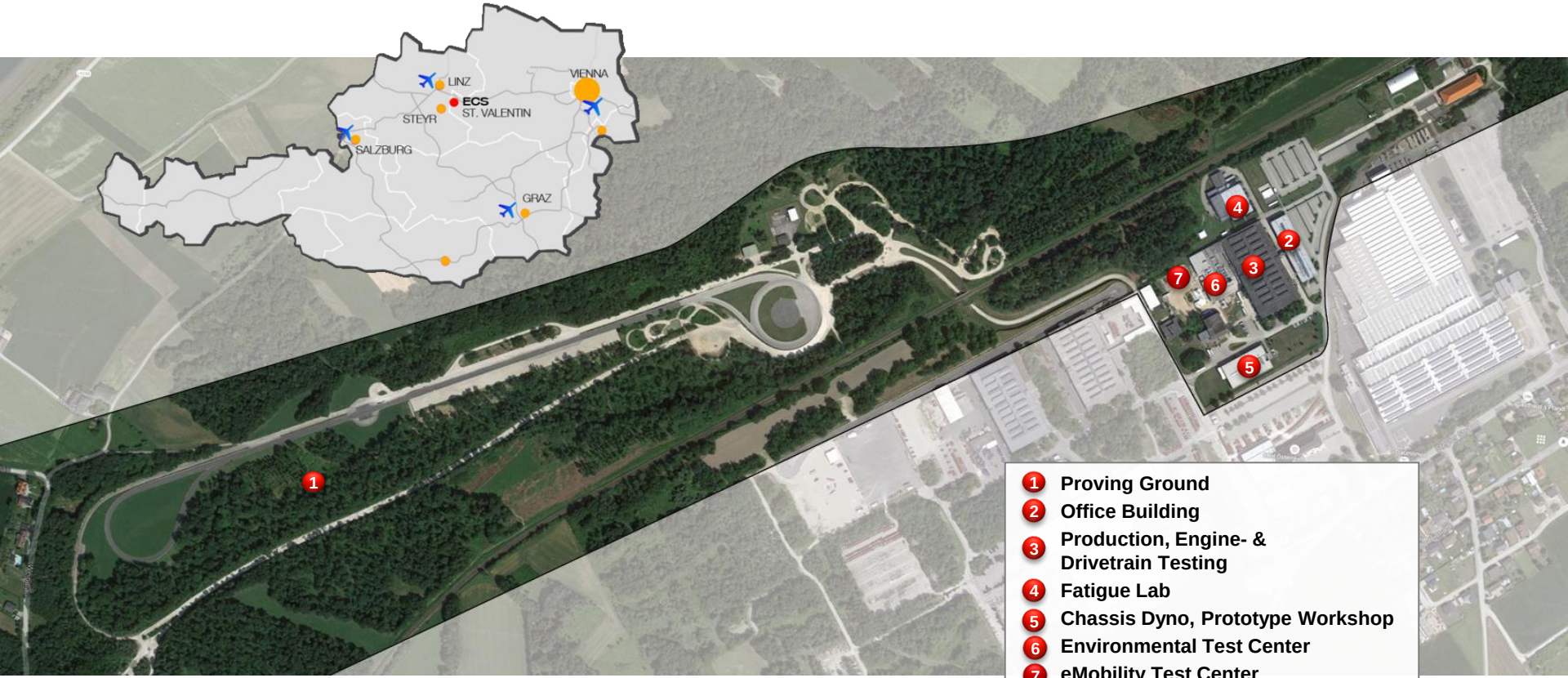
2005 — **MAGNA MAGNA POWERTRAIN**

2015 — **MAGNA**

Merger of Magna Powertrain Eng. Locations:

- Albersdorf
- Auburn Hills
- Concord
- Bad Homburg
- Pune (JV Magna Steyr)
- Sankt Valentin
- Traiskirchen
- Troy

Area Overview



Location St. Valentin - Portfolio

ENGINEERING SERVICES

Vehicle Engineering

Propulsion Engineering

Software & Simulation

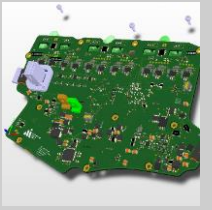
Testing Services & eDrive Testing

PRODUCT ENGINEERING

eDrive Systems

E-Motor Design

Electronics & SW Development



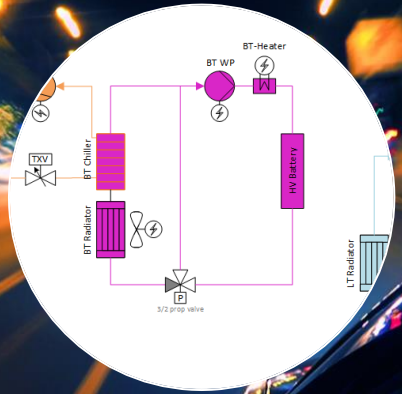
LOW VOLUME PRODUCTION

- Products
  - Transfer case
  - Axle drive
  - Electrohydraulic power steering pump
  - eDrive systems and components
- Assembly
- End-of-Line Testing

