Electrification at AVL

November 5, 2019

Kevin J. Rhodes, PhD

AVL's Electrification Competencies
More than 20 years of Experience

More than 2500 people for Electrification

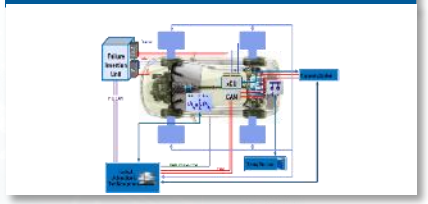
Simulation & Testing Technology

Development from Concept to SOP

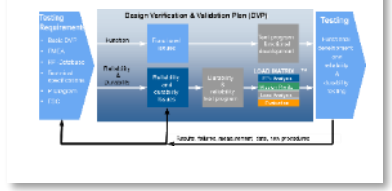
Propulsion system development services:

System Design & Simulation

System Integration



System Validation & Calibration



Number of Powertrain System SOP projects (2019):

10 x

Mild and Plug in Hybrids

4 x

Battery Electric Vehicles

3 x

Fuel Cell Electric Vehicles

Component development projects 2019:

14 x

Battery

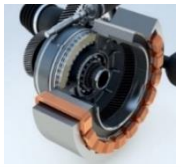
12 x

Fuel Cell

12 x

Power Electronics

2 x



Parallel Hybrid

6 x

e-axle

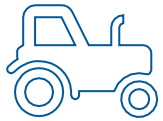
5 x

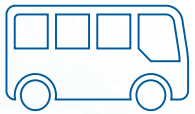
Hybrid Transmission

Electrification Range Applications

Commercial Vehicle (On/Off Road)


Heavy Duty


Agricultural

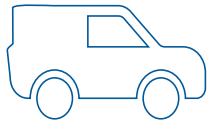

Buses


Construction


Light Duty

Passenger Car & 2 Wheelers

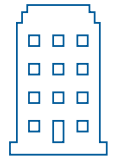

Cars/SUV


LCV

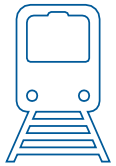

2-Wheeler

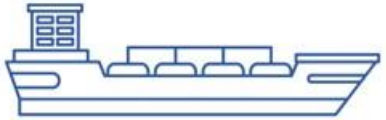

Pick-up

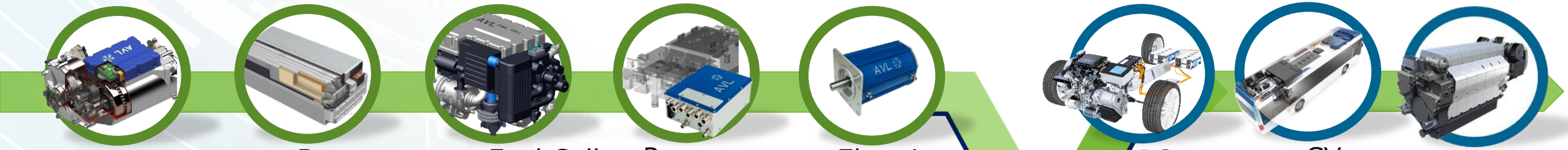
High Power (Stationary, Rail, Marine)


