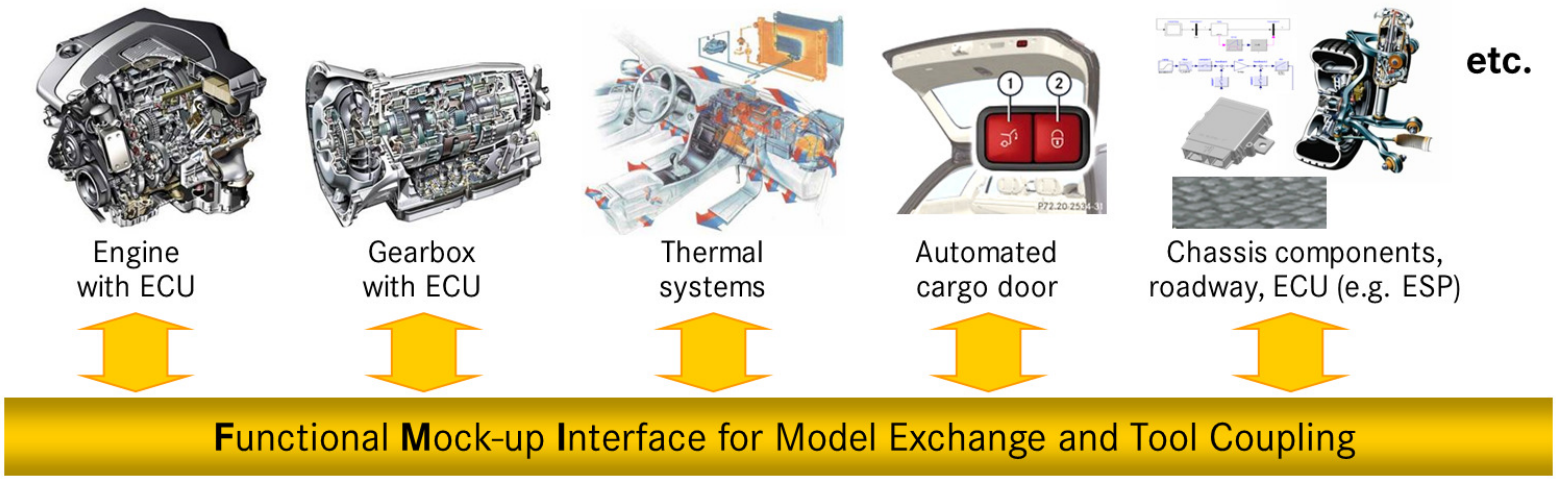


FMI Applications at Daimler

Bernd Relovsky, Daimler AG

10th International Modelica Conference
Lund University Campus, Sweden, March 10th, 2014

Mercedes-Benz

FMI Vision and Objective

Overall goal: Secure functionality of complex technical systems

- for customer comfort and safety
- at less costs

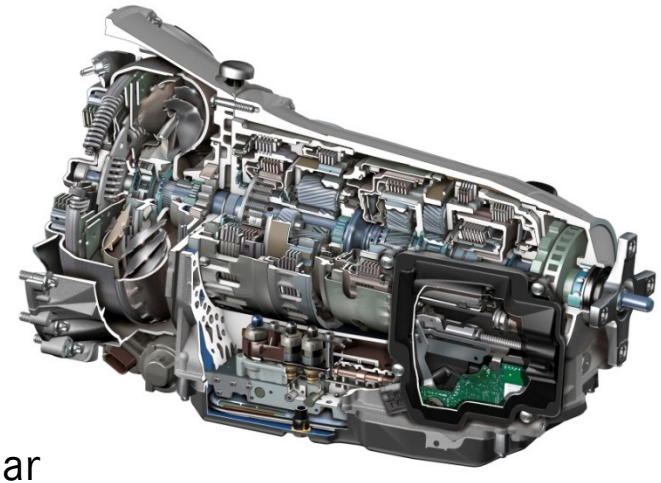
"Good products at little costs"