Propulsion Engineering

Electrification

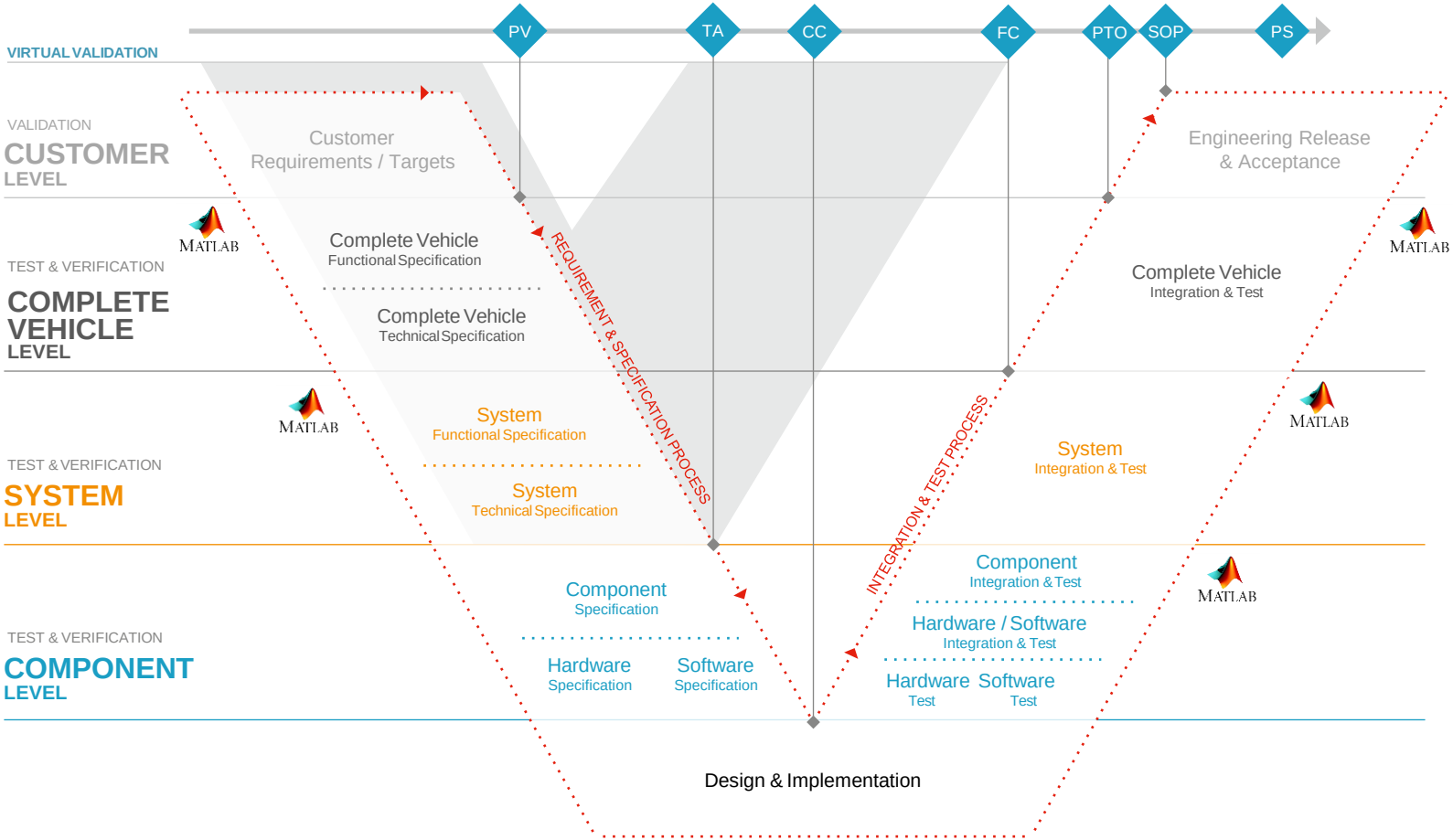
Advanced Mobility Functions



Thermal Management

Engine & H2 Systems

Mathworks supported Toolchain along V-cycle

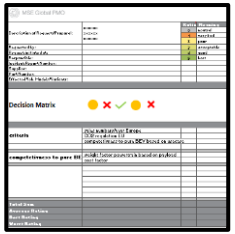


USECASE
Product Investigation

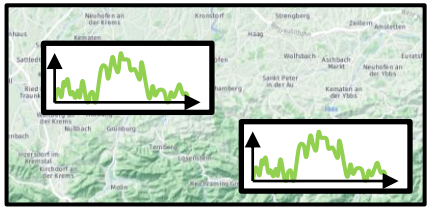
Product Investigation / Specification

- Base vehicle(s) and vehicle use case definition for target market
- Vehicle specifications / targets and features
- Definition of worst/best case drive cycle scenarios
- Complete vehicle simulation for different variants (BEV, FCEV, Hybrid, HV system / battery, H2 storage system)
- Powertrain and EE architecture / configuration incl. HV system