Buildings


Data Centers


Trains


Ship



AVL Electrified Powertrain Development

AVL Instrumentation for System Development & Optimization

HIL Testbench

Powertrain Testbed

HIL / Power HIL

E-Drive Testbed

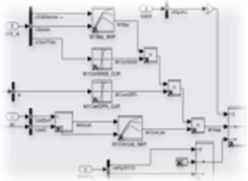
Gearbox Testbed

System Testing / HIL

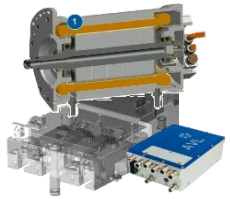
Vehicle Integration

Vehicle Calibration & Testing

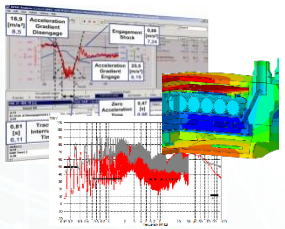
Software & Controls



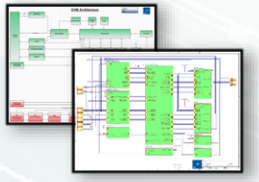
Component Development



CAE & Simulation

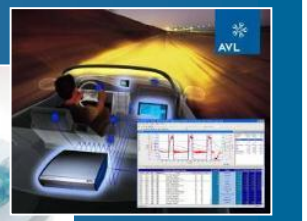


Architecture & Concept



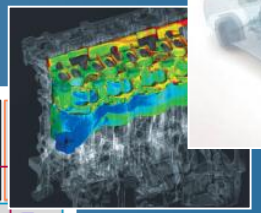
System Requirements

AVL-DRIVE

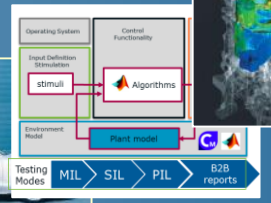


AVL-CAMEO

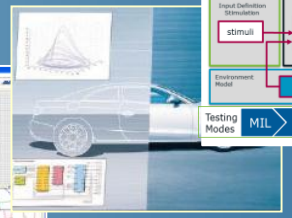
AVL-FIRE



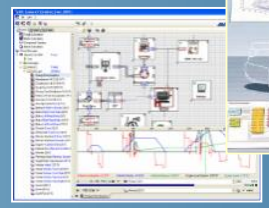
AVL-MAESTRA



AVL-INMOTION



AVL-CRUISE



maestra

EXCITE

CRUISE

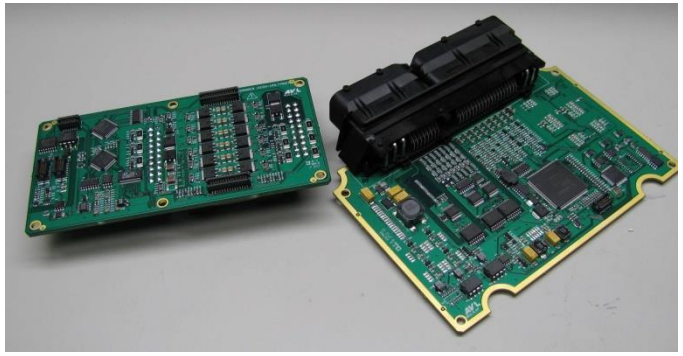
BOOST

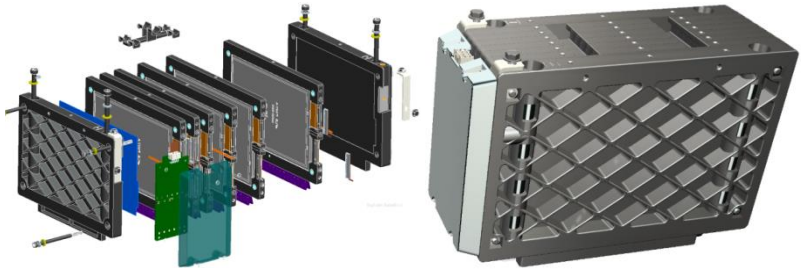
FIRE®

AVL Software Tools for Powertrain System Development & Optimization

California Technical Center

AVL California is solely focused on design, development and testing of alternative energy systems with expertise in …





Applied Engineering

- ❑ System level development and advanced technology assessment
- ❑ Vehicle mechanical and electrical integration
- ❑ System controls / software design, calibration and integration
- ❑ Battery Pack design/integration including BMS hardware and software
- ❑ Prototype fabrication and build

Testing

- ❑ Electronics laboratory
- ❑ Powertrain system testing
- ❑ Vehicle test cell for optimizing energy flow and system dynamics including wheel slip, ABS, vehicle stability and regenerative braking control and calibration.
- ❑ Battery test cells

Ann Arbor New Energy Lab

- 3 battery test cells with 5 channels for battery cycling tests up to 320kW and 1000VDC
- Electronics and battery module and pack assembly labs
- Dynamic thermal cycling capabilities from -40°C to 180°C
- E-Motor test cell, HIL-SIL
- Vehicle applications area and hoist for passenger car to class 8 vehicles
- ISO/IEC 17025-2005 accredited

Passenger Car Electrification

MODULAR BATTERY MANAGEMENT SYSTEM

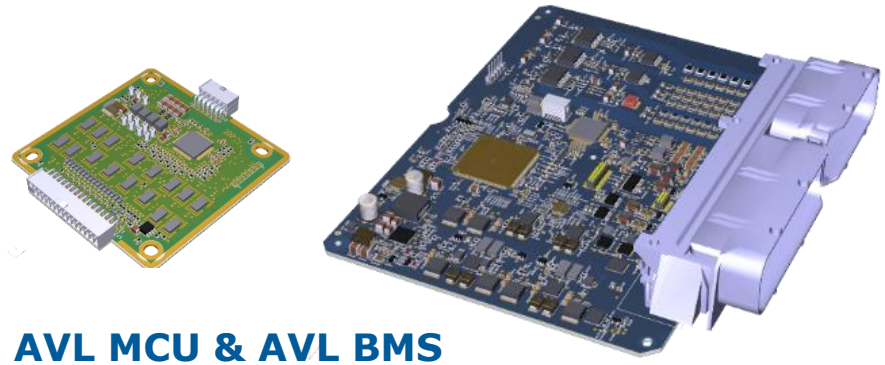
SAFETY & DIAGNOSIS
- Isolation detection
- HV interlock
- Safety monitoring
- Diagnosis functions
- Error-management

CORE BATTERY FUNCTIONS
- State of Charge (SOC)
- State of Health (SOH)
- Balancing
- State of Function (SOF)
- Cell failure / wear detection

