



Model-based development with “eFMI”

From Physical Models to ECU Software

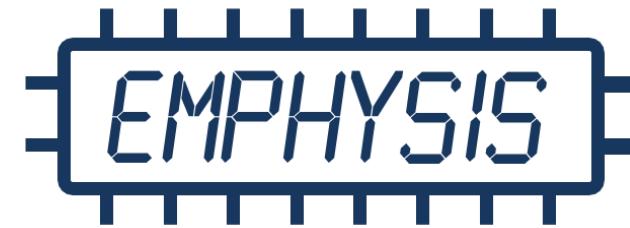
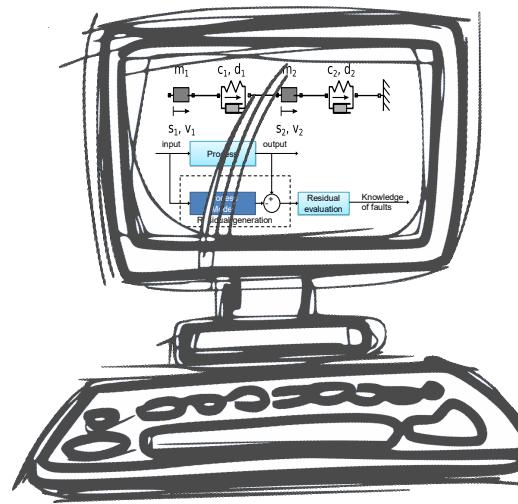


Recorded July 17, 2021

Oliver Lenord (Bosch Research)



voice



Aug. 2017 - Feb. 2021



March 2021-





Publicly Funded Project EMPHYYSIS

Partners by Country and Position in the Value Chain



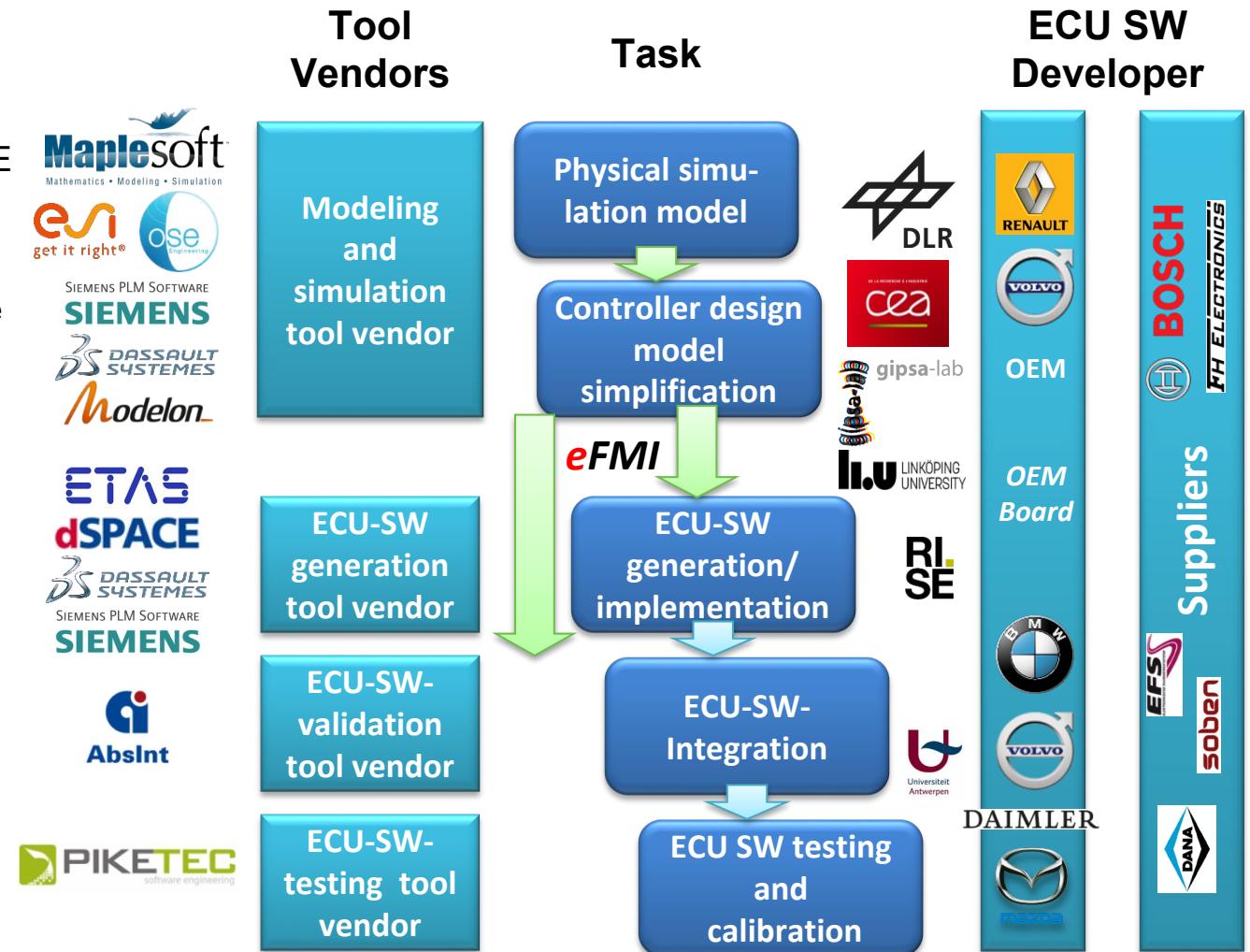
- **Germany**
 - Bosch
 - DLR
 - ETAS
 - ESI ITI
 - AbsInt
 - PikeTec
 - dSPACE
 - EFS