Aspired solution: Digital functional mock-ups substitute (late and expensive) physical mock-ups

- **Challenge**: Overcome domain barriers between *software, electrics, mechanics, etc.* in existing simulation tools & technologies

- **Answer**: Functional Mock-up Interface (FMI) standard initiated 2007 by Daimler within ITEA 2 project Modelisar

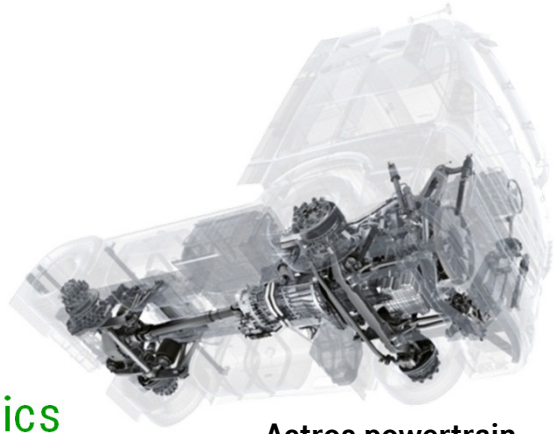
System function example:
Shifting time and quality



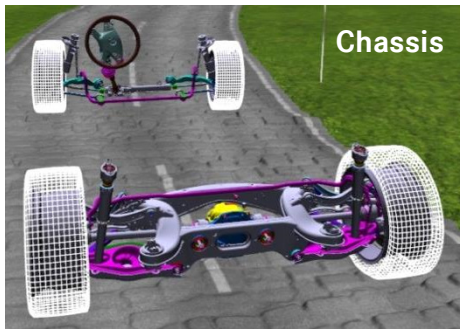
System example:
7G-TRONIC PLUS gearbox

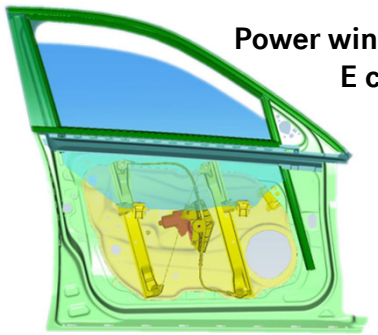
Overview of FMI Application Examples at Daimler

- Software-in-the-loop (SiL) simulations at all gearbox projects of Mercedes-Benz passenger cars
  - High potential for savings at hardware-in-the-loop systems
- SiL simulations at Trucks CAE, esp. powertrain dynamics
  - Application both of FMI for Model Exchange and of FMI for Co-simulation
  - Exchange of FMUs with suppliers
- SiL Multi-body chassis and ride simulations
  - Internal exchange of damping control algorithm as FMU.
    Exchange of FMUs with suppliers targeted.
- SiL simulations for assessment of anti-pinch robustness of power window
  - Co-simulation of internal plant model with anti-pinch function from supplier