AUXILIARY FUNCTIONS
- Start-up / Shutdown
- Signal acquisition / actuator control
- Main contactor control
- Pre-charge function
- Thermal management

INTERFACE & COMMUNICATION
- Vehicle interface
- Diagnosis interface
- Logistic-information
- Actuator control (external)
- Re-programming

Function Overview – AVL BMS



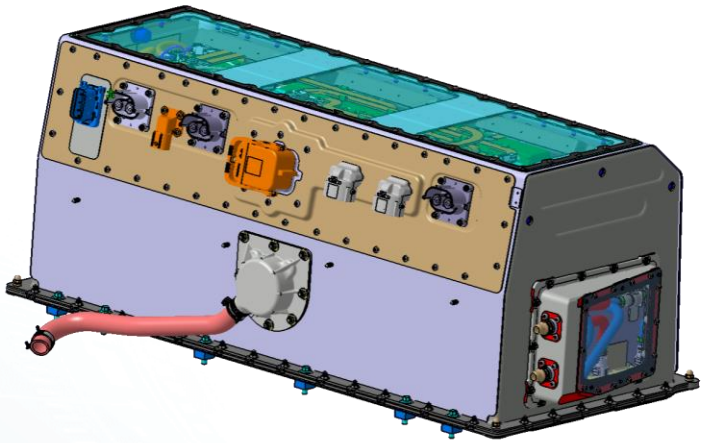
AVL MCU & AVL BMS
(3rd generation)

Highlights

- Battery cell model included, covering the most of market available battery cells
- Tolerance & aging compensation
- Variants to be supported by calibration
- from 48 V up to 1000 V
- Up to 18 cells per module
- Up to 6 temperature sensors per module

- **MOST ACCURATE BATTERY/CELL STATE CONTROL**
- **MODULAR PLATFORM & MODEL BASED CONTROLS**
- **FLEXIBLE ADAPTION TO CUSTOMERS REQUIREMENTS**

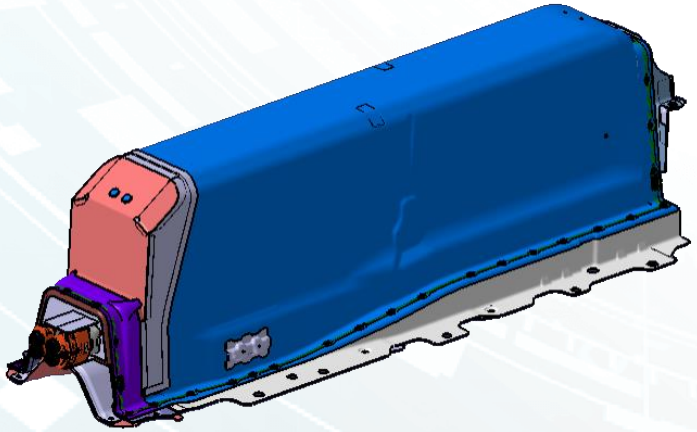
Battery Development - Volvo Polestar One



2016 to 2017 – development for PHEV to C-Sample

Technical Data & Technology

- E-Capacity: 31.4 kWh
- Planned production volume: >3000 Units
- Distributed system – one battery in tunnel area and one in trunk
- 3 module strings in parallel
- Modules with integrated liquid cooling
- Sheet metal battery housing

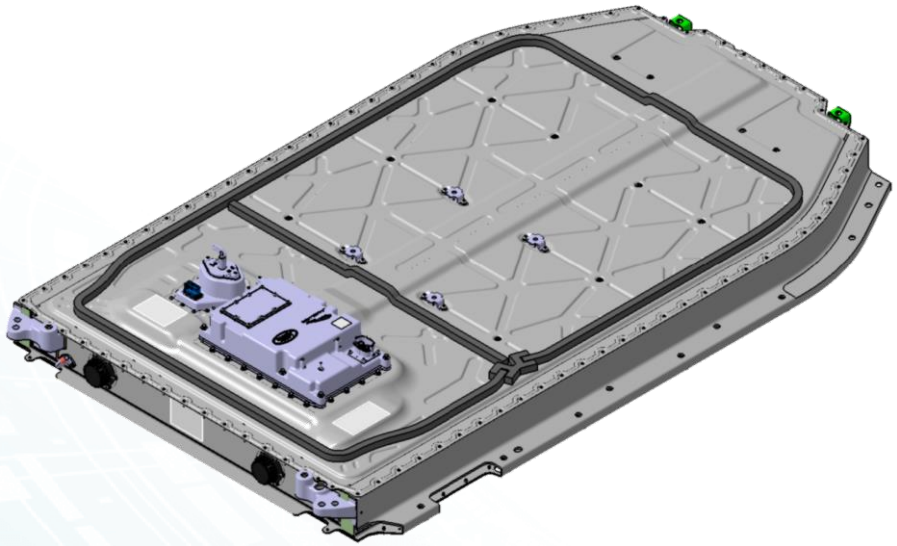


Source: AutoBild 2018

Product Feasibility | Concept Design | Prototype Development | Development & Series Preparation | Product Validation | SOP | Product Life Cycle