- **France**
 - Siemens SAS
 - Dassault Systèmes SE
 - Renault
 - CEA
 - University of Grenoble
 - FH Electronics
 - OSE
 - Soben

- **Sweden**
 - Dassault Systèmes AB
 - Volvo Cars
 - Modelon
 - Linköping University
 - SICS East

- **Belgium**
 - Siemens NV
 - Dana
 - University of Antwerp

- **Canada**
 - Maplesoft



→ More than 100 PY invested over 3.5 years



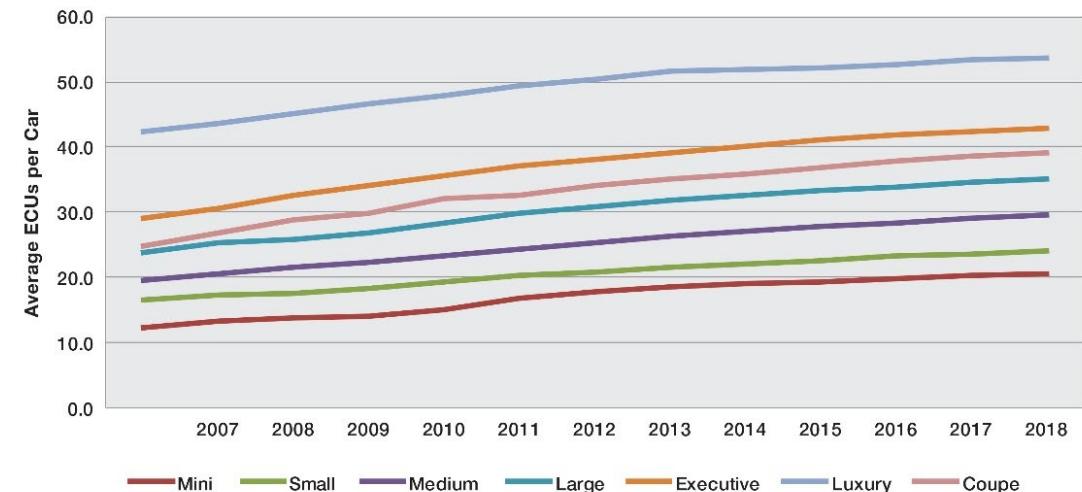
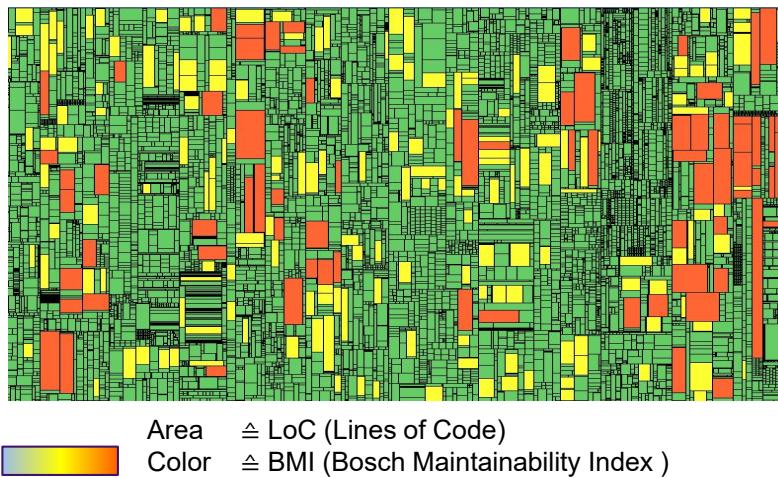