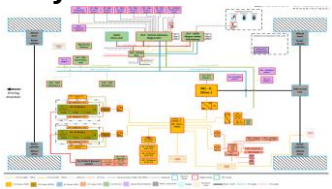
Vehicle Targets



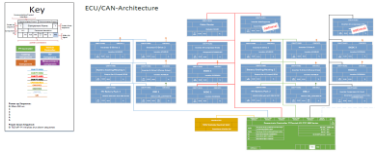
Driving Cycle Library



System Architecture

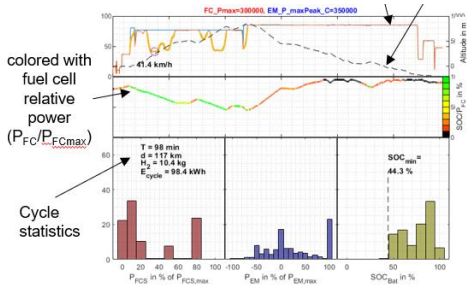


xCU & CAN Architecture

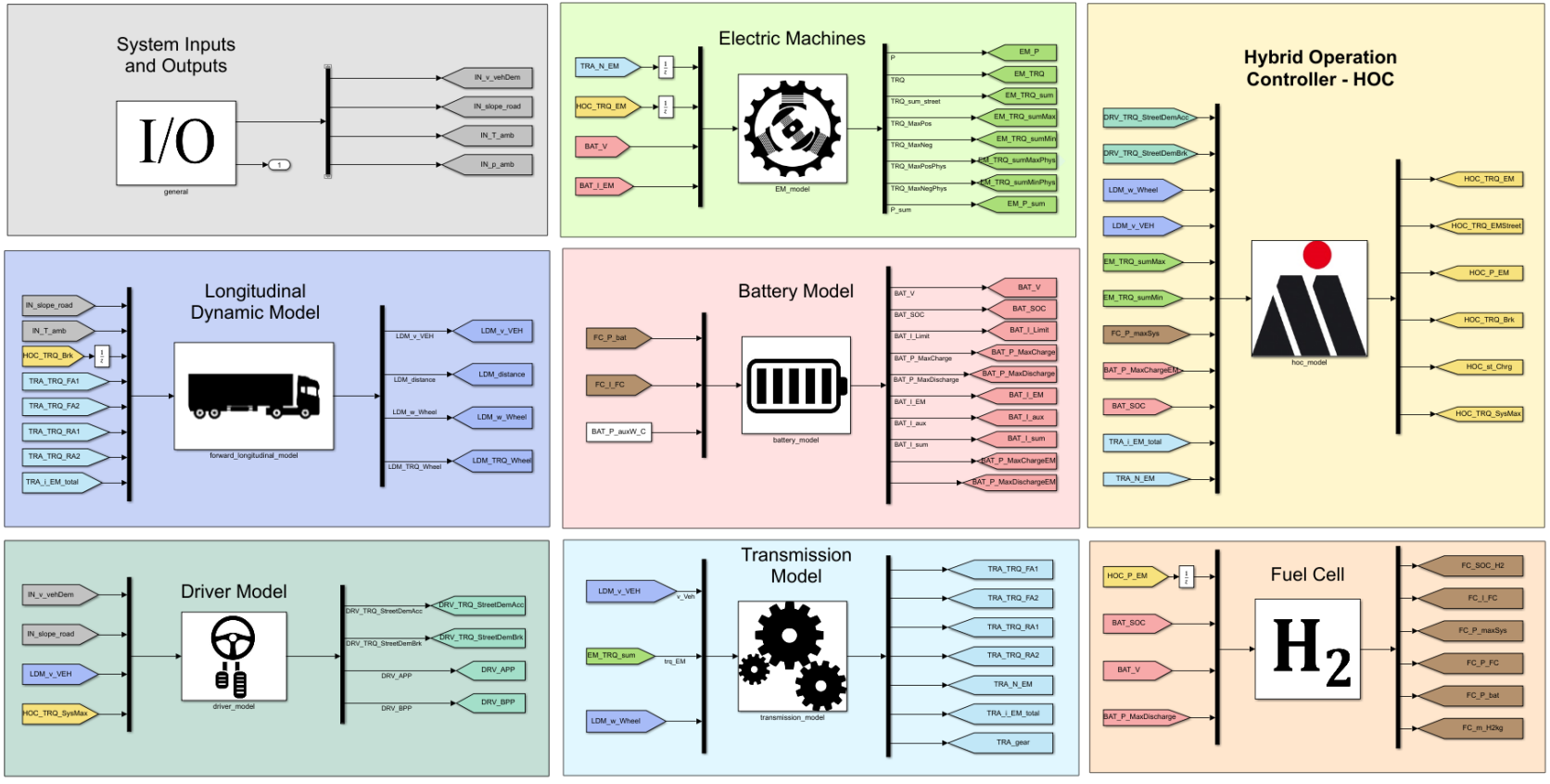


Drivetrain / Components

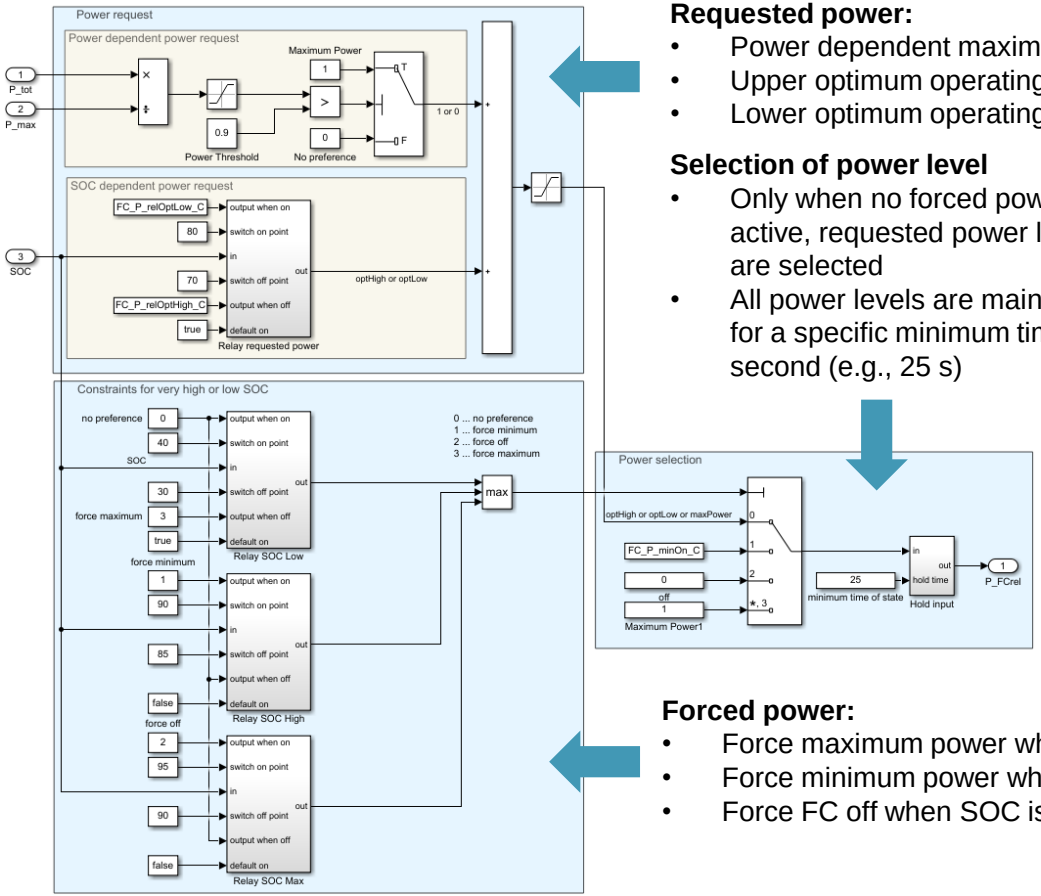
Simulation: Vehicle + PT Specification



Matlab/Simulink simulation model



Fuel Cell Control Strategy



Requested power:

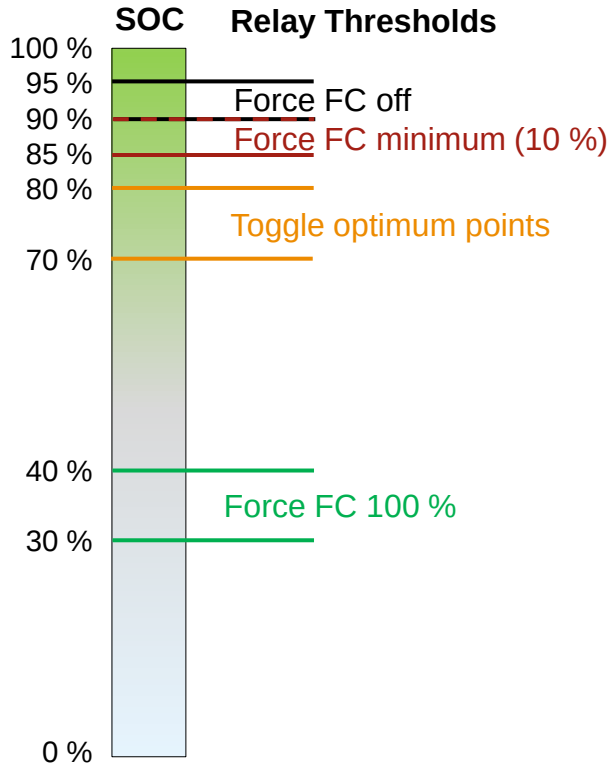
- Power dependent maximum
- Upper optimum operating point
- Lower optimum operating point

Selection of power level

- Only when no forced power is active, requested power levels are selected
- All power levels are maintained for a specific minimum time in second (e.g., 25 s)

Forced power:

- Force maximum power when SOC is low
- Force minimum power when SOC is high
- Force FC off when SOC is at maximum



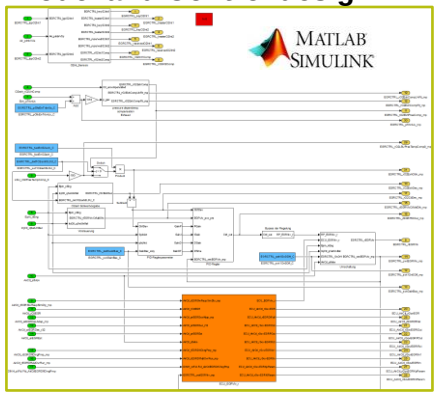
USECASE
Concept Development

Calibration services

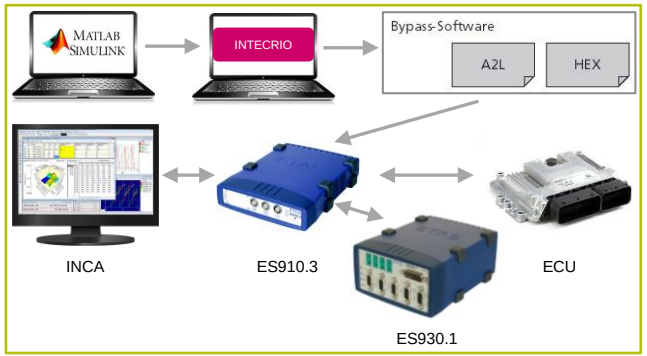
Rapid Prototyping workflow for Exhaust Flap control

- Model and Control design in MATLAB Simulink®
- RP-Hardware ES910.3 and ES930.1
- RP-Software INTECRIO
- Measurement & Calibration INCA

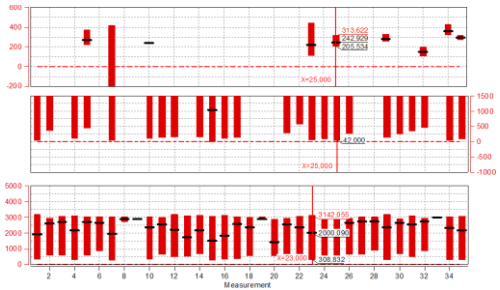
Model and Control design



Rapid Prototyping System



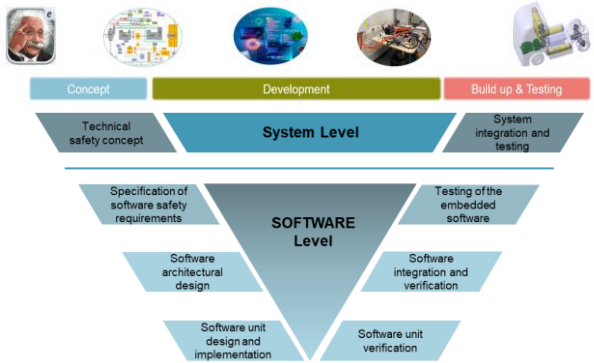
Calibration (HiL, test bench, vehicle)