AVL involved

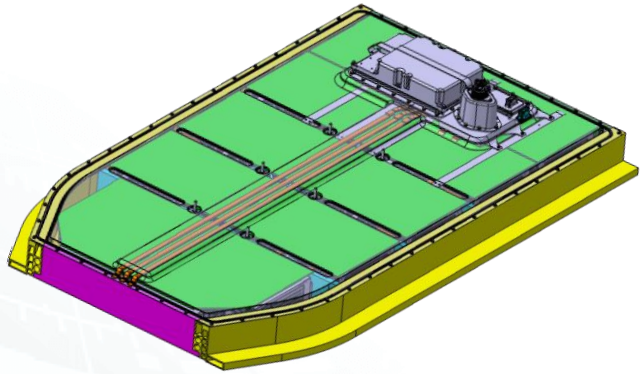
Battery Development - JLR iPace



2014 to 2017 –development for BEV in A- to C-Sample

Technical Data & Technology

- E-Capacity: >80 kWh
- Planned production volume: >5000 Units per year
- Cooling integrated in housing frame incl. production concept by AVL
- Extruded profiles no die casted parts
- Structural aluminum housing
- Reduced manufacturing and assembly costs by AVL production concepts
- >40 B-sample Prototypes built by AVL



https://motor.at/news/jaguar-i-pace-so-faehrt-sich-das-in-graz-gebaute-elektroauto/400047095

Commercial Vehicle Electrification

Battery System Development for Electric Bus

System Specification

- Bus configurations of 6 and 8 sub-packs based on customer request
- Each Sub-Pack contains Twelve 12s2p Module Configuration
- Each Sub-Pack has 13.1 kWh capacity
- Total bus capacity of either 80 kWh or 105 kWh based on configuration selection

Highlights

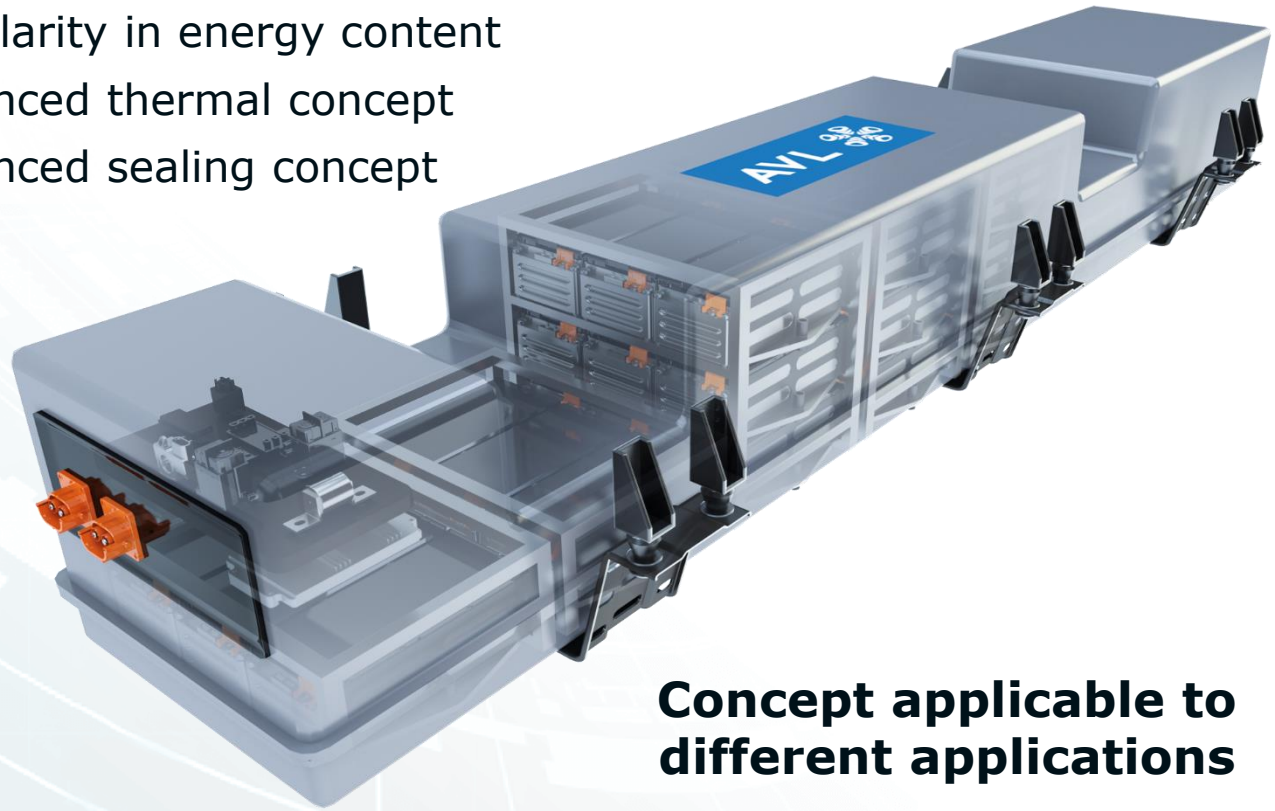
- Integration of existing battery modules (cost effective solution)
- Parallel integration of multiple battery packs (scalable energy content)