Why?

Challenges in the Field of Automotive Embedded Systems



Engine Control SW Complexity Measurement



Source: Strategy Analytics



Benefits of Lower SW Complexity

- Less SW maintenance effort
- Less SW calibration effort
- Less ECU resources demand

→ Need for Complexity Reduction



→ Need for Functional Innovation

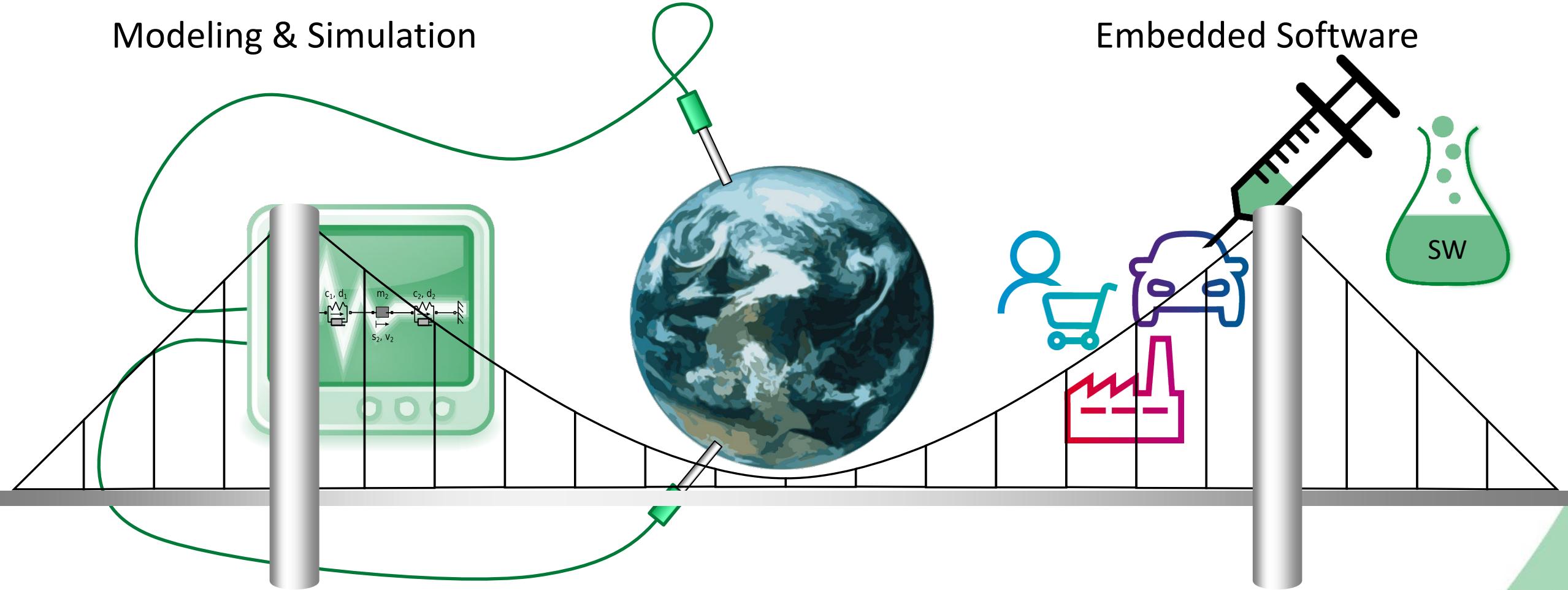




Why? Bridge the gap

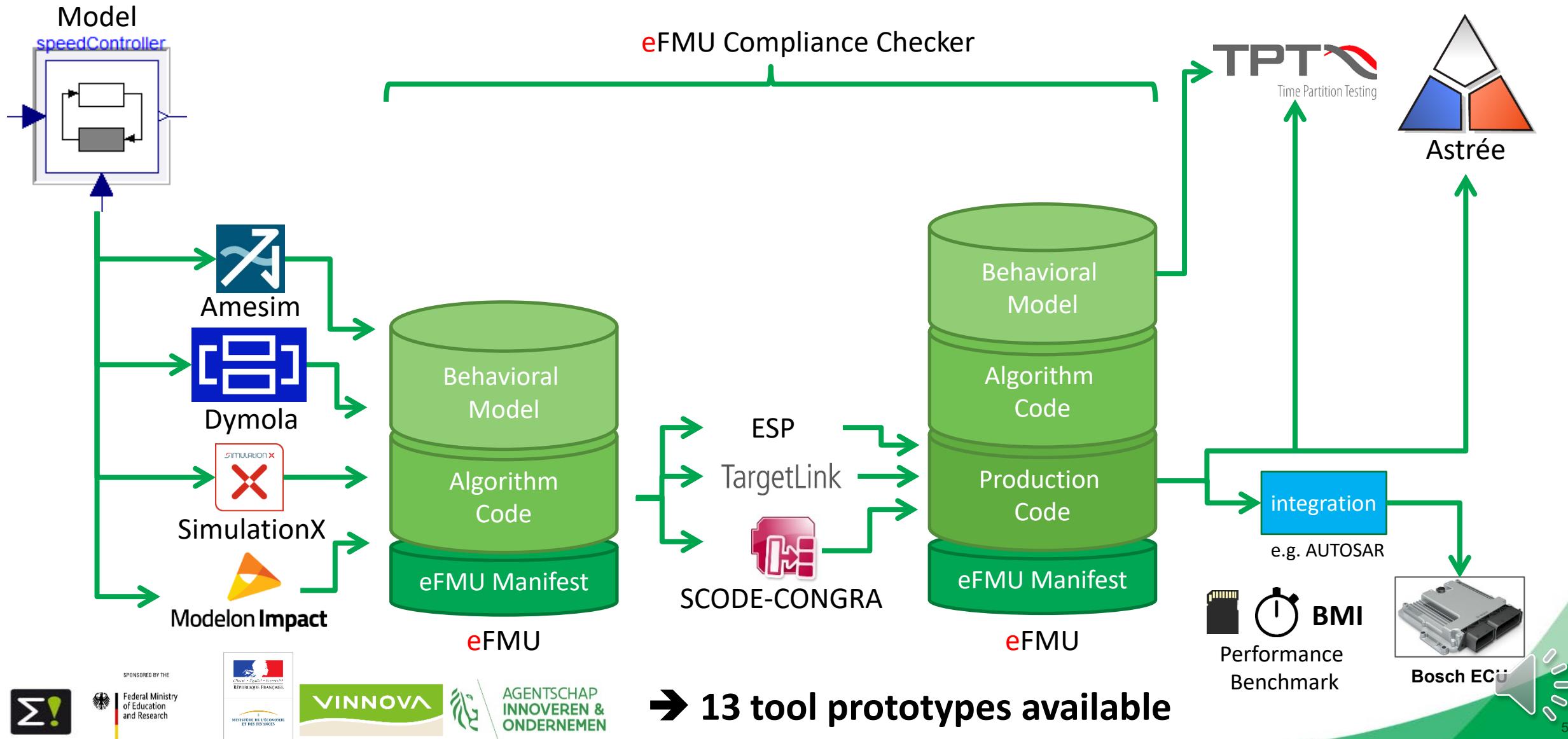


Modeling & Simulation



Embedded Software

Readiness eFMI Tool Chain





eFMI Readiness

D7.2 eFMI Performance Assessment (Bosch)