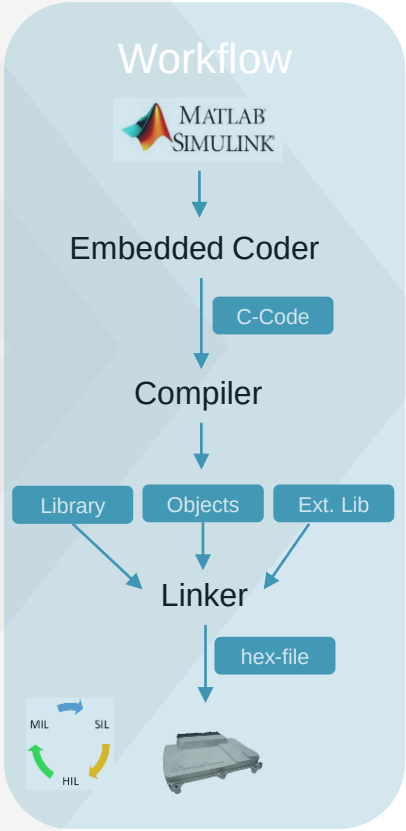
Software Tool Chain

Function and Software Solutions

- **Key-Facts SW development**
  - Function- and SW solutions **independent from control unit supplier**
    - Integration on customer platform
    - Third party hardware
  - Multiple development collaboration models possible from **prototype** to **serial** software
    - Complete ASW development and integration
    - Function specific software block integration (object-code)
  - Tailor-made software concepts with short time to market
  - Development from single SW-modules up to **complete system functions**
  - **State-of-the-art** development processes and tool landscape considering **ISO26262**

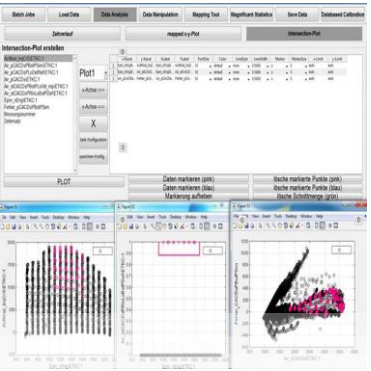


- **Base component functions**
  - **Basic functions**
    - Power provision and energy management
    - Control of electric drive system
    - Torque management
    - Thermal management
    - Component protection
    - Control of electric HV auxiliaries
      - Brake air compressor
      - Steering pump
    - Control of H2 system (FCEV, HSS)
  - **Comfort functions**
    - (Adaptive) Cruise Control
    - Speed limiter
    - Creeping
    - Hill hold
    - Traction control functions e.g. ASR
  - **Safety & monitoring functions**
    - HV system safety
    - H_2 system safety



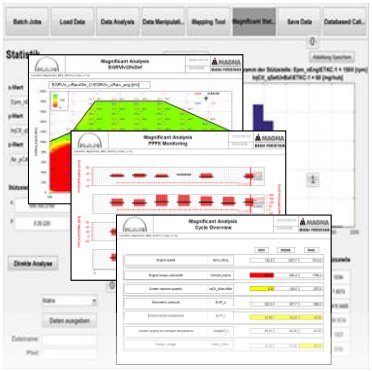
USECASE
Model based calibration

Calibration Support Environment (CSE)



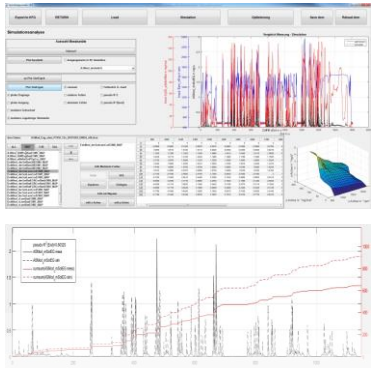
Data Analyses

- **Customized data handling**
  - Restrictions
  - Calculations
  - Batch jobs
  - Stationary detection
  - Dynamic detection
- **Multiple graphical data visualization**
  - Time plots
  - XY plots
  - Intersection plots



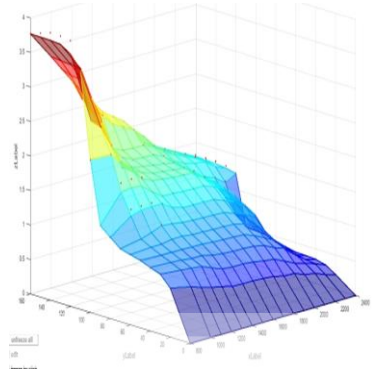
Magnificent Statistics

- Operation point based statistical evaluation (Mean value, standard deviation, min/max, error…)
- Validation and Robustness checks (fleet data, application data,…)
- Optional visualization in Concerto



Databased Cal. Tool

- Databased simulation and optimization tool
- Simulink interface for function implementation
- Processing of multiple measurements
- Data locking for lookup tables
- Interface with Map Tool
- Dataset export (*.DCM)
- Various calfitting methods



Map Tool

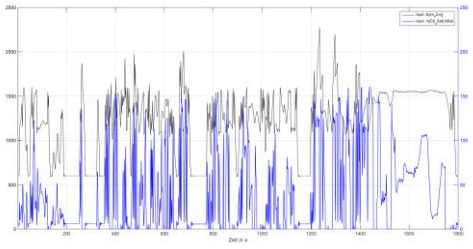
- Map generation from measurement data
- Various fitting algorithmic procedures
- Manual table manipulation
- Interfaces for Excel and the Data Cal. Tool

Failure Path Analyzer

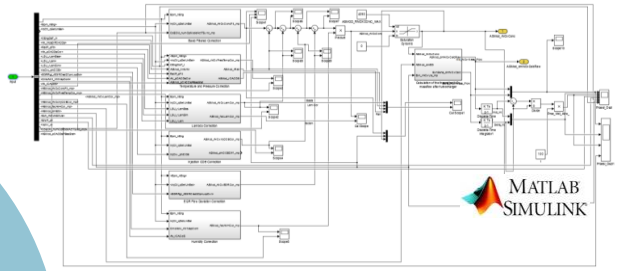
- Fault path management in accordance with the applicable national law
- P-code and SPN-code checker
- Inhibition matrix and error class calibration management
- Documentation of the fault path management