Actros powertrain





Power window
E class

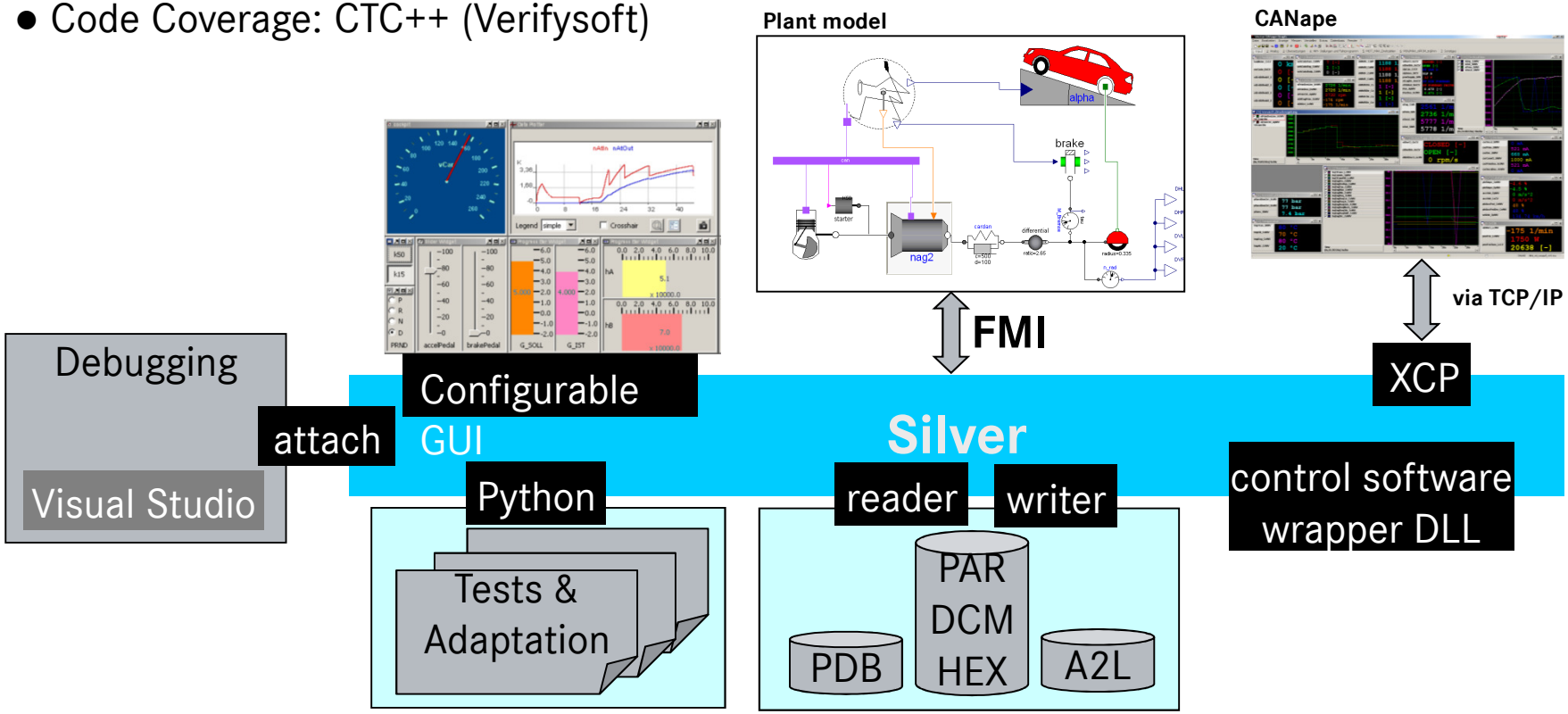
Integration of a Gearbox SIL-Project

SiL environment

- Simulation: Silver (QTronic)
- Measurement: CANape (Vector)
- Debugging: Visual Studio (Microsoft)
- Automated Test: TestWeaver (QTronic)
- Code Coverage: CTC++ (Verifysoft)

Debugging with Visual Studio:

- suspend simulation at any time
- attach Visual Studio Debugger to Silver



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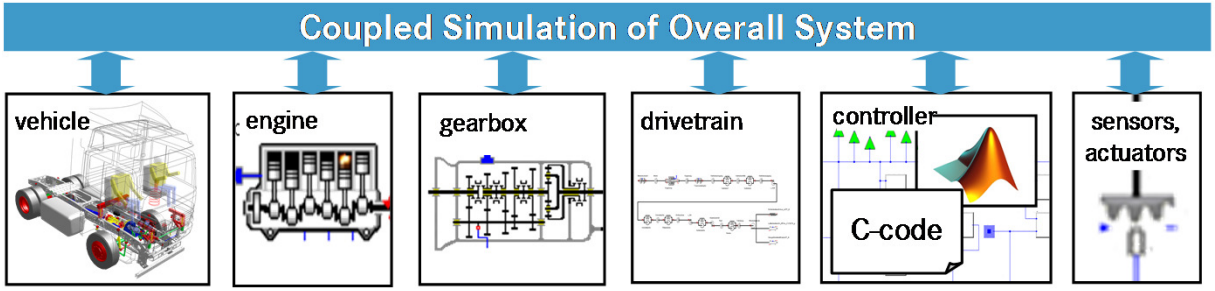
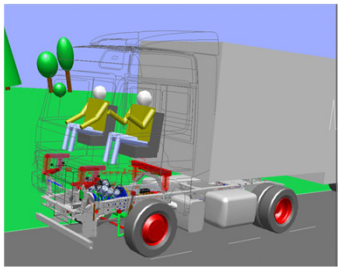
Mechatronic Shifting Simulation at Daimler CV

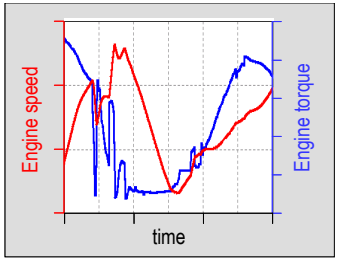
- SiL simulation for optimizing gear shift times and shifting comfort in heavy-duty trucks
- Challenges:
  - Handling of sub-models from different simulation tools
  - Finding efficient solutions for modeling, coupling, and solving
  - Improvement of offline-coupling with missing feedback of mbs-vehicle with drivetrain



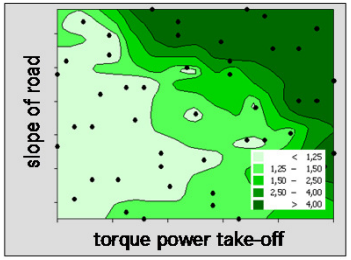
⇨ Optimization of Shifting Comfort



⇨ Optimization of Shifting Time



⇨ Concepts, Robustness, Sensitivity



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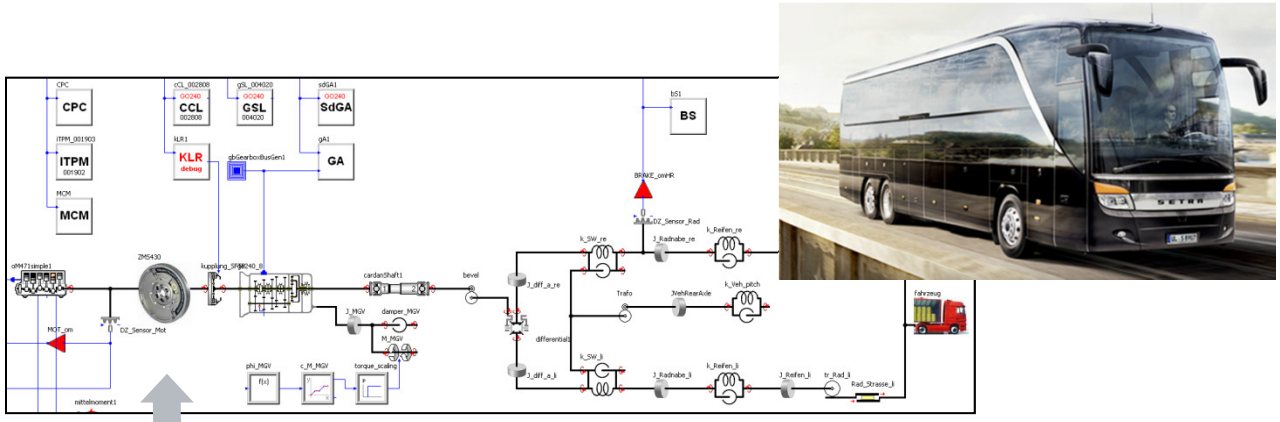
Example for Model Exchange using FMI

Numeric analysis of automated shifts within busses

⇨ Model Import of a SIM-X DMF (Dual mass flywheel) model into a SIM-X vehicle model using FMI