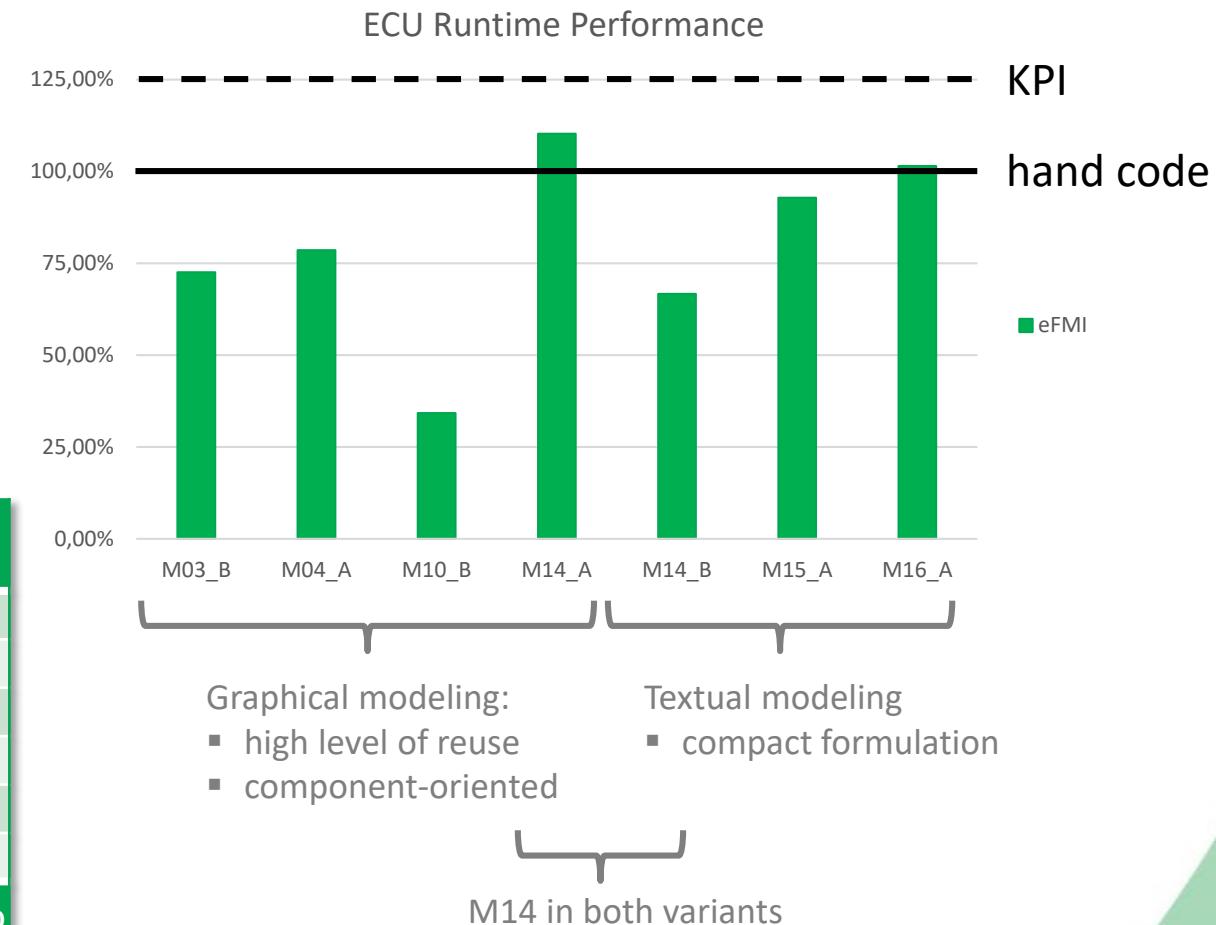


ECU Runtime Performance:

- In all cases the eFMI generated code is below the +25% KPI margin.
- In 5 of 6 examples an eFMI exists that outperforms the hand code.
- In average the best performing eFMUs are **26% faster than the hand code.**

#	Name	Difficulty*	Relative ECU Runtime		
			Average	Min.	Max.
