Model-Sharing in the service of Innovation for the Automotive Industry

Roland Lismonde - Robert Bosch (France) SAS
Model-Sharing in the service of Innovation

Agenda

1 Robert Bosch - overview
2 Model Based Development
3 Model-Sharing and cooperation with OEM
4 Next steps / challenges
5 Summary
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Robert Bosch : Four business sectors

Automotive Technology

Industrial Technology

Energy and Building Technology

Consumer Goods

Diesel Gasoline Systems
Model-Sharing in the service of Innovation

Robert Bosch: overview of Automotive Technology

Powertrain systems

Safety systems

Comfort systems

Diesel Gasoline Systems

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# Model-Sharing in the service of Innovation

## Organizational Context within the Divisions DS and GS

<table>
<thead>
<tr>
<th><strong>DS - Diesel Systems</strong></th>
<th><strong>GS - Gasoline Systems</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger Cars</td>
<td>Air Management</td>
</tr>
<tr>
<td>Commercial Vehicles</td>
<td>Continuously Variable Transmission</td>
</tr>
<tr>
<td>Exhaust-Gas Treatment, Sensors, Starting Devices for all segments</td>
<td>Direct Fuel Injection</td>
</tr>
<tr>
<td>New Business and Growth Areas for all segments</td>
<td>Fuel Injection</td>
</tr>
<tr>
<td><strong>Electronic Diesel Control Unit</strong></td>
<td>Fuel Supply</td>
</tr>
<tr>
<td></td>
<td>Sensors and Ignition</td>
</tr>
<tr>
<td></td>
<td>Transmission Control</td>
</tr>
<tr>
<td></td>
<td>Hybrid, Electric Vehicle, Fuel Cell</td>
</tr>
<tr>
<td></td>
<td><strong>Electronic Gasoline Control Unit</strong></td>
</tr>
</tbody>
</table>

**DGS-EC - Diesel Gasoline Systems - Electronic Control Business Unit**

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Diesel Gasoline Systems

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Handling increasing complexity

- Quality
- Costs
- Speed
- Calibration Efficiency
- ECU Resources
- Variant Management

Solutions
- Software Architecture
- Standardization
- Design Simplicity
- Simultaneous engineering
- Model Based Development
- Multi/Many-Core Processing
- AGILE Organization

MDI enables to keep pace and efficiently handle rising complexity

Diesel Gasoline Systems

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MBD versus Conventional Development

Conventional Approach

- System Analysis
  - Prototyping through H/W
    - Engine Test Bench
  - Function Design
- Function Model
- Source Code
- Unit Testing
- Function validation

MBD Approach

- System Analysis
- Concept Eval
  - Concept Control Model
  - Plant Model
- PC Environment
  - MiL – Model in Loop
    - Overall Control Model
    - Plant Model
  - SiL – Software in Loop
    - Control Model
    - Plant Model
- Lab Environment
  - RP/PiL
    - Control Model
    - Plant Model
  - HiL
    - Plant Model
  - VeC
    - Vehicle

Earlier detection of bugs along the V-cycle

Diesel Gasoline

MiL – Model in Loop
SiL – Software in Loop
PiL – Processor in Loop
HIL – Hardware in Loop
VeC – Vehicle

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Model-based development

Bosch ECU

Model-based requirement

Commissioned Software sharing

Exchange of models and model artefacts in order to ease Software development and cooperation between two or several partners
# Model-Sharing in the service of Innovation

Better cooperation with OEM: 5 levels of Model-Sharing

<table>
<thead>
<tr>
<th>Cooperation Levels</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Level 0**        | • Processing of Bosch model  
                    • Build simulation environment at customer |
| **Level 1**        | • Non functional adaptation and processing of customer model  
                    • No delivery of model artefacts to customer |
| **Level 2**        | • Non functional enhancement and processing of customer model  
                    • Delivery of enhanced model and model artefacts to customer |
| **Level 3a**       | • Functional modification of customer model  
                    • Delivery of modified model to the customer |
| **Level 3b**       | • Functional modification of Bosch model by customer  
                    • Delivery of modified model to Bosch |
| **Level 4**        | • Joint development  
                    • Comparable level of contribution from Bosch and customer  
                    • Sharing of created Intellectual Property |
# Model-Sharing in the service of Innovation

Matlab / Simulink tool chain as open system

<table>
<thead>
<tr>
<th>Support of different role-based tasks at OEM side</th>
<th>Ease definition of a common reference development process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced use of Matlab strengths: scripts</td>
<td>Ease specific OEM / supplier developments</td>
</tr>
<tr>
<td>Processing of OEM Data Dictionary (database)</td>
<td>Increase the quality and reduce the low added value tasks</td>
</tr>
<tr>
<td>Automated processing of OEM models to Robert Bosch system for code generation</td>
<td>Reduce the development time</td>
</tr>
<tr>
<td>Establish standards (MDX and/or AUTOSAR) used for code generation</td>
<td>Provide a frame to reduce the customisation for each OEM, Ease the integration in 3rd Party Software</td>
</tr>
</tbody>
</table>
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Front-loading process: back-to-back tests with MIL / SIL

- OEM Data Dictionary
- Matlab Workspace
- Implemented model (fixed- or floating-point)
- Code generation
- Compilation

OEM model

Stimuli from OEM

Additional test cases to improve the coverage

Stimuli + test cases

MIL tests with Test Execution Tool

MIL results

SIL or PIL or HIL tests with Test Execution Tool

SIL or PIL or HIL results

Back to Back Comparison
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Transition to MBD in Powertrain domain

Function Model & Auto Coding
- Mature in legacy tool-chain
- ML/SL evolving and used in production
- AUTOSAR R4.x & Multicore evolving

Organization
Training
Infrastructure

Standards

Virtualization of environment
- Bosch library for Plant Model
- Commercial tools
- virtual HW evolving

Car 2 Car
Network
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Cross-domain simulation

Long term challenge with FMI / FMU
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Summary

MBD enables efficient handling of rising system complexity in Automotive applications

Successful application of Model-Sharing requires:
- Alignment of Process, Methods and Tools between different partners
- Seamless integration of all phases through appropriate tool-chain
- Support for Standards (e.g. AUTOSAR, FMI) can be a leverage
- Multi/Many-Core Simulation for future oriented development

Close and substantial collaboration among OEMs, Suppliers and Tool Vendors is required
- Strategic partnership between MathWorks and Bosch has been established
- A lot of work is currently on going for support of AUTOSAR R4.x and support of FMI/FMU in long term
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Thank You