AVL Contribution

- Battery system layout and design
- System development – geometrical, electrical, thermal & functional integration
- Battery Management System (BMS) development and calibration
- Prototype build
- System testing and validation

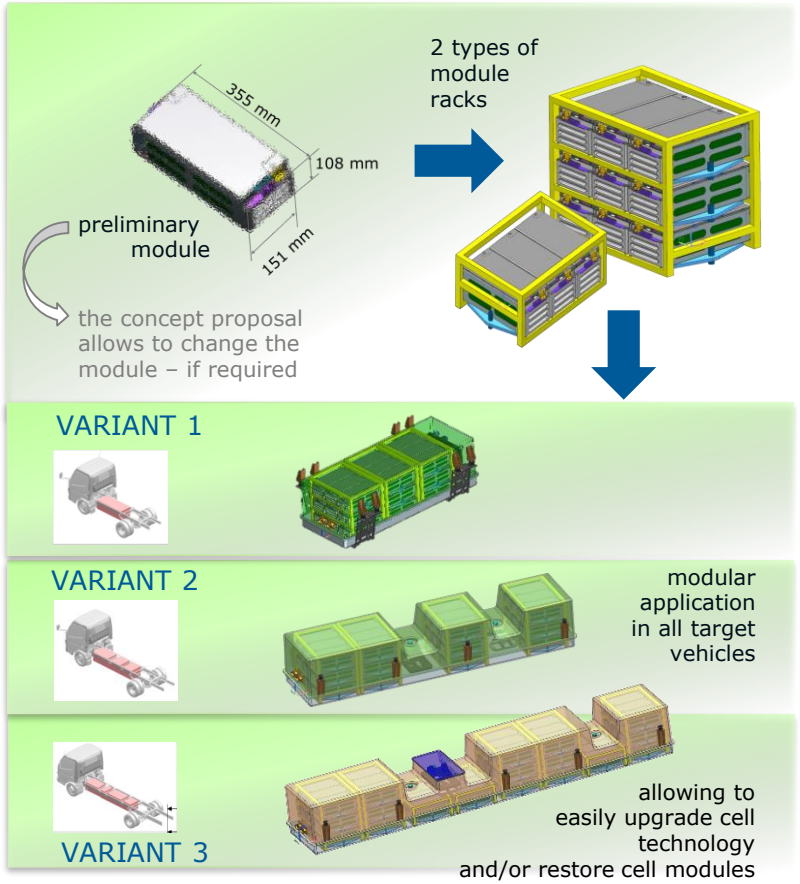
Modular Battery Design for Truck & Bus

- Integration of existing modules
- Flexibility in module / supplier selection
- Modularity in voltage level
- Modularity in energy content
- Advanced thermal concept
- Advanced sealing concept



Concept applicable to different applications

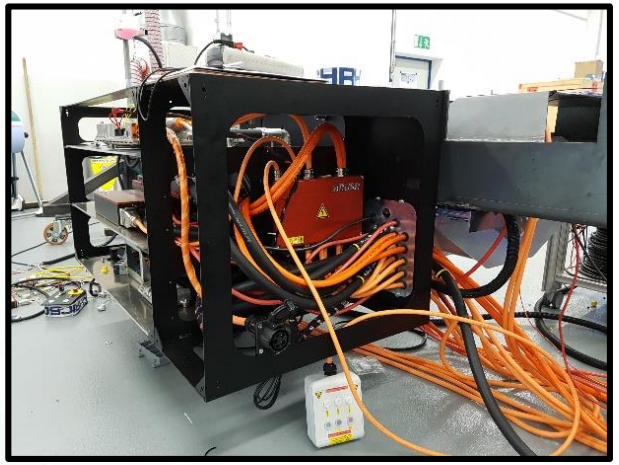
(truck & bus)

