INTEGRATED OPEN DEVELOPMENT PLATTFORM FÜR TEIL- UND VOLLAUTOMATISIERTE FAHRZEUGANTRIEBE

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SUSTAINABILITY REQUIRES AN EFFICIENT MOBILITY SYSTEM
Nissan research vehicle presented at the ITS World congress 2013 equipped with 5 cameras and 6 laser scanners.

MobilEye Motorway automated driving on 7/2014 [provided by VALEO].

Full vehicle testing of brake assistant.
POWERTRAIN OPTIMIZATION INCLUDING CONNECTIVITY

- ACC system as comfort and safety feature
- Powertrain specific ACC
- Green ACC with advanced navigation system
- Coasting Assistant with traffic sign recognition
- Predictive cooling system or DPF regeneration
- Holistic System Optimization considering connectivity

Adaptive Cruise Control optimized for specific powertrain
Green ACC
Coasting Assistant
Automated Powertrain subsystem optimization
System Architecture Change

Connectivity/Environmental Perception

Conventional Powertrain
Standard Cruise Control
Adaptive Cruise Control
Adaptive Cruise Control (ACC)
Routing Information:
- Local geography
- Speed limits
- Traffic signs
- Other traffic
- ...

Objectives:
- Reduction of CO₂-Emissions
- Reduction of Pollutant Emissions
- Extended Lifetime

Predictive Management of:
- Exhaust Aftertreatment (DPF/SCR)
- Hybrid System (Battery)
- Thermal System (Radiator by-pass)
- Auxiliaries (e.g. A/C)

Energy Saving Potential 10% (e.g. EU Project OpEneR)
REAL TIME SETTING OF POWERTRAIN OPERATION STRATEGY IN FORMULA 1

Driver Action:
Setting of Powertrain

Live-Telemetry

Actual Vehicle Status

Traffic Conditions

Radio

Simulation of Multiple Strategy Options

Source: formula1.com

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COMPLEX CONTROLS ARCHITECTURES

Information

Driver

e.g. Thermal Management

VCU

ECU

TCU

XCU

...

e.g. Gear Selection

Information

Driver

VCU

ECU

TCU

XCU

...

.....
PREDICTIVE TRANSMISSION CONTROL

TODAY: Gear selection mainly based on pre-calibrated shift maps.

TOMORROW: Selecting right gear based on predicted road, traffic, weather, driver

- Model based calibration.
- Energy efficient, precise, intelligent shifting.
- Optimal timing & comfort of shifting, no hunting for gears.
- Adaptive strategies, that react to driver style, sporty, economical, ...

Is the ‘traditional’ shift map still required? For limp home?
CONNECTED VEHICLE POTENTIAL

INFORMATION LEVEL

VEHICLE INFORMATION

OPTIMIZATION

GLOBAL

FUEL ECONOMY

HYBRID OPERATING STRATEGY

Example: eDrive even at low SOC
**SMALLER RANGE EXTENDER**

Range Extended Vehicle Traction Machine 80kW

*Connected Powertrain™ enables HW/SW change*

- **REx control**
  - completely drain battery before charging

- **Range Extender** ~80kW
  - unrestricted operation
  - 99,99%

- **Connected Powertrain**
  - Range Extender ~30kW
  - 99,98%

- **size weight cost**

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*Public*

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A3PS MV - Peter Prenninger | 2014-12-11 | 10
EXAMPLE 1: ECO-ROUTING

PATH 1
conventional navigation system with traffic information

PATH 2 – ECO ROUTING
system takes account of traffic information, topology and powertrain state

... or PATH 1 – ECO ROUTING for DPF regeneration
EXAMPLE 2: HYBRID PREDICTIVE ENERGY MANAGEMENT

Traffic jam

Energy needed for eDRV

Storage place needed for recuperative braking

GPS ➔ Energy request info:

▪ + 1: To charge the battery for future Discharging events

▪ - 1: To Discharge the battery for future Charging events

![Diagram showing traffic jam, downhill, and GPS information](image)

![Graph showing virtual SOC vs. real SOC](image)
EXAMPLE 2: HYBRID PREDICTIVE ENERGY MANAGEMENT

Model Based Predictive Energy Management with GPS, ...

Downhill anticipation

Battery SOC target calculated by prediction of the downhill braking recovered energy

Target: To discharge the battery by consuming elec. energy (eDRV, boost)

Initial SOC

Without GPS Predictive Control

With GPS Predictive Control

Mechanical brake replaces Electrical brake

Cycling area
EXAMPLE 3: COASTING ASSISTANT FOR OEM

Coasting Assistant developed in OEM project aiming at energy-efficient recuperation by considering

- Detailed overall powertrain characteristics
- Predictive road information (e.g. road gradient preview)
- Driver preferences (e.g. comfort level, travel time, ...)

4.7% energy consumption improvement on real 3D driving route
POWERTRAIN OPTIMIZATION INCLUDING CONNECTIVITY

System Optimization

Connected Powertrain

Connected Vehicle

Target Achievement

SYSTEM OPTIMIZATION
Mastering this complexity requires a holistic approach with sophisticated development methods and tools.
TEST BENCH FOR POWERTRAIN DEVELOPMENT INCLUDING CONNECTIVITY TECHNOLOGY

(Rest) Vehicle + powertain simulation

Driver simulation

Track simulation

Environment + traffic condition simulation (fog, night, rain, snow, traffic jam, ..)

Maneuvres tests (Park, ACC, lane ass, ..)

Torque stimuli: Dyno

Video Stimuli &Simulation

Radar Stimuli &Simulation

Ultrasonic Stimuli &Simulation

Lidar Stimuli &Simulation

GPS stimulation

Shaft

GPS Sensor

Navi

Autom. Driving

BCU

TCU

ECU

VCU

UMTS Sensor

V2V + I2V simulation

TEST BENCH FOR POWERTRAIN DEVELOPMENT INCLUDING CONNECTIVITY TECHNOLOGY

Public
TEST BENCH FOR POWERTRAIN DEVELOPMENT INCLUDING CONNECTIVITY TECHNOLOGY

• Scenario out of environment situation
• Calculation of Echo
• Control of stimulation unit
HF PART EMULATION

Radar: 76-81 GHz
Echo: from 100ns to 3us
Development of **predictive control strategies**, to increase vehicle efficiency & safety using data from radar, video, GPS navigation, car-to-infrastructure, car-to-car, ...
OPENER ELECTRIC VEHICLE PROJECT CONNECTIVITY

**Pure Electric 4WD Vehicle**
Development of a connected & integrated predictive energy management system

**Satellite Navigation**
Optimized overall energy management with the integration of 3D digital route map & e-Horizon incl. the slopes and curves ahead

**Radar & Video**
Intelligent radar sensor technology and video cameras to monitor the vehicle surroundings

**HMI**
Encourages the driver to optimally control the vehicle in the most energy efficient, comfortable and safe way, especially under highly dynamic real world conditions

**C2X Technologies**
Traffic information coming from car-to-car (c2c) and car-to-infrastructure (c2i) technologies

**Regenerative Braking System**
High performance 4-wheel regenerative braking system for optimal energy recuperation
Co-Simulation Platform with 1D Powertrain & 3D Vehicle Dynamics for Virtual Controller Development:

- **Simulation Toolchain:**
  - 1D Electric Powertrain Simulation Model.
  - Vehicle Dynamics, 3D Road & Driver.
  - Control System & Simulation Integration.

- **Supporting Tools:**
  - DoE – Optimization.
  - Road Data Handling.
  - GPS Navigation Data.
**ADAPTED DEVELOPMENT FOR THE CONNECTED POWERTRAIN™**

- **Seamless** simulation toolchain supports connected development.
- **Model & test case reuse** from Office PC, to HiL, to Powertrain Testbed.
- **Reproducible** real-world traffic & environmental conditions during development.
FUNCTION EXAMPLE: COASTING ASSISTANT

C2I Communication
Digital Map GPS Navigation System
Electronic Horizon

V = 100km/h
V = 50km/h

Driver releases throttle
E-Braking Recuperation or Freewheeling

Driver releases throttle on recommendation
Autonomous Powertrain Control during deceleration

Energy improvement with optimal speed profile
+20% recuperated energy
human driver
recuperated energy
optimized
SUMMARY & OUTLOOK

- The Connected Powertrain™ goes beyond System Optimization and the Connected Vehicle

- The Connected Powertrain™ includes optimizing Powertrain Components considering Environmental Information

- The Connected Powertrain™ will change the System Architecture, allowing a breakthrough in System Performance

- The Connected Powertrain™ requires a holistic approach with sophisticated development methods and tools

- Under the brand Connected Powertrain™ AVL offers all required services in Engineering, Simulation and Testing