M03	PID	low	-7%	-27%	+29%
M04	Drivetrain	medium	+9%	-21%	+44%
M15	Air System	medium	+38%	-7%	+132%
M10	Inverse Slider Crank	high	-65%	-66%	-64%
M16	ROM	high	+4%	+1%	+6%
M14	Rectifier	high	+3%	-33%	+44%
Average			-3%	-26%	32%

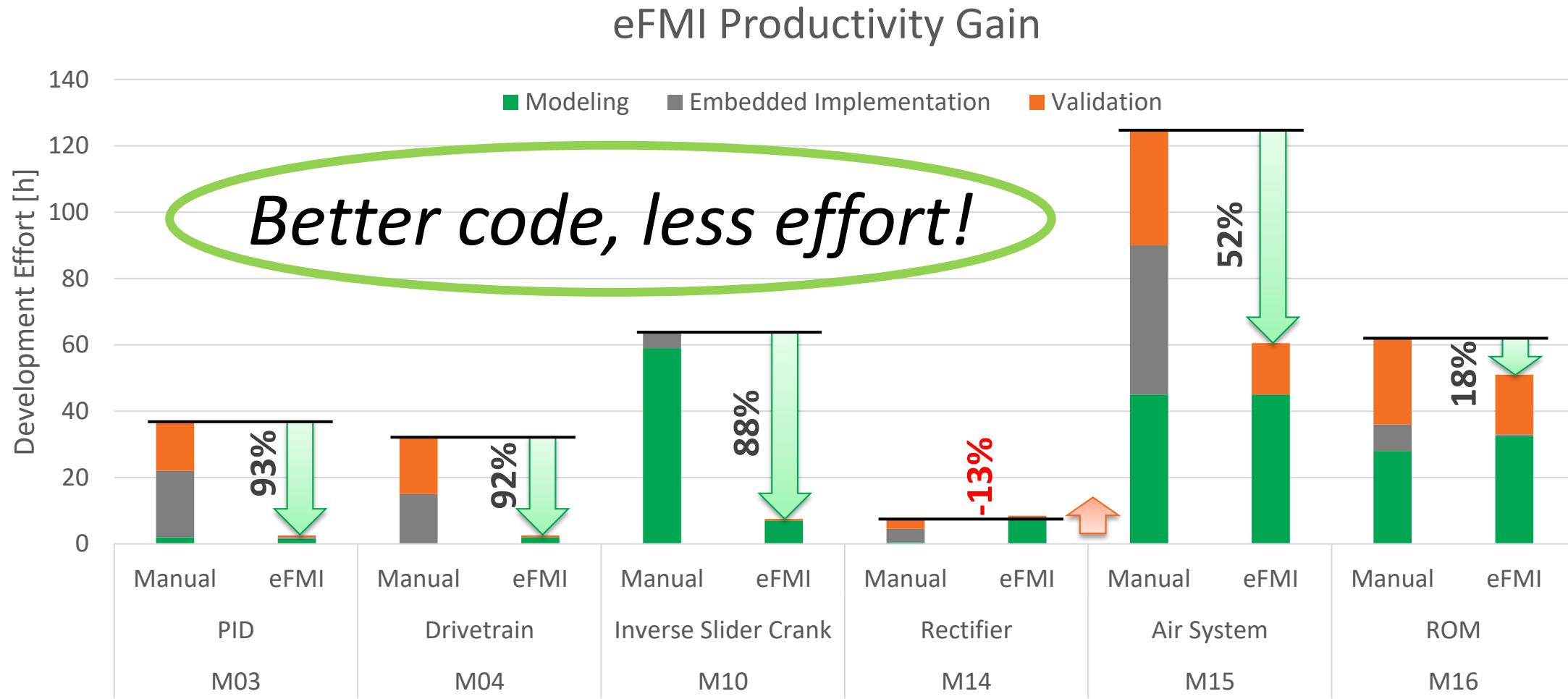
*Difficulty for an automated procedure to achieve same quality as manual implementation.

