simulating REALITY™

MSC SOFTWARE

Leveraging Integrated Concurrent Engineering for vehicle dynamics simulation



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VEHICLE DYNAMICS EXPO 2008

Agenda

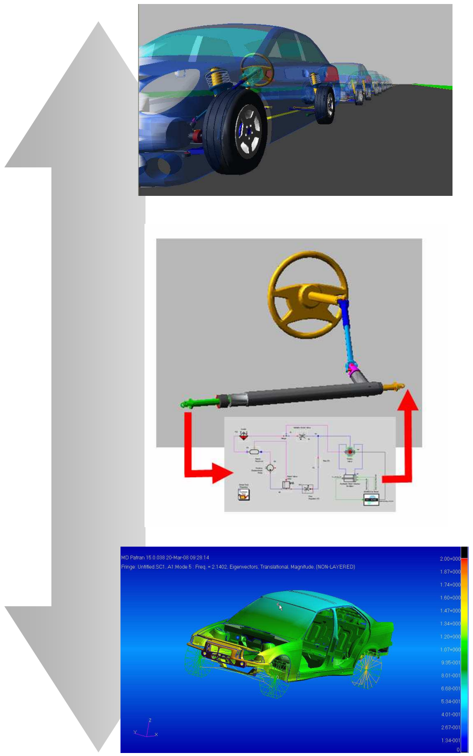
- **Challenge of vehicle dynamic simulation:**
  - **frequency domain coverage**
  - **necessity for a multi discipline model**

- **Benefits of using multi discipline simulation environment and solvers for full vehicle simulations**

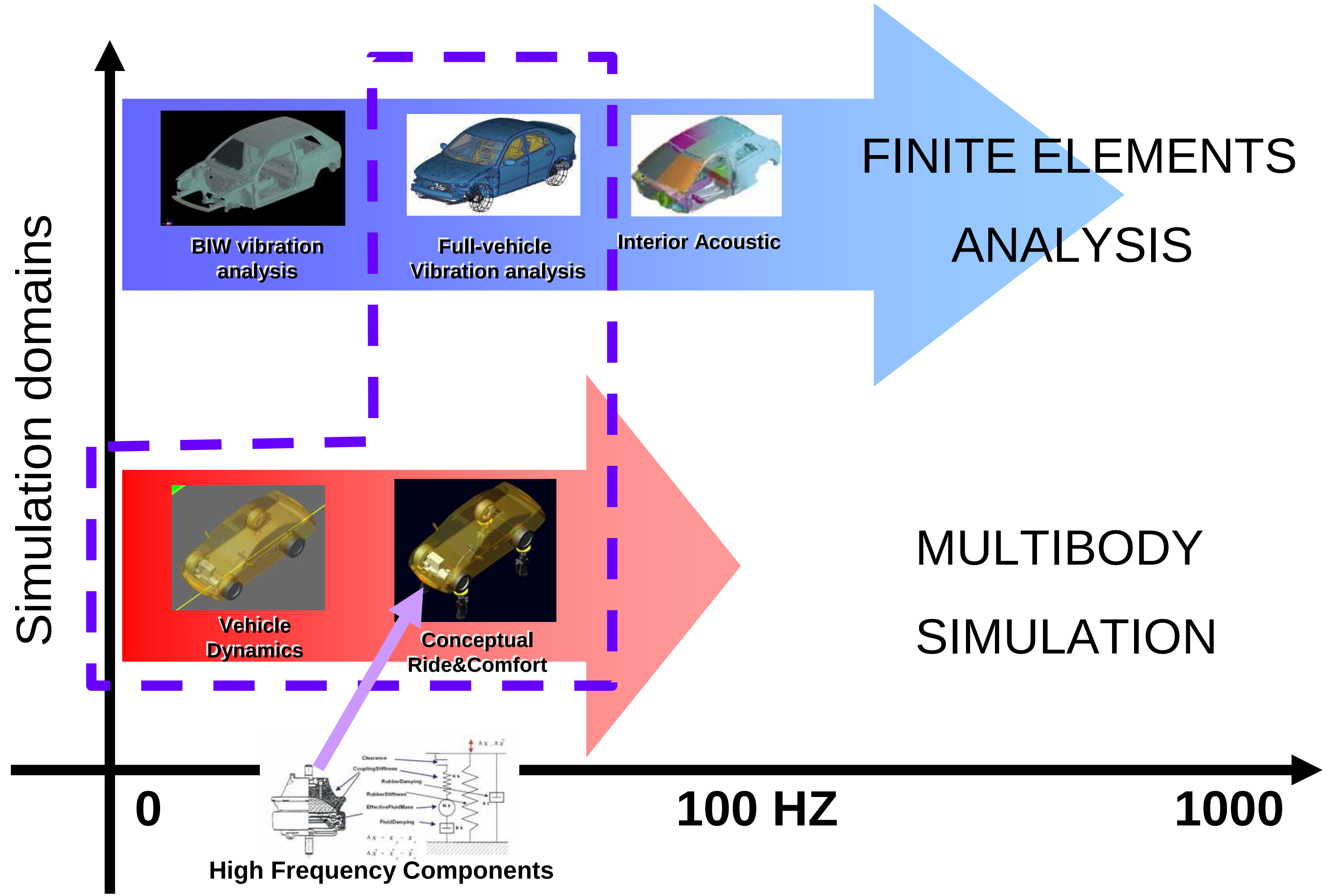
- **Steering and Braking example:**
  - **influence of power steering technology on steering wheel response to a brake cyclic excitation**

- **NVH example:**
  - **consistent model for full vehicle modal and vibration response**

- **How Simulation Data Management is used to handle multi-domain full vehicle models**



Full vehicle simulation domains



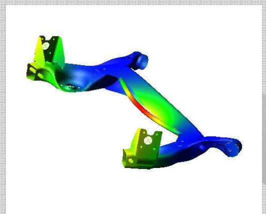
High fidelity vehicle model

Accurate suspension elasto-kinematic behavior
- Discrete and organic model
- Flexible bodies (Finite elements model)

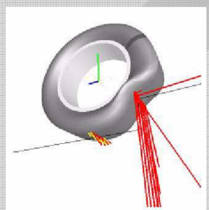
Advanced non-linear and frequency dependent components
- Structural tire model
- Freq. dep. Bushings

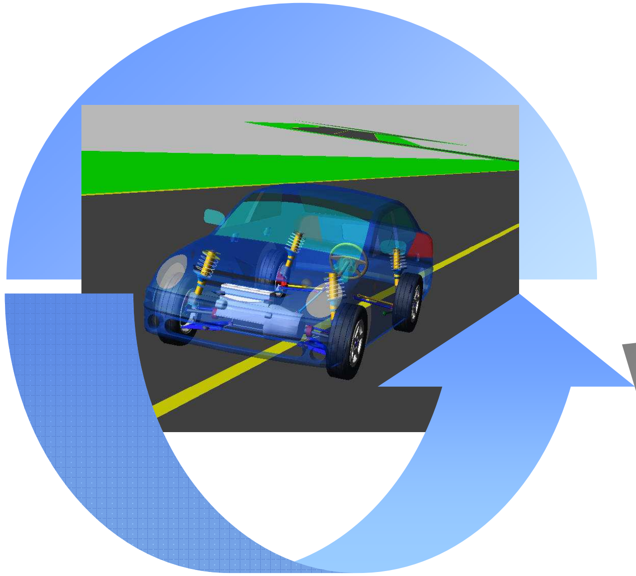
Electronic/hydraulic components
- Damper, active suspension, power steering
- ESP/ABS