Engine Calibration Services – Model-based Calibration

Measurements Testbed & Onroad



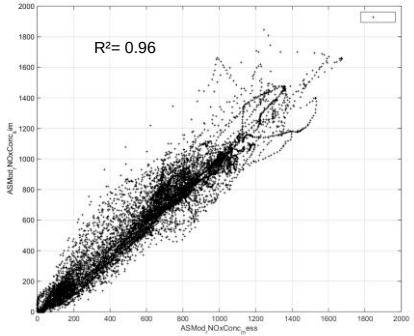
Model-building & Validation



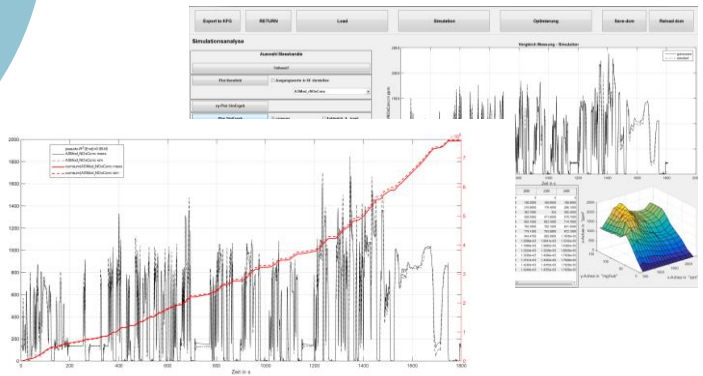
Model-based Calibration Workflow with CSE (Calibration Support Environment)

- Air-Path
- NOX-Emissions
- Soot
- Heat-transfer & temperature models
- And more

Verification Tests Bench/Onroad



Offline-Pre-calibration & Optimization



USECASE
RDE – System Optimization

Methodology
Engineering approach RDE optimization

Worst Case Cylce Methodology

Measurement data

Measurement
- Fleet data
- RDE Trips
- Testbed measurements
  - Chassis dyno
  - High altitude and climate testbed
  - Engine dyno

Vehicle specification
- Technical data
  - Vehicle data
  - Engine
  - Gearbox
    - Manual
    - Automatic
  - Driving dynamics
  - Thermalsystem
  - Exhaust aftertreatment
- Vehicle type
- Emission level

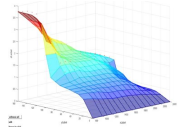
Automated data exchange

Validation of simulation results

Vehicle data for modeling the virtual vehicle

Simulation

CSE (Calibration Support Environment)
Efficient and automated identification of critical load points such as NOx peaks and preparation of worst case events
- Driving dynamics
  - Kick down
  - Acceleration
- Route profile
  - Altitude
  - Track
    - Urban
    - Motorway
    - ….



Worst Case Szenarien

HTC (Hybrid Tool Chain)
Gesamtfahrzeugsimulation

HYBRID TOOL CHAIN

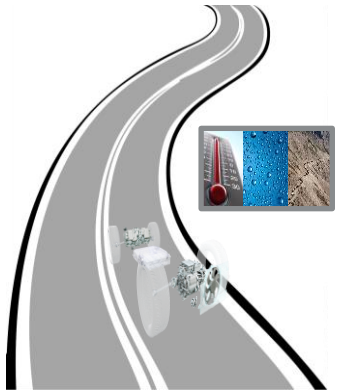
- Conventional and hybrid vehicle simulation
- RDE Simulation
  - Creation of a large number of artificially generated cycles
  - finite worst case cycle sections
  - Assessment of the legal framework of the worst case cycle
    - route allocation
    - Environmental conditions
    - dynamics
  - Emission simulation using data-based models (NOx, CO, HC, CO2)

Identification of critical points and assessment of determined worst case cycle

RDE compliant Worst Case Cycle

Worst Case Cycle

Worst Case Cycle
- Vehicle specific



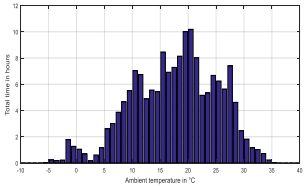
Event detection
Engineering approach RDE optimization

EVENTS

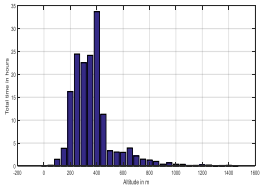
Boundary conditions
- Velocity profile
- Inclination
- Ambient temperature
- Elevation profile
- …