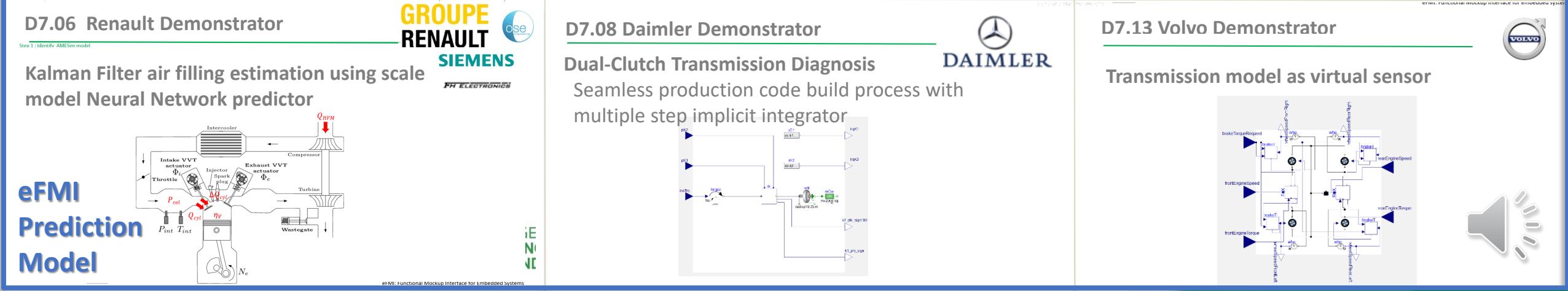
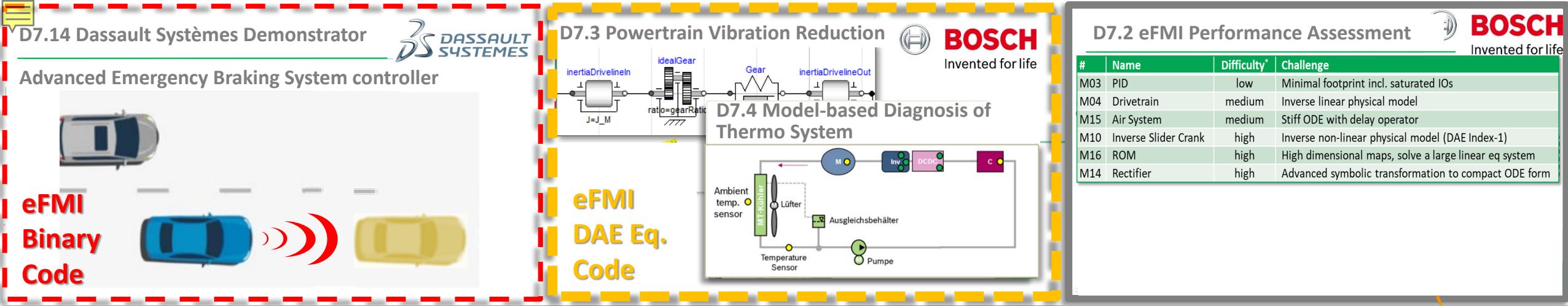




eFMI Readiness

D7.2 eFMI Performance Assessment (Bosch)







eFMI Outlook

Business Impact



Increase Productivity

- Reuse
 - Model Libraries
 - Numerical Service Functions
- Automation
 - Model Transformations
 - Code Generation
- Seamless Tool Chain