Structural components

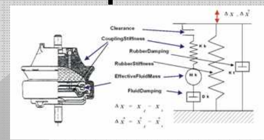


Advanced structural tire model

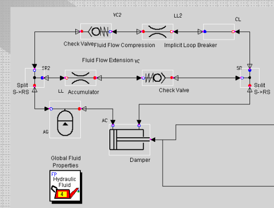




Frequency dependent components

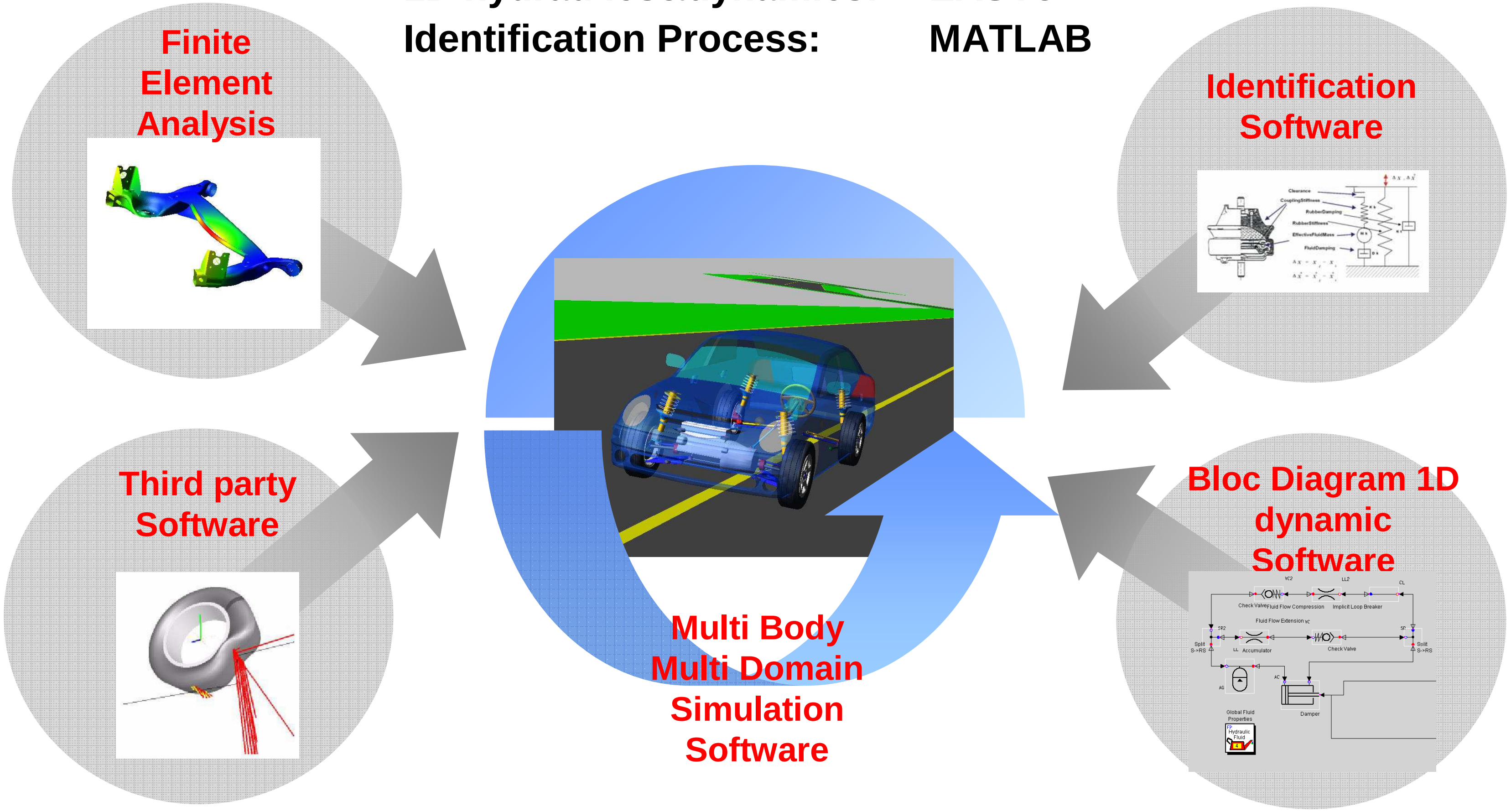


Damper Model



Multi domain vehicle model: an example of Ride and Durability simulation

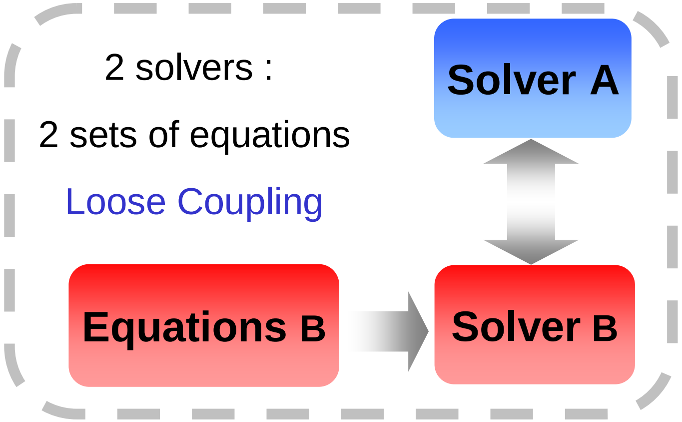
Multi Body:	**ADAMS**
Finite Element:	**NASTRAN**
Tire Model:	**FTIRE**
1D hydraulics&dynamics:	**EASY5**
Identification Process:	**MATLAB**



Multi-domain solver – hydraulic example

Use of Co- simulation:

- Solver A is solving multi body mechanical equations
- Solver B is solving hydraulic equations
- 2 solvers and 2 sets of equations solved independently
- Data exchange between the 2 solvers
- Loose coupling only

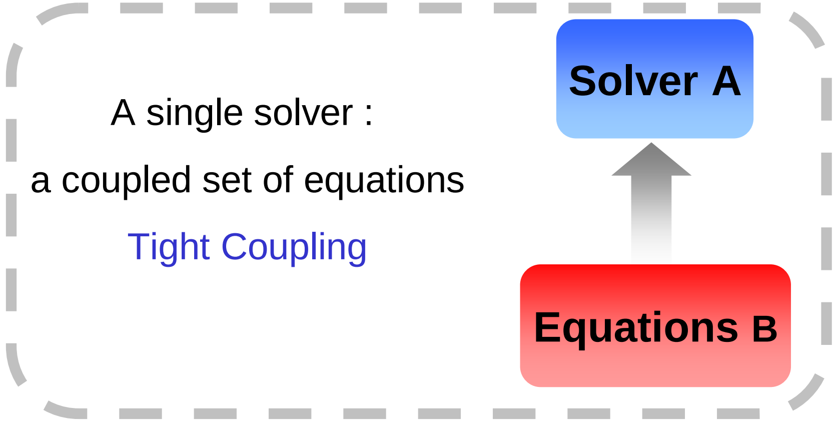


Use of a multi-domain single solver:

- One single set of equations: multi body + hydraulic
- “State of art” Solver solves this heterogeneous set of equations
- Tight equations coupling

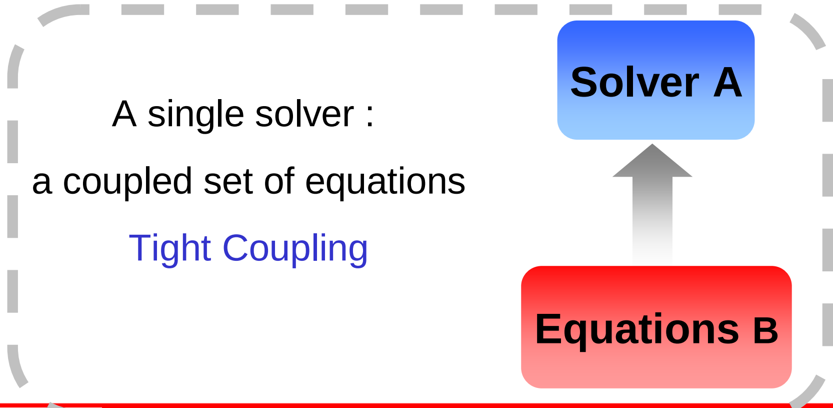
Preferred scenario for a multi-domain simulation:

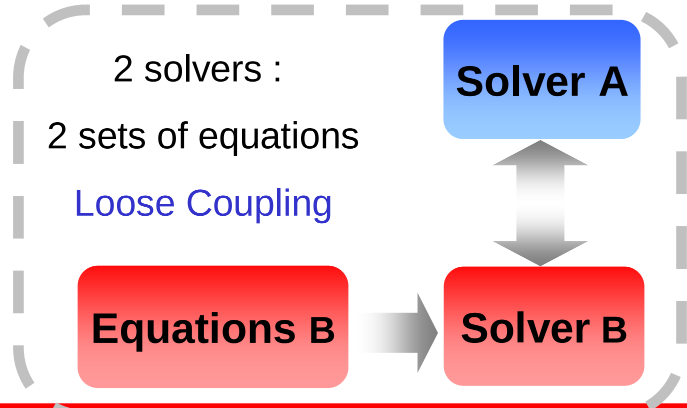
- Multi body model is tuned independently using Solver A
- Hydraulic model is tuned independently using the same Solver A:
  - Discontinuities handling (hydraulic components)
  - High stiffnesses handling
- The hydraulic set of equations must be inserted directly in the multi body model (without any translation)
- The Solver must handle heterogeneous set of equations



Advantages and trade off about using multi discipline solver for vehicle simulation

	Embeded Simplified Equations coupled resolution		Embeded Full Equations coupled resolution		Full Equations Cosimulation	
Control System	speed	+	speed	+	speed	O
	accuracy	-	accuracy	+	accuracy	+
	robustness	+	robustness	O	robustness	+
Power Circuits Electric / Hydraulic	speed	+	speed	O	speed	O
	accuracy	-	accuracy	+	accuracy	O
	robustness	+	robustness	O	robustness	+
Flexible components	speed	+	speed	-	speed	-
	accuracy	-	accuracy	+	accuracy	O
	robustness	+	robustness	-	robustness	O

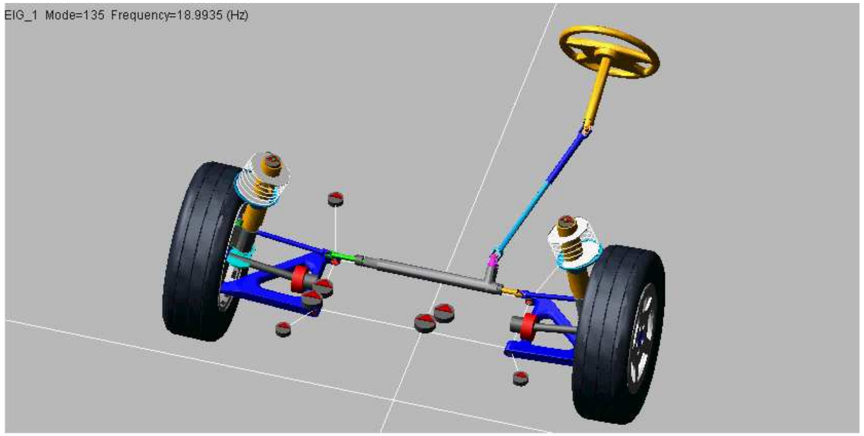


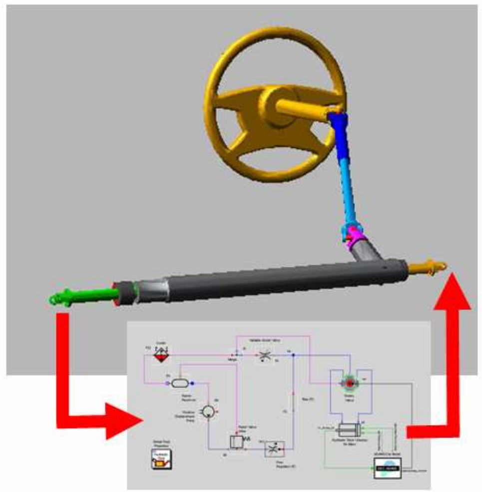


Example 1: Highly coupled multi-domain simulation

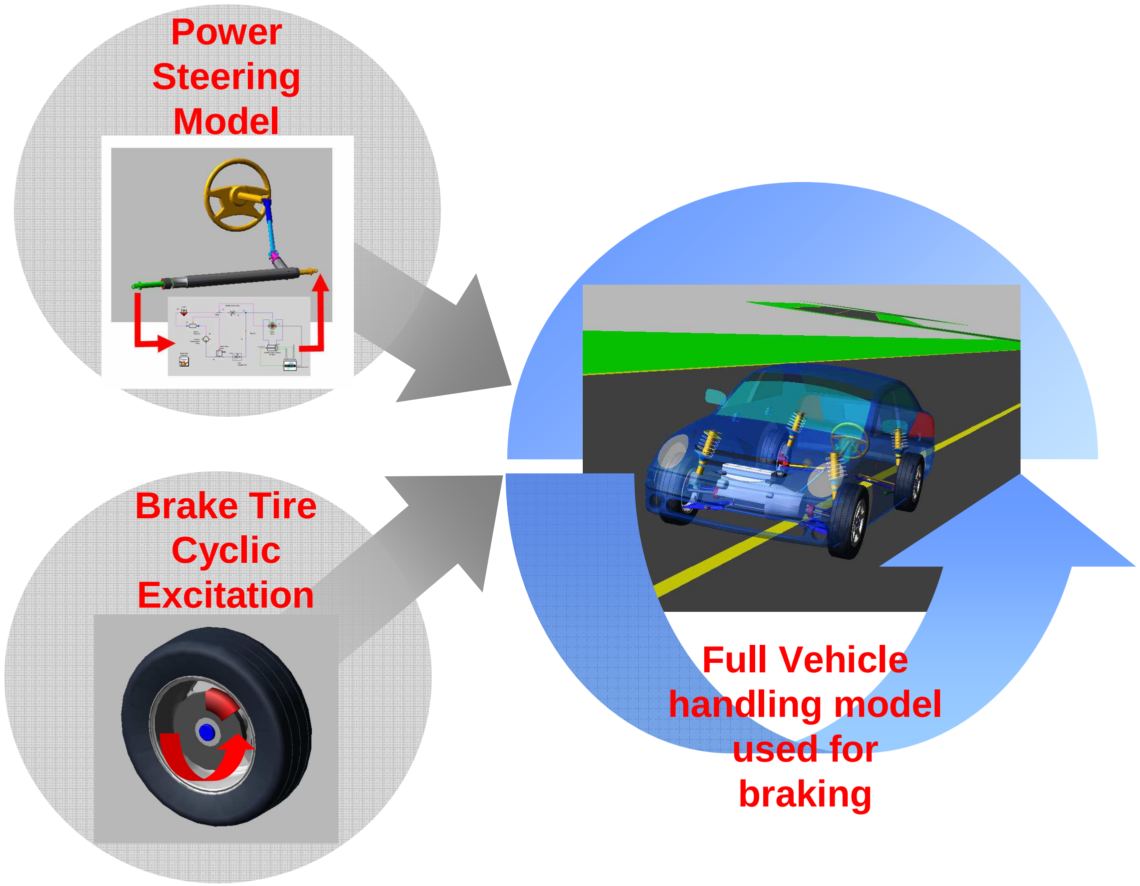
Study coupling and interactions between power steering system and front suspension MacPherson vibration modes