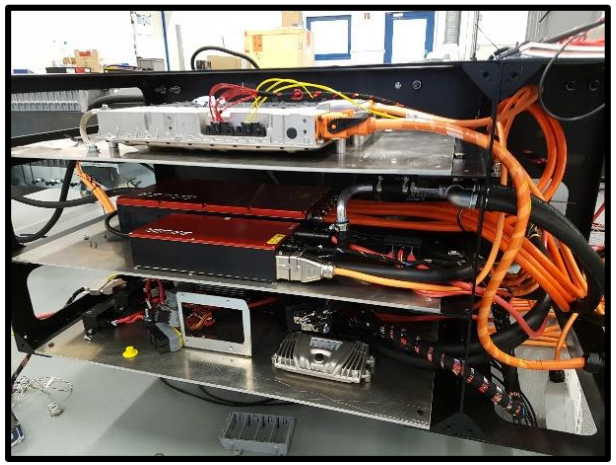


Modular Battery Concept

E-FUSO VISION-ONE
Full Functional Show Truck

Vehicle Built at AVL





Simulation Meets eAxle Development

Track Correlation for eAxle Development

Electric AWD rear axle

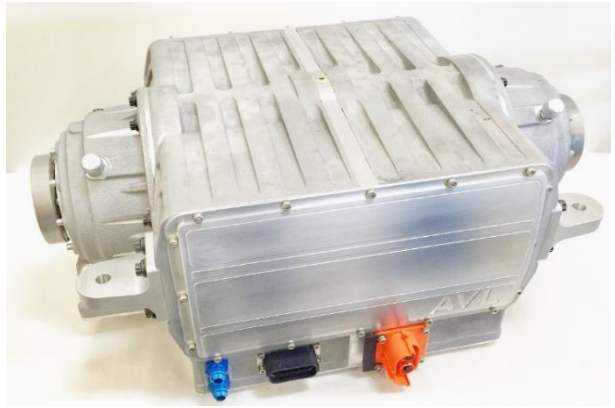
- Reduced C02 emissions and fuel consumption
- Enhanced traction and stability
- Efficient packaging
- Modular solution

Specifications

- 150kW total power
- 330V 9kWh battery w/ BMS
- 1500Nm max output each wheel
- Torque vectoring (<50ms response time)
- EV mode range → 30 km
- EV mode V_{max} → 130 km/h