Model import of DMF by FMI

- ✓ Effort for communication and handling greatly reduced with FMI
- ✓ Reasonable efficient
- ✓ Model import worked pretty much „out of the box“
- ✓ DMF-know how completely hidden, only measurable behavior transferred

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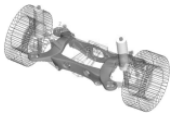
Demand for Efficient sub-model-coupling in Chassis Simulation / Ride Simulation

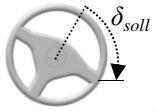
Full vehicle MBS model requires a variety of data and different components

- e.g. sub-models of tire, bushing, damper, control algorithms, digitized road profile, driver

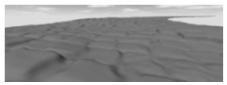
MBS-Model



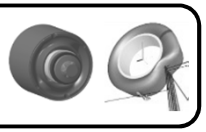
Driver



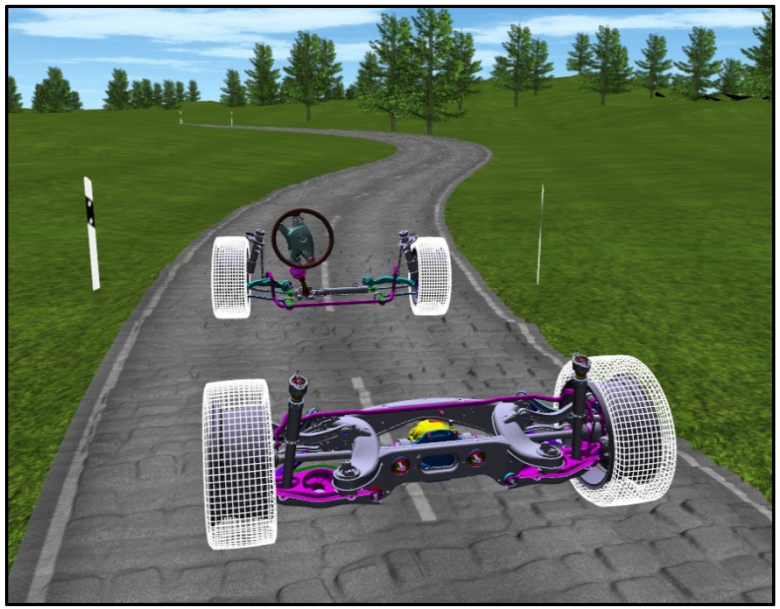
Road Profile



Component Models



Control Algorithms



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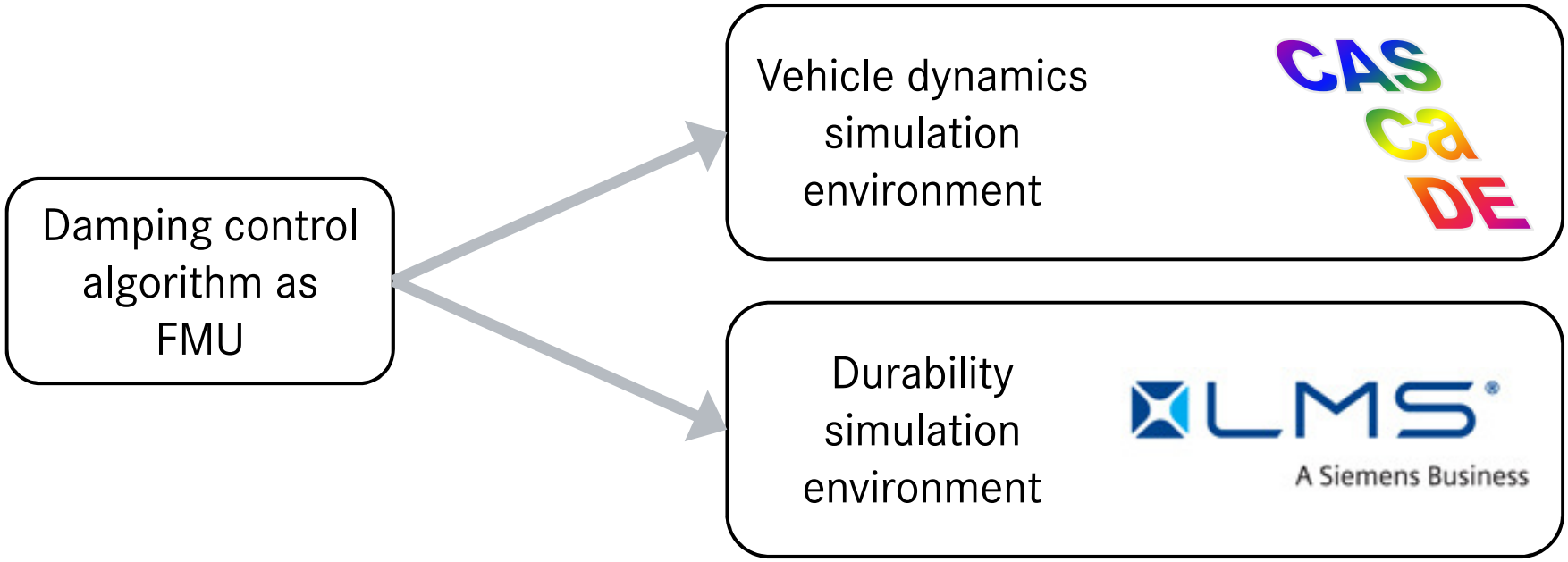
User‘s Point of View

Example of coupling a damping control algorithm

- Available as FMU
- Reduction of system boundary dependence
- Fast and reliable coupling



Reasonable effort on side of calculation engineer

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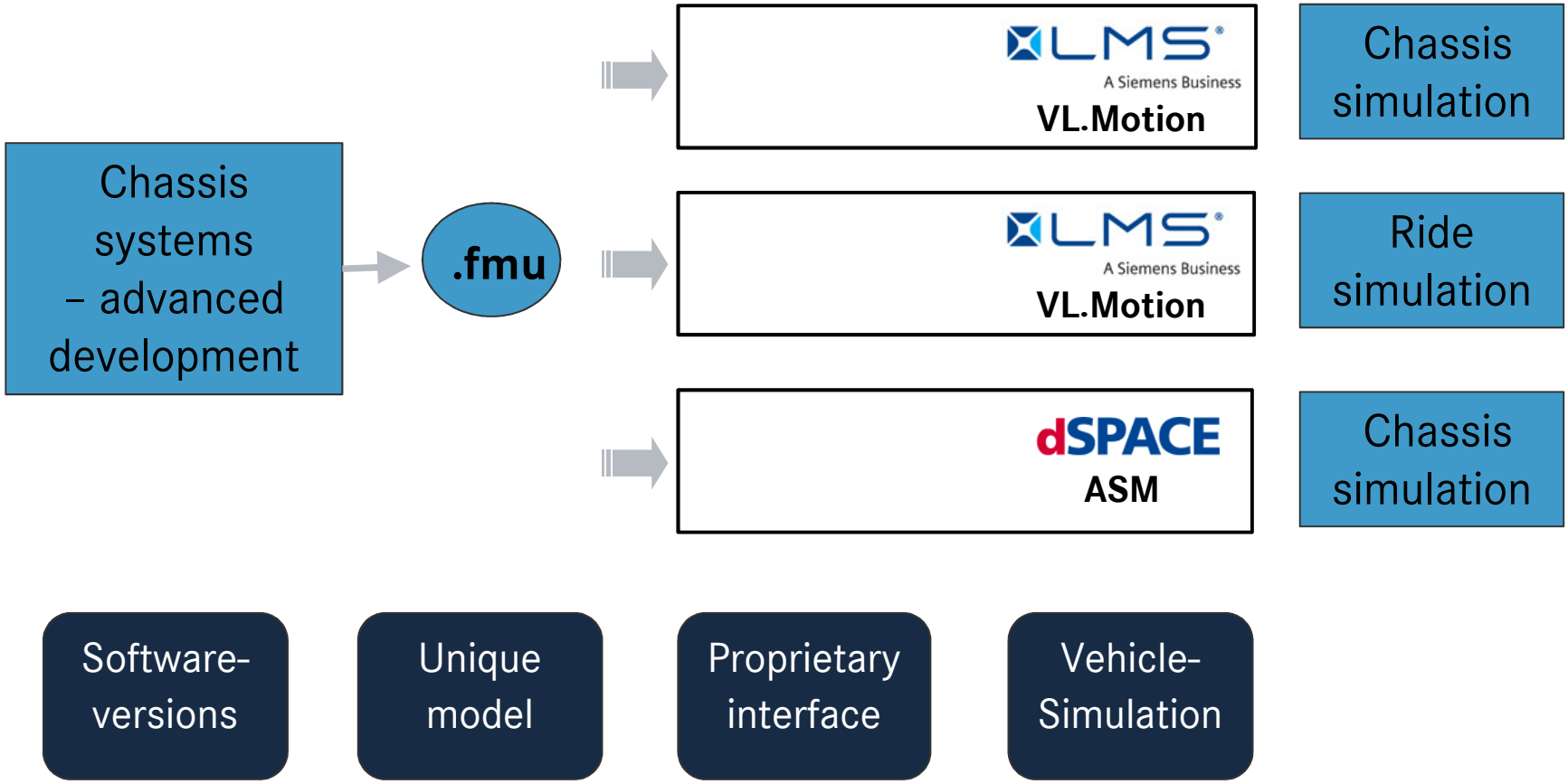
Supplier‘s Point of View