Master Complexity

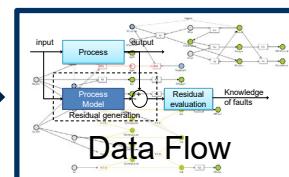
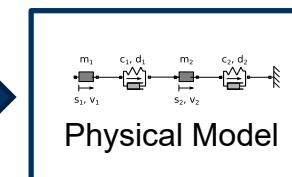
- Software Design
 - Abstraction
 - Encapsulation
- Separation of Concerns
 - Physical Behavior
 - Data Flow
 - Embedded Code



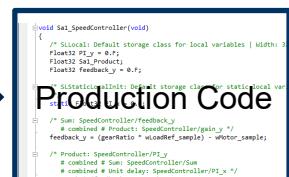
Software Innovations

- Tool Vendors
 - Added Value
 - Expand Market in MBD Domain
- Supplier/OEM
 - New Advanced Functions
 - Replace HW with SW
 - New Modes of Collaboration

Physical Modeling & Simulation



ECU Software Development



Services Functions



Bosch ECU



Bosch VCU



RTPC, e.g. ETAS RTPC





Voice of the Customer

Statements of Members of the OEM Advisory Board



“Reusing the same, universal and physical plant model as eFMI in MiL, SiL, HiL and on the ECU is a technological breakthrough with considerable potential to reduce the development time.” (Zdeněk Husář, Daimler)

DAIMLER

“What we demonstrated using eFMI for the model-based development of a virtual sensor is the way to do it.” (Per Jacobsson, Volvo Cars)



“eFMI will revolutionize the translation of models to embedded SW.”
(Yutaka Hirano, JSAE)



JSAE: Japanese Society of Automotive Engineering





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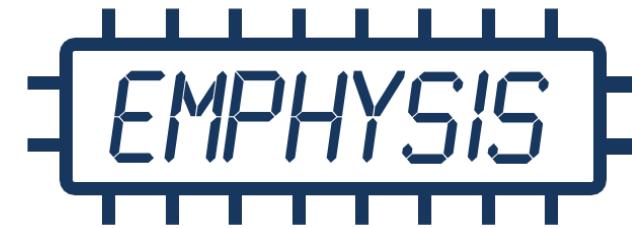
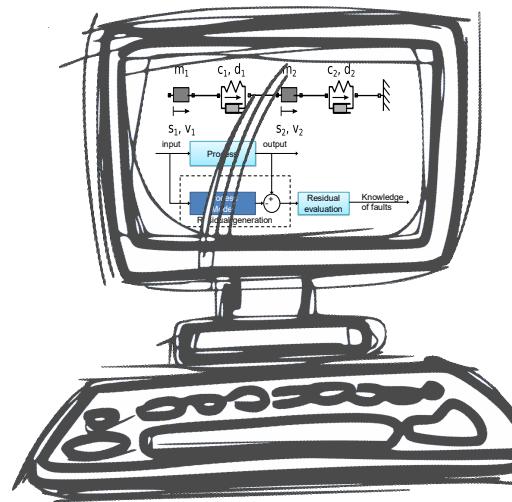
From Physical Models to ECU Software



Recorded July 14, 2021

Oliver Lenord (Bosch Research)

- Look-up EMPHYYSIS results: <https://emphysis.github.io/>
- Visit us on <https://efmi-standard.org/>
- Join the Modelica Association Project: MAP-efmi
<https://modelica.org/>



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