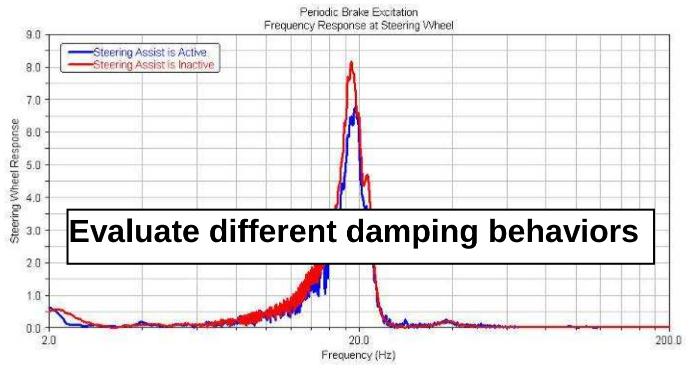
- **Trends: Low bushing stiffness >> suspension modes become troublemakers**
- **Transmission of tire/brake excitations to the steering wheel: bad driver perception**
- **Use of electric power steering v.s. hydraulic power steering may change the damping behavior**
- **Critical Modal frequency may shift for different full vehicle life situation (braking, turning)**
- **Using multi-domain simulation is usefully used to evaluate different power steering designs and interactions with the critical suspension modes**

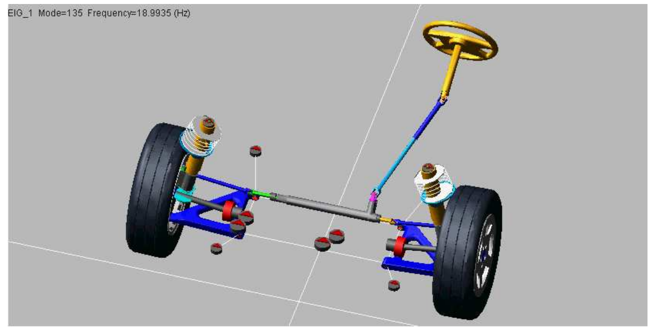




Multi-domain Braking simulation model

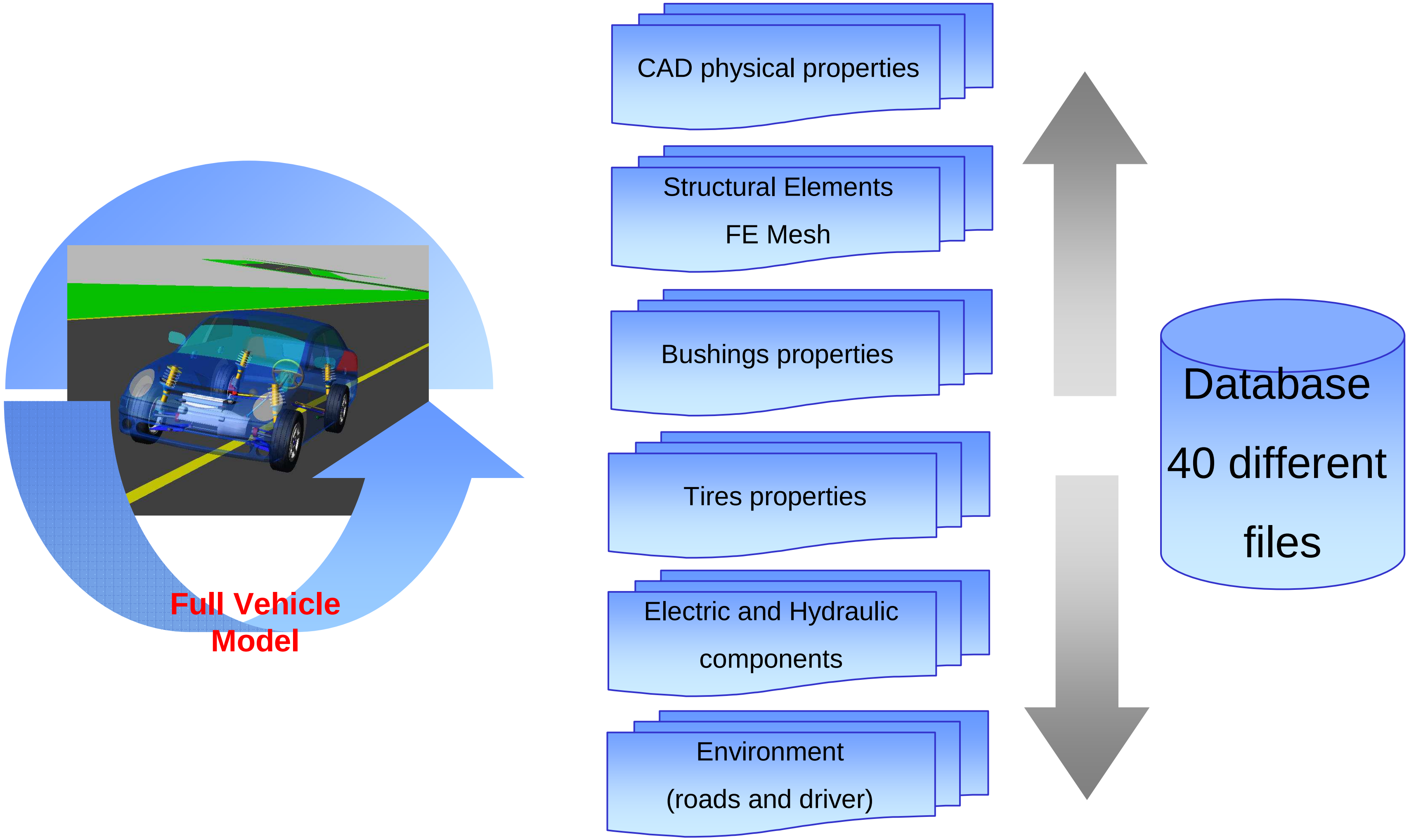






- **Braking is changing the local bushing stiffness**
- **Bushings are working near their non-linear saturation limits**
- **Brake in Turn: non-symmetric suspension compression > mode frequency shift**

