# FMI Based Integration of System Simulation and FEM for efficient Simulation of Realistic Crash Scenarios

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Scenarios for homologation of road vehicle safety currently consist in a rather small set of initial conditions for front, side, and rear impacts. Advanced driver assistance systems (ADAS) are now able to brake or attempt crash avoidance maneuvers that will mitigate impacts if not avoid them. These ADAS pre-crash conditions are currently not considered in safety testing. As it would be extremely expensive to cover a variety of such scenarios through physical tests, a current trend for homologation is to complement physical tests by virtual tests.

Braking and steering maneuvers that change the positions and initial conditions of the vehicle and its occupants will come into virtual testing scenarios in the coming years. To achieve this virtual testing objective, one possible solution is to integrate system level models with the Finite Element-based vehicle model. In this way, the behavior of control algorithms as well as mechatronic actuators is added to the model of the vehicle-structure. Our presentation demonstrates a co-simulation-based approach to integrate Modelica based SimulationX models with FE-based VPS models using FMI (Functional Mock-up Interface) for Co-Simulation.

We utilize some of the new features introduced in FMI 3.0:

- Terminals: to enable error-proof and user-friendly interface definition between system and FE-world
- Intermediate Update Mode: to ensure a numerically robust and accurate co-simulation by interpolation techniques
- Build Configuration: to enable seamless and automatic cross-platform workflows.

We showcase our solution by integrating a system level ABS brake model which includes a control algorithm and the hydraulic actuators with the vehicle model to simulate a realistic pre-crash scenario. The approach is not restricted to crash simulations. It enables other use-cases like:

- Modeling of complex load cases (example: controlled hydraulic cylinders act on a mechanical structure)
- Integration of control algorithms to FE-models (airbag activation, seatbelt tensioner)

- Modelling of human bodies with active muscles
- Replacement of flexible FE bodies by rigid multi body system models for reduction of computation time
- Integration of dynamic reduced order models for reduction of computation time.