General Benefits of FMI Applications

- **Extension of co-development from digital mock-up to functional mock-up**
- **Plug&play exchange and reuse of models**
- **Enhanced simulation capabilities**
- **Efficient frontloading and early integration of suppliers into cross-domain system simulation**
- **IP protection of simulation models**
- **Flexibility w.r.t. simulation tools**

FMI-based Initiatives in Automotive Industry

A) BMW, Daimler and Ford started in Q2 2012 an initiative to establish FMI as the **standard for simulation model exchange between OEMs and suppliers**

These OEMs as well as Chrysler, Fiat, GM, Jaguar Land Rover, Nissan, Renault, Toyota and Volkswagen signed at GAAG conference in Oct 2012 a **commitment to support this initiative**

Up to date, it was signed in addition by Audi, HKMC, Honda, Isuzu, PSA, Suzuki, Tata, Volvo and Volvo Cars.

FMI-based Initiatives in Automotive Industry

B) A *Smart Systems Engineering* project with **OEMs, suppliers and IT tool vendors** started in October 2012 at ProSTEP iViP

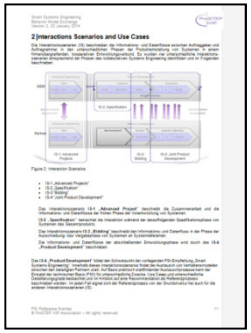
Members "Smart Systems Engineering"

- **OEMs:** BMW, Daimler, Ford, MAN
- **Suppliers:** AVL, Bosch, Continental
- **Tool vendors:** Dassault Systèmes, dSPACE, ITI, LMS, PTC, Siemens
- **Consulters:** :em, Invensity, ProSTEP, Unity
- **Institutes:** HTW Berlin, IPK FhG, TU Darmstadt, U Kaiserslautern, Virtual Vehicle

Current results:

Recommendation for exchange of behavior models between 2 partners within a collaborative development process (incl. reference process, use cases, description templates for exchanged models and activities)

-> Ready for download in April



When do you start “driving” FMU?