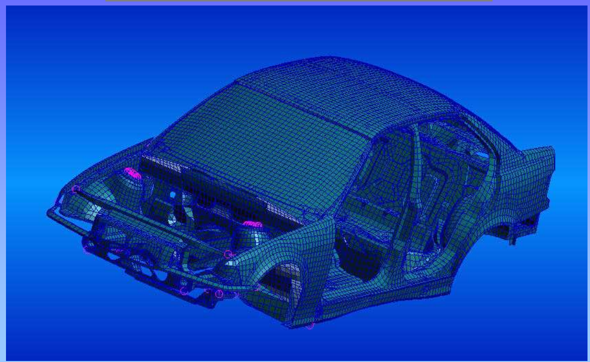
Distributed and multiple data sources



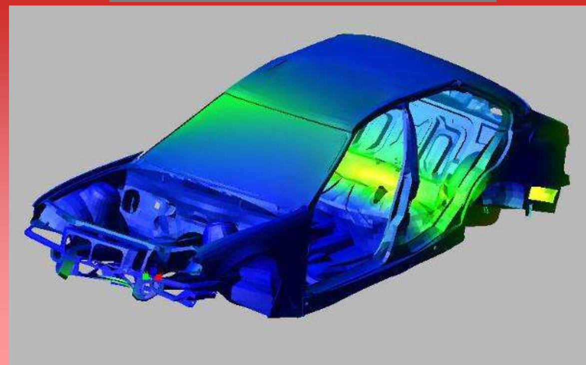
Example 2: Accurate NVH Model Exchange between FEA and Multi Body Simulation

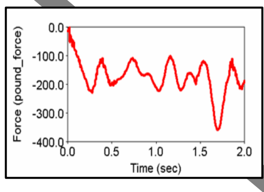
Flexible Body Generation

MD NASTRAN

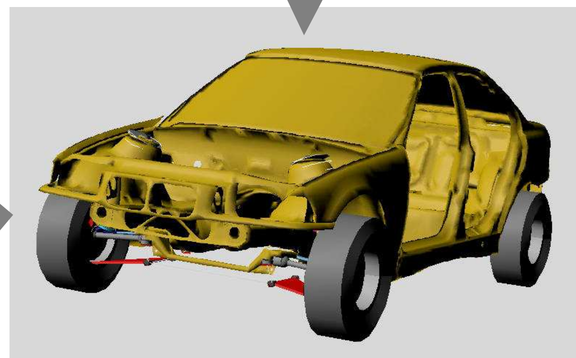


MD ADAMS





Time&Modal loads

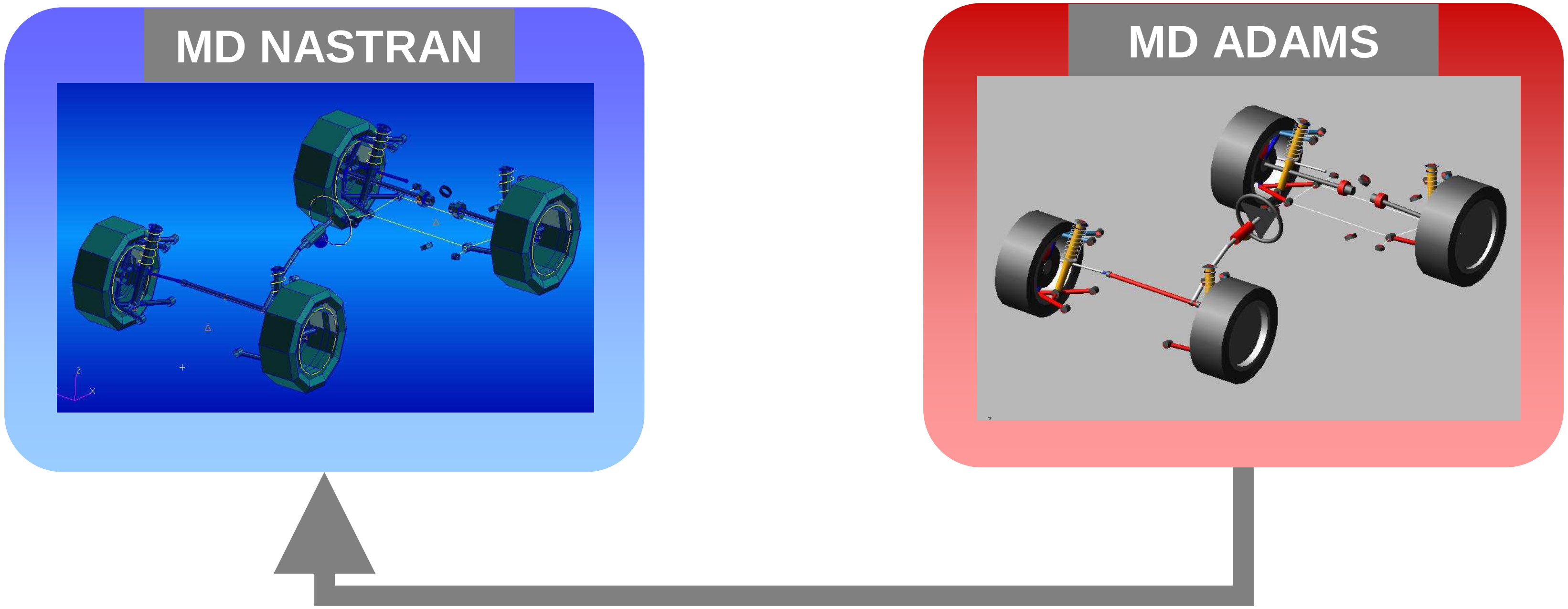


Full vehicle model with flex bodies:

- **Better handling simulations**
- **Accurate vibration simulations**
- **Modal stress recovery**
- **Recover time and modal loads**

Exchange from Multi Body to FEA

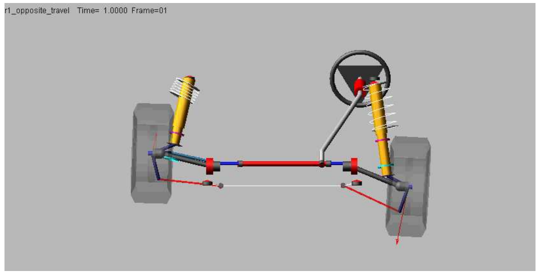
- **ADAMS Subsystem Benefits in MD NASTRAN :**
  - **Accurate dynamic representation**
  - **Use DMIG for complex ADAMS components**
  - **Recover ADAMS DATA and linearization position**