Operation modes

- EV | HEV | AWD | FWD

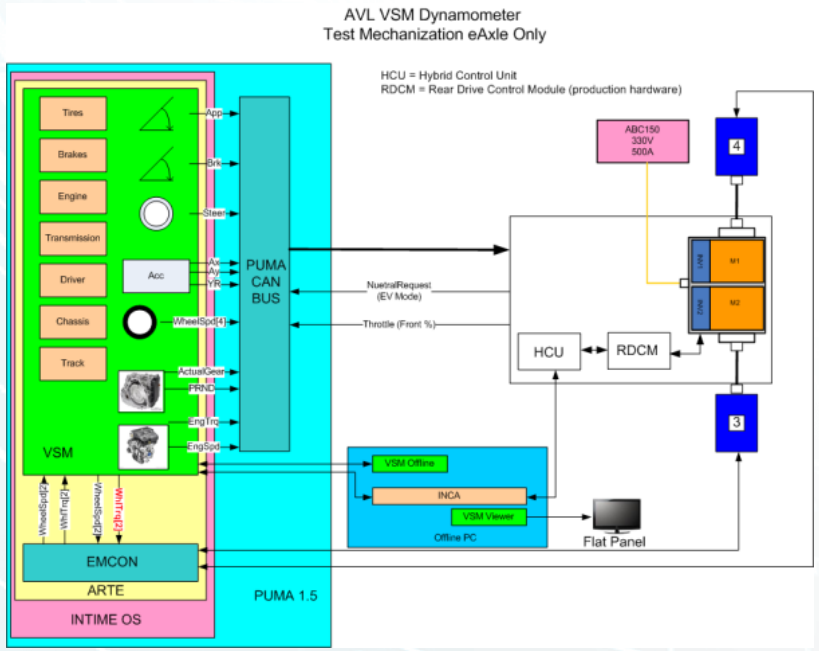


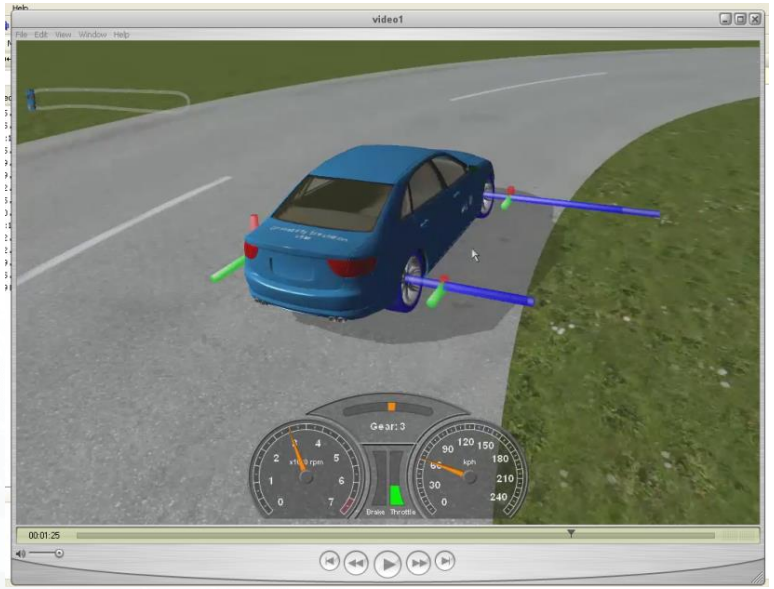
AVL Project Responsibilities

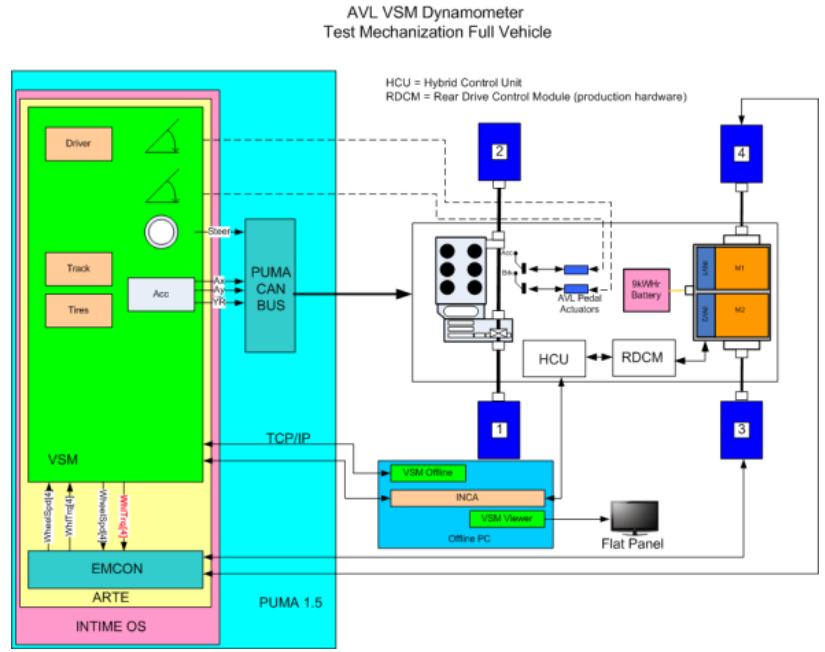
- Software developed using existing controls library
- Vehicle level model allowing Torque Vectoring
- Mechanical design of the eAxle assembly
- Physical integration of eAxle, all HV components and controls to demo vehicle
- Powertrain dynamometer testing of completed vehicle

eAxle Development with AVL VSM

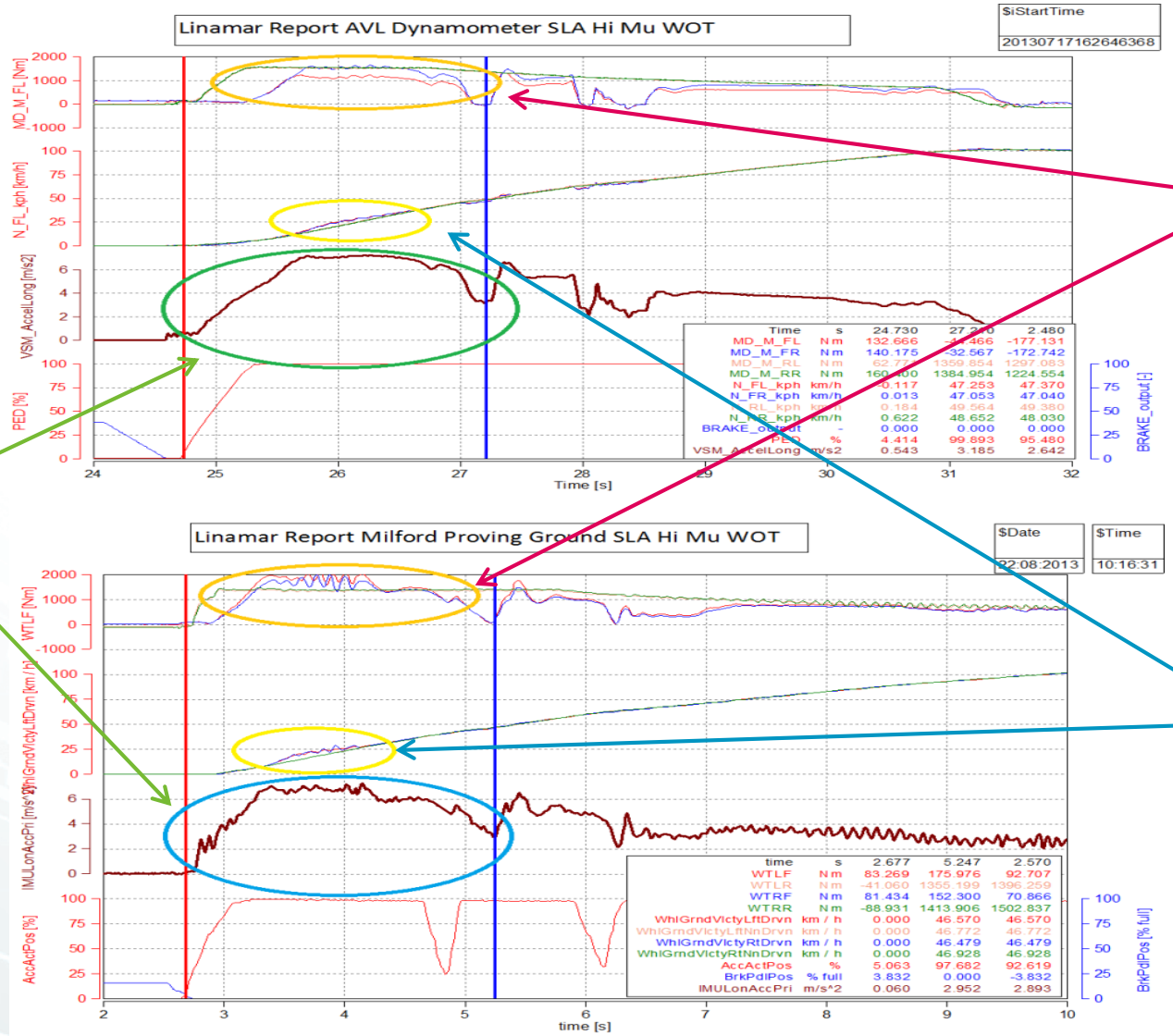
- AVL VSM used to develop and validate torque vectoring concepts with SIL and HIL in advance of vehicle integration
- Aggressive schedule incorporating AVL AWD dynamometer made possible with unique progression from component to vehicle level testing covering all weather surface conditions