Systems
- Thermalsystem
- Engine
- Exhaust Aftertreatment
- …

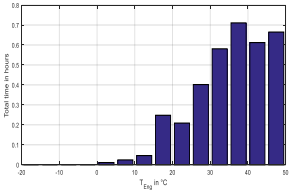
Ambient temperature

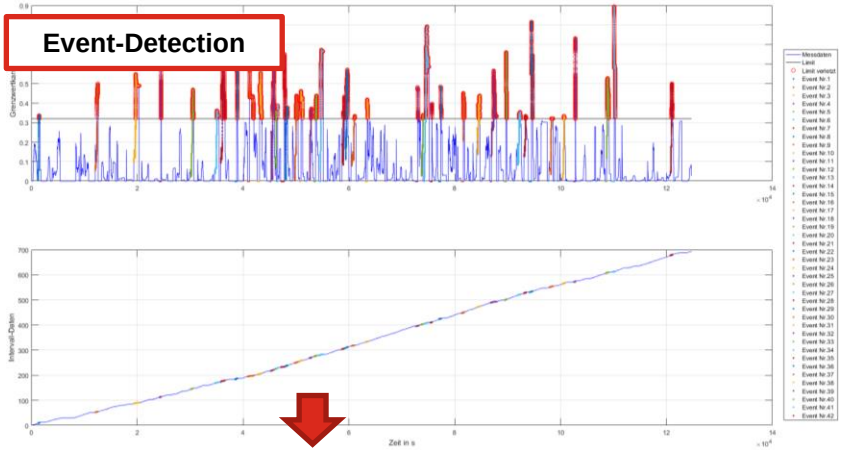


Altitude



Starting temperature





Virtual cycle generation
Engineering approach RDE optimization

EVENTS

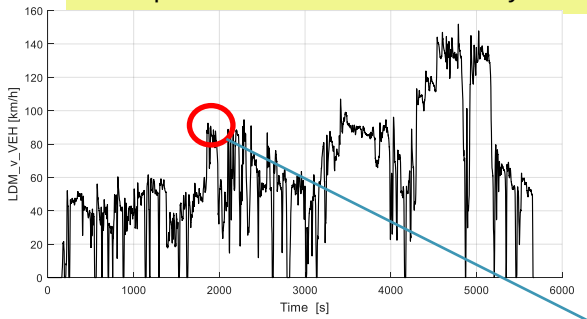
Boundary conditions
- Velocity profile
- Inclination
- Ambient temperature
- Elevation profile
- …

Systems
- Thermalsystem
- Engine
- Exhaust Aftertreatment
- …

EVENTS

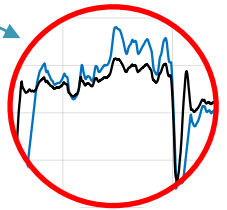
Cycle definition

Example based on RDE reference cycle



Overlay and variation of critical and real world driving sequences
- speed
- dynamics
- elevation profile
- temperature

RDE compliant cycle Zyklus
Worst Case Zyklus



Engineering approach RDE optimization

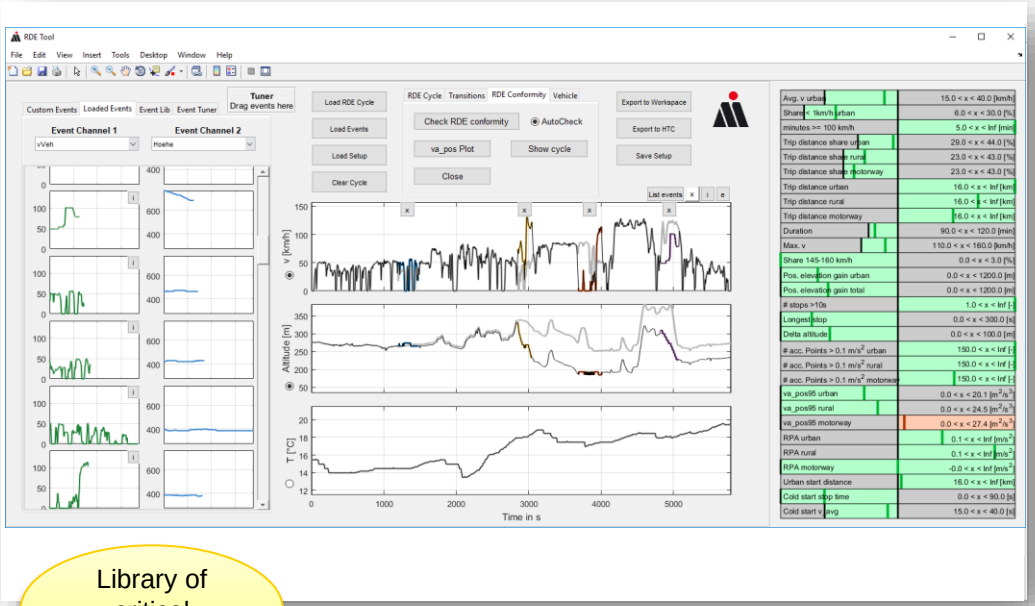
EVENTS

Boundary conditions
- Velocity profile
- Inclination
- Ambient temperature
- Elevation profile
- …

Systems
- Thermalsystem
- Engine
- Exhaust Aftertreatment
- …

EVENTS

RDE: Cycle generation and regulation compliance check

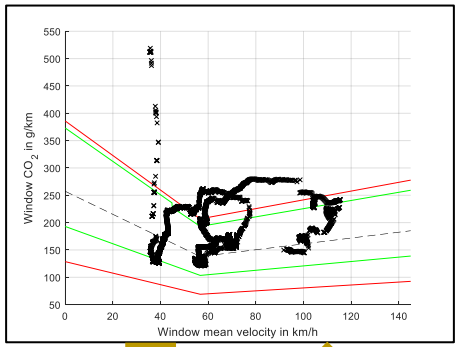


Library of critical events

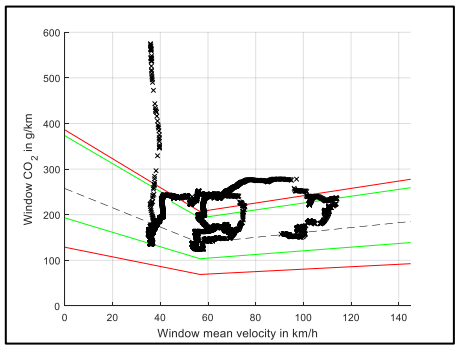
Features
- Highly automated cycle analyzer Drivability check
- Library of critical real world driving events
- Event generator
- Disturbance generator