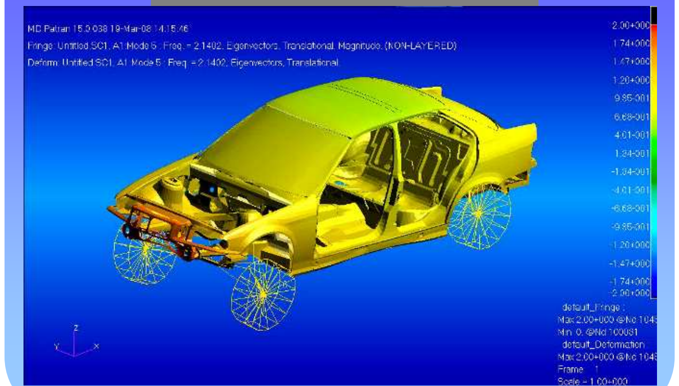
NASTRAN Subsystem Generation

Accurate Noise and Vibration FE analysis

- **Accurate Modal Analysis :**
  - **NASTRAN suspension in phase with ADAMS model**
  - **ADAMS linearization in exact roll and compression position**



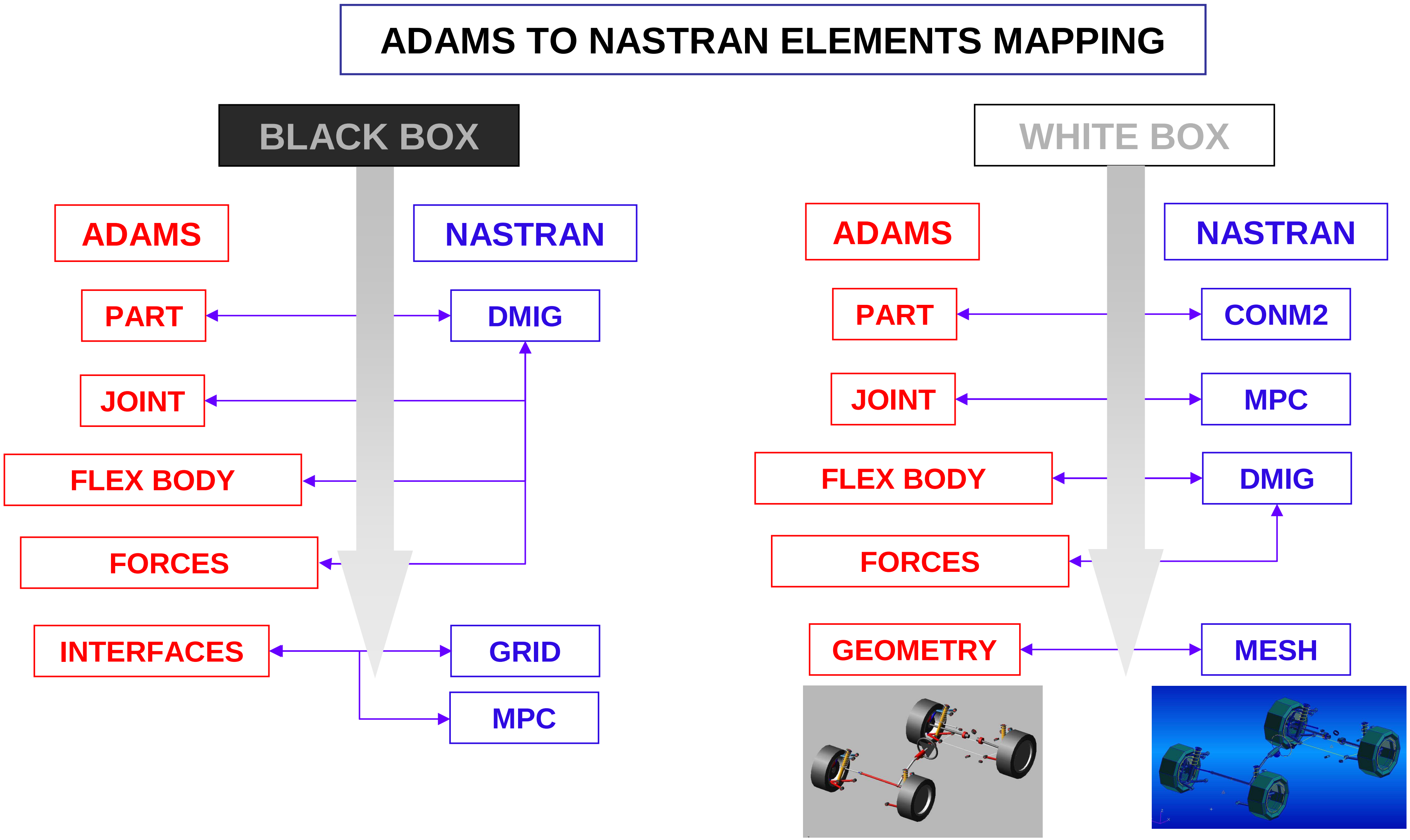
MD NASTRAN



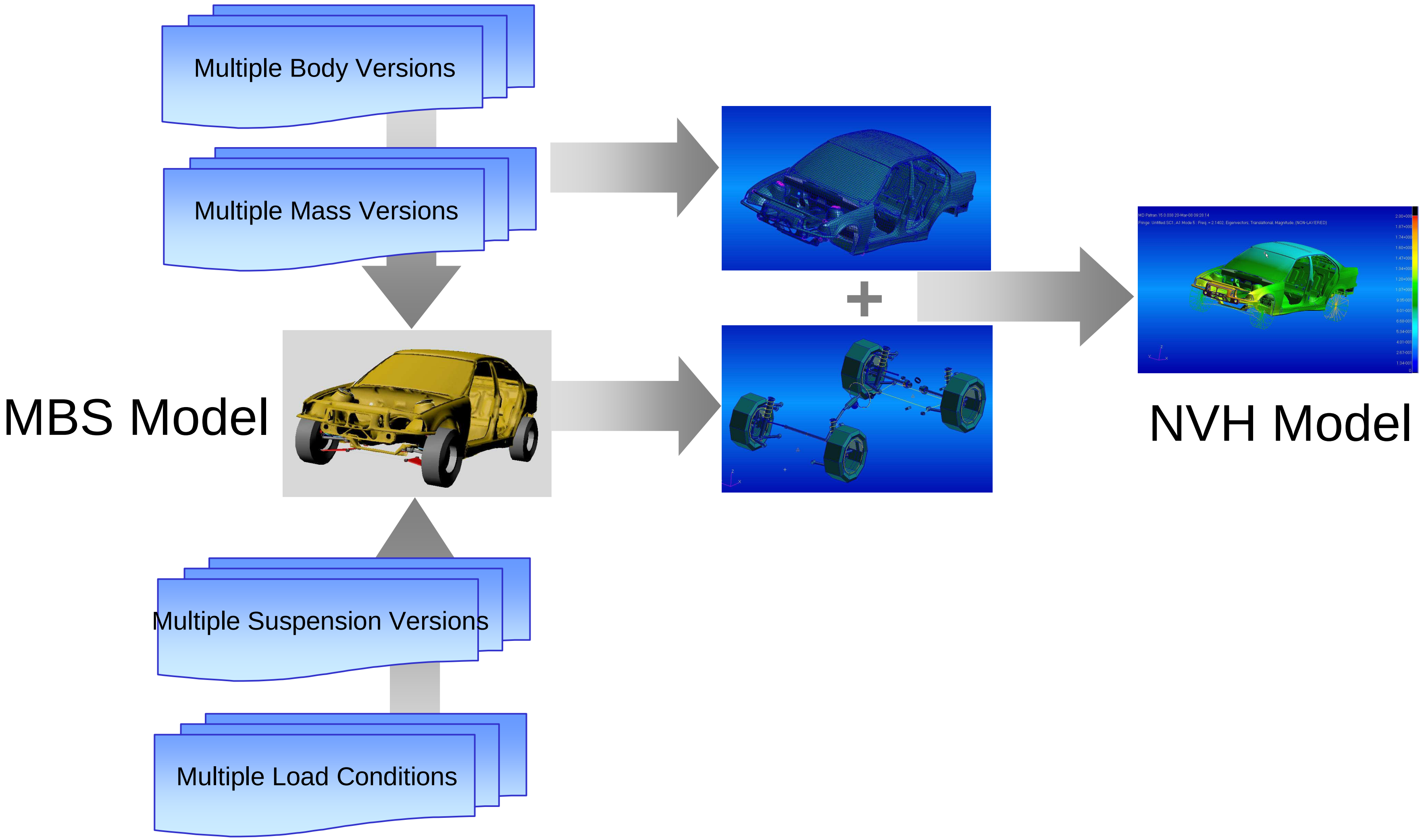
MD ADAMS

NASTRAN Format Subsystem Generation

ADAMS –> NASTRAN Subsystem Exchange

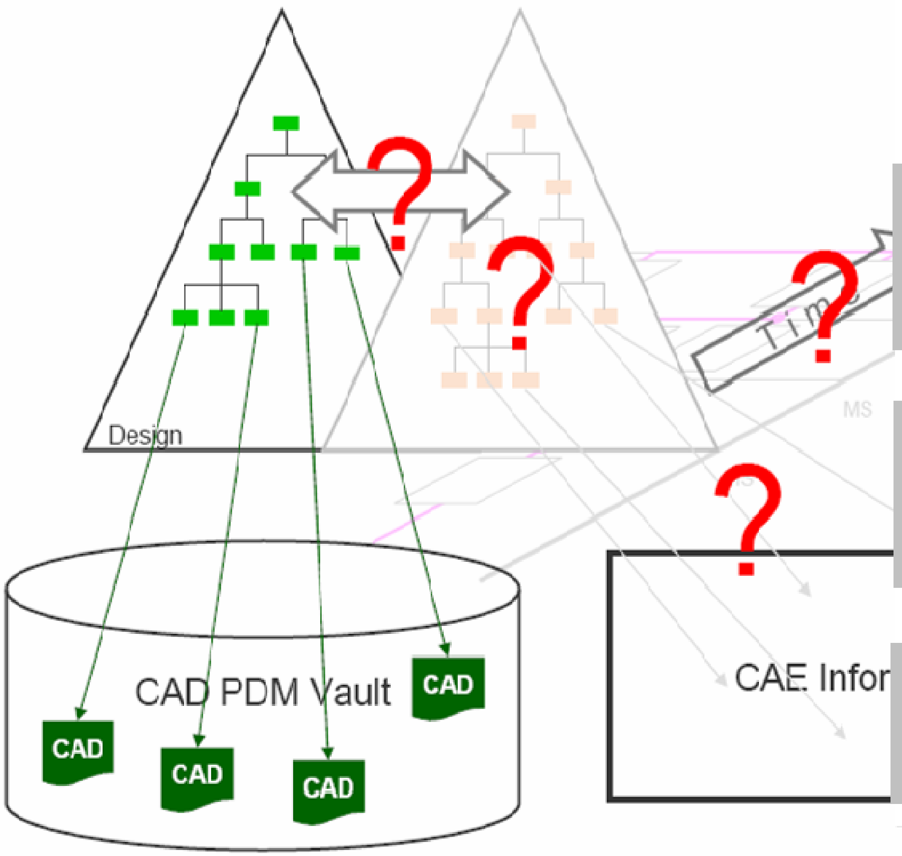


Example 2: Model and subsystems multiple versions



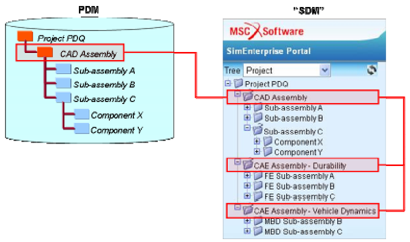
Simulation Life Cycle Management Challenges

- 4 Challenges
  - Maintain Product Context for CAE information
  - Make CAE information referable
  - Keep inter-relations of CAE information with other domains
  - Manage CAE information during the product lifecycle



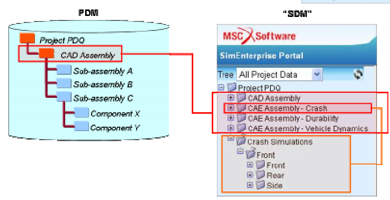
Unique model configurations for each discipline

Unique model types for same geometry



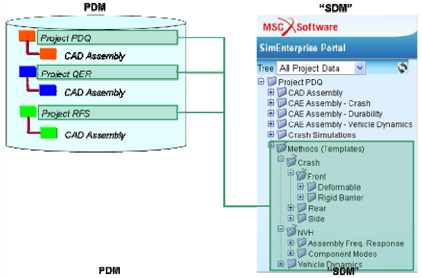
Multiple simulations or "studies" for each geometry

Different configurations and variants of models for each simulation or study



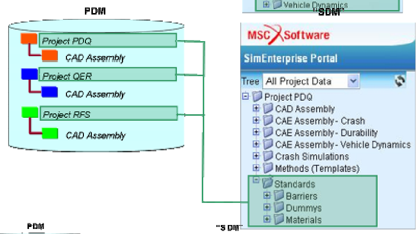
Models and results associated with methods used to create them: CAE is "path dependent"

Methods are not associated with a particular geometry, configuration, or project



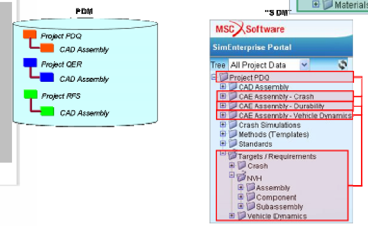
Many "standard" entities are required for simulation that have no geometric counterpart

Standards are not associated with a particular geometry, configuration, or project



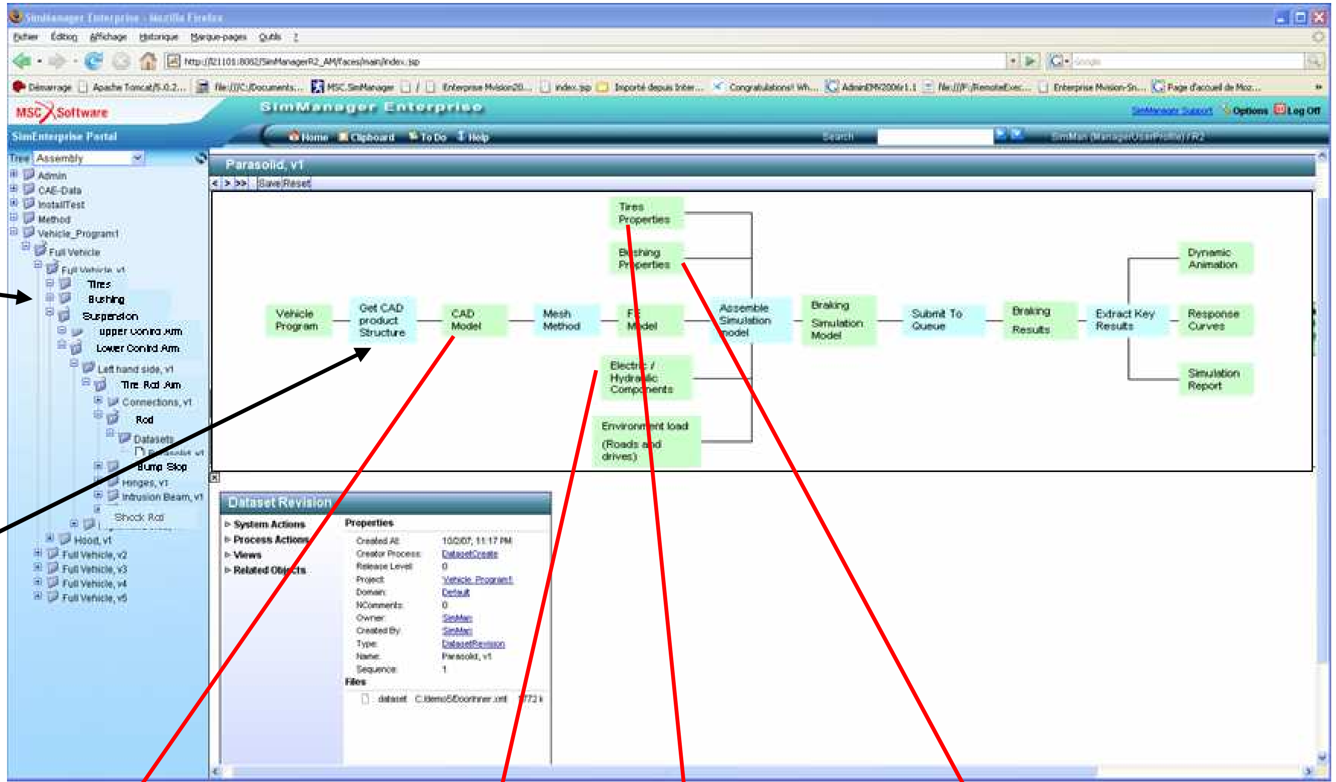
Simulations are run to assess performance against targets or requirements

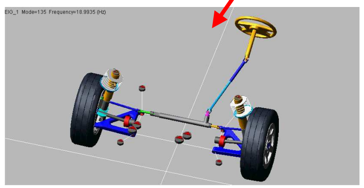
Every geometry has many discipline specific requirements

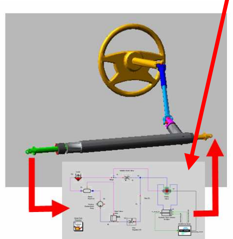


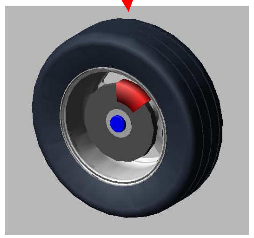
Simulation Audit ability and Traceability

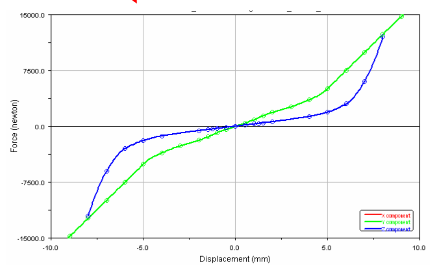
- **Each simulation object appears in project tree**
- **Objects are related to their parents and Childs**
- **Methods used to generate objects from others are controlled**





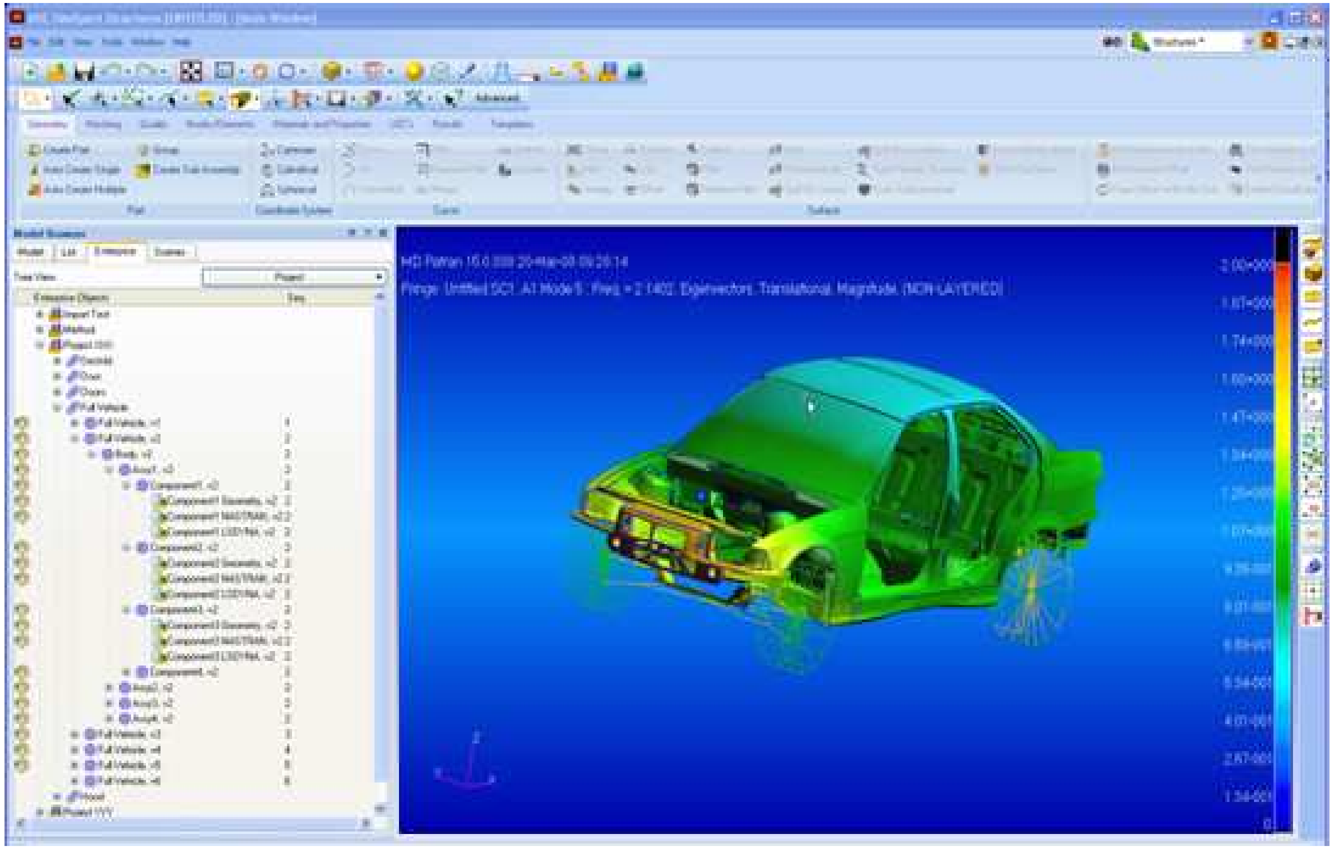




