Virtual Integration Using the FMI Standard and the Integrated Evaluation in the Complete Vehicle based on XiL-Methods
Agenda

(1) General trends and challenges

(2) Motivation

(3) Approach – Global vehicle validation

(4) FMI – Functional Mock-up Interface Standard

(5) Progressive Virtual Vehicle Integration

(6) Outlook - Data Management based on ASAM Standards
General Trends and Challenges

Trends in the automobile industry

Energy Efficiency  Integrated Safety  Communication
Internet of Things
General Trends and Challenges

Urbanization necessitate new mobility concepts

„Pusher“ in Tokyo’s subways

Scooter traffic jam in China
General Trends and Challenges

Road Safety evolution in Europe

ESC for passenger cars
ESC for trucks and trailers
Emergency brake for trucks
Lane departure warning for trucks
ABS for Motorcycles
General Trends and Challenges

Control Systems are Core Technologies to Improve Safety

Chassis Controls

Advanced Driver Assistance Systems
General Trends and Challenges

CO2 history and evolution worldwide


Solid dots and lines: historical performance
Solid dots and dashed lines: enacted targets
Solid dots and dotted lines: proposed targets
Hollow dots and dotted lines: unannounced proposals

Grams CO2 per kilometer, normalized to NEDC

US-LDV
California-LDV
Canada-LDV
EU
Japan
China
S. Korea
Australia

China 2020: 105
Japan 2020: 105
EU 2020: 95
US PC 2025: 91
EU 2025: 70

(Recom. European Parliament)

[1] China’s target reflects gasoline fleet scenario. If including other fuel types, the target will be lower.
General technology trends

New technologies will help ... but will also increase the complexity

Multifaceted powertrain concepts

Connected Vehicle
In spite of everything – emotion and driving experience plays still a key role!
Motivation

Major issue for customer values are the **global vehicle character**

We need more the vehicle view from outside as the system view from inside!
Motivation

Vehicle character is a result of well integrated system & functions
Motivation

The big battle against the increasing complexity

- Flexible Processes
- Intelligent Methods
- Standardized Tools
- Variants
- Technology
- Integration Effort
- Network Functions

Validation and Testing Effort vs. Time
Motivation

The Later Failures are Found, the More Expensive They Are

- Requirements & Performance Targets
- Module Design
- Component Design
- System Design
- Design
- Implementation
- Product
- System Integration & Validation
- Module Integration & Verification
- Component Verification
- Validation against Global Vehicle Target

But today very late or even too late!
Motivation

What is the differences between verification and validation?

Verification

Have we done the things right?

Validation

Have we done the right things?
Motivation

What will be the Impact of Any Change in Terms of Agility, Safety, Comfort, Emission and Costs?

Management...

... Engineers
Motivation

How to achieve an earlier vehicle evaluation & validation?

Early evaluation and validation
Approximately **60%** of development time no real prototype available

Validate global vehicle
Less than **10%** of the engineers get evaluation experience in global vehicle

Can we lead back engineers to the global vehicle experiment?
Approach – Global vehicle validation

We need evolution jump with new methods, integrated tools, standards and processes
Approach – Global vehicle validation

Continuous vehicle integration along the development process

Component, module and subsystem integration

Vehicle integration (assembling)
Approach – Global vehicle validation

Continuous vehicle integration along the development process

- Target & Requirements
  - Verification against Spec.
  - Validation against Global Vehicle Target

- Model-in-the-Loop
  - Verification against Spec.

- Software-in-the-Loop
  - Verification against Spec.

- Hardware-in-the-Loop
  - Verification against Spec.

- Product
  - Validation against Global Vehicle Target
Approach – Global vehicle validation

Agile Development: Testing based with continuous integration

Integration at System Level
- Chassis Rig, In-Vehicle

Integration at Sub-System Level:
- Powertrain Test Rig

Integration at Component Level:
- Engine, GearBox, Steering etc.
The fusion of real and virtual prototypes as well as real and virtual testing will play a key role in the future model based system development.
FMI – Functional Mock-up Standard

Open model exchange and integration ability are very important

FMI was a result of the European funded project started 2008

Key Facts and Mission:

- FMI defines a standardized interface to be used in computer simulations for multi-physical systems.
- Virtual product digitally assembled from a set of models
- FMI provides the means for model based development of systems
- Models exchange, model integration and co-simulation are independent from the heterogeneous authoring tools
- FMI is now promoted by the Modelica Association
- Today more than 50 tools support export and/or import for FMU – Functional Mock-up Units
- FMI 2.0 is now in a beta release (https://www.fmi-standard.org/)
FMI – Functional Mock-up Standard

From model and data mix-up to clear integration structure
FMI – Functional Mock-up Standard

Virtual vehicle integration and virtual test driving

Model Library

MATLAB SIMULINK

DYMOLA

Authoring Tools

Test and Integration Platform

Driving maneuver and scenario catalogue
Progressive Virtual Vehicle Integration

Virtual vehicle integration of virtual and real components

Virtual Engine
Real Engine
Virtual Gear Box
Real Gear Box
Virtual Chassis
Virtual ADAS
Virtual HVAC

VTD
Virtual Test Driving

Virtual Vehicle Integration
Progressive Virtual Vehicle Integration

Continuous Vehicle Evaluation Along the Development Process

- Office / MiL
- Office / SiL
- Lab / HiL
- Real Vehicle

Models & Parameters
Test Maneuvers & Evaluation Criteria

CarMaker
Progressive Virtual Vehicle Integration

The Real-World Operation Emission Standards will be introduced

PEMS – Portable Emission Measurement System

wwwavl.com/real-life
Progressive Virtual Vehicle Integration

Road2Rig: Real Life Emission at mountain road
Progressive Virtual Vehicle Integration

Road2Rig: Real Life Emission at mountain road

Engine-in-the-Loop

Graph showing emission CO and distance for two different vehicles.
Outlook - Data Management based on ASAM Standard

Where can we get qualified model data and how can we assure result quality and documentation according the ISO 26262?

Data Management (Product Lifecycle Management / Require Management)

- Collaboration between different groups & locations
- Responsibilities and access authorization
- Variant handling
- Data merging
- Traceability of modifications
- Documentation

VTD
Virtual Test Driving
Virtual Vehicle Integration
FMI
Outlook - Data Management based on ASAM Standard

By using existing real world testing standards for the virtual world!
Simulation parameter management based on A2L standard and existing calibration tools and processes

Metadata
- Unit
- Min
- Max

Converter
- .csv
- .a2l
- .hex

VDM
- Parameter Description
- Parameter Values
- Label Identifier
  - CM_ PowerTrain_ET_FullLoadPower

CRETA
CAMEO
AVL
fOX
TFMS
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Thank You.