Application Example RDE Cycle Methodology

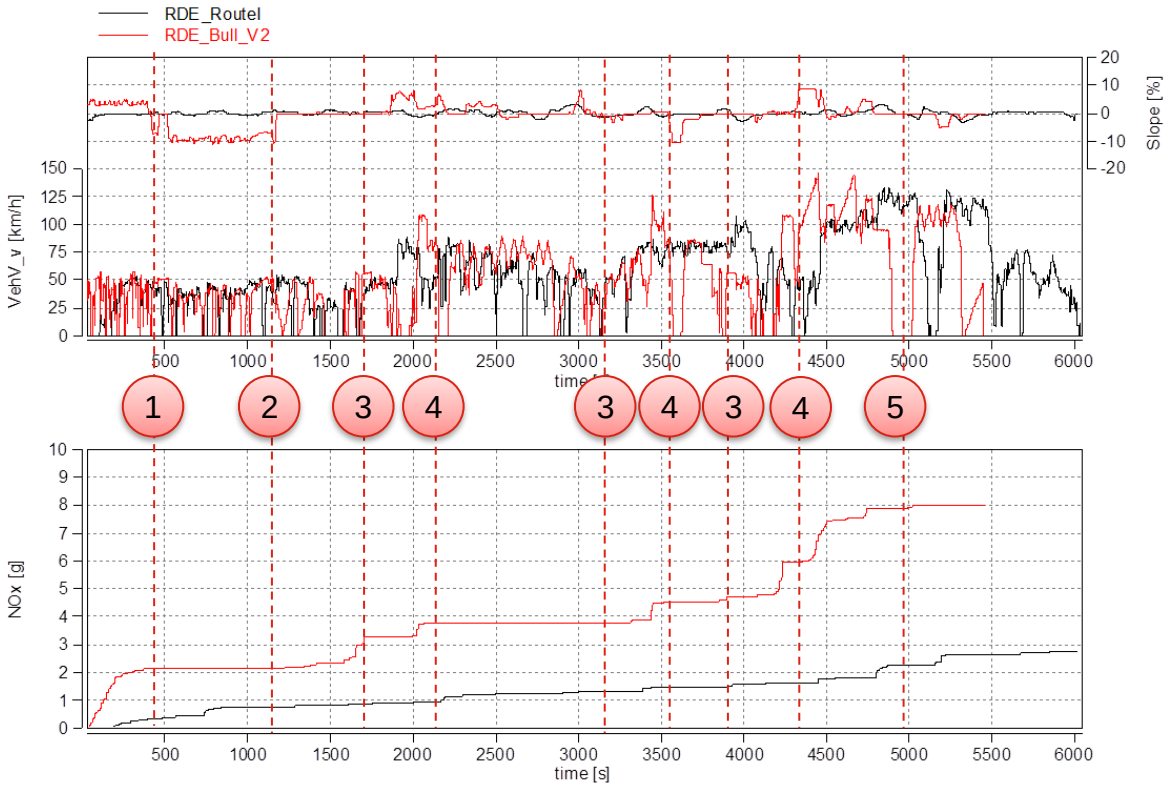
Verification of simulation results



Simulation results



Chassis dyno results
Chassis dyno results



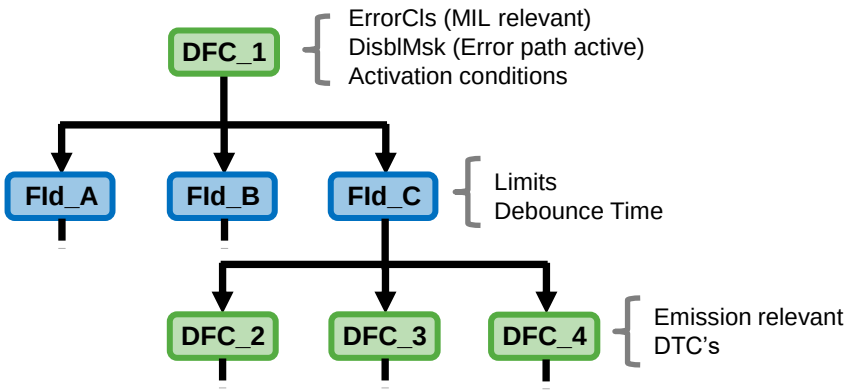
1 — 5 Critical emission events & adaptions

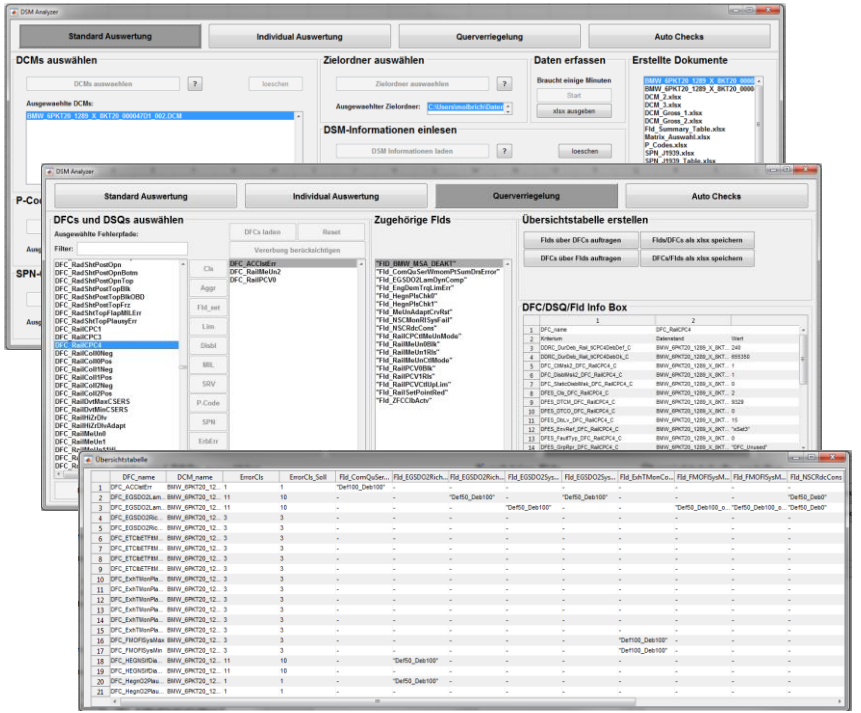
USECASE
Date Evaluation

OBD – Manager

Feature Overview

- High number of error paths and possible error responses -> High complexity
- Tool support processes to facilitate calibration
- Creation of overview tables
- Error management related dataset comparisons
- DINH viewer
- Automated validation of error class inheritance including application
  - recommendations and automatic data export






MAGNA
Forward. For all.