Correlation Lab to Milford Proving Grounds
Straight Line Acceleration, WOT, High Mu



Acceleration Shape and Timing

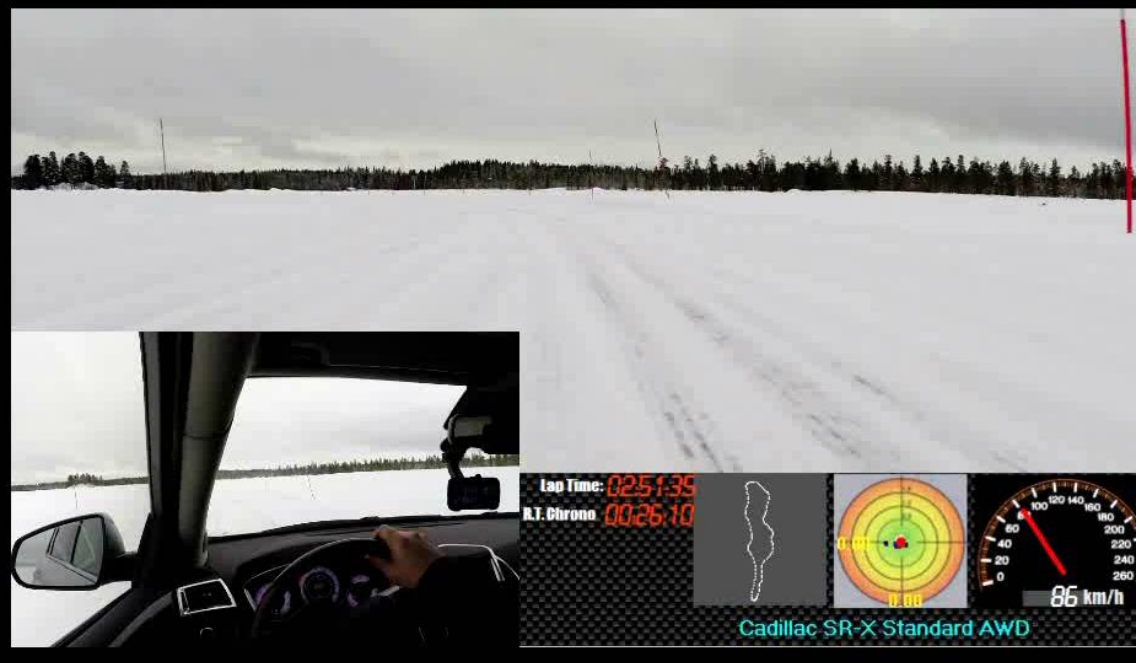
Oscillation Frequency 8.3 Hz

Wheel Slip Event On Front Axle

eAWD Track Performance

eAWD

Standard AWD

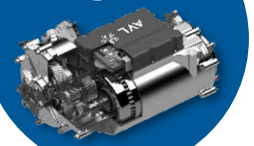


Electrification at AVL
Development Services and Competences

- Testing
- Concept
- Simulation
- Benchmarking
- Hardware Design
- SOP Development
- System Integration
- Software Development
- Technology Consulting
- Industrialization support

Software & Controls

System Integration

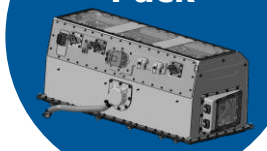


E-Motor

Battery Management System

HV & LV Electronics

HV Battery Pack



AVL delivers solutions from concept and components to production ready electrified powertrain systems for a wide array of applications including passenger and commercial vehicles


AVL
www.avl.com
Thank You!

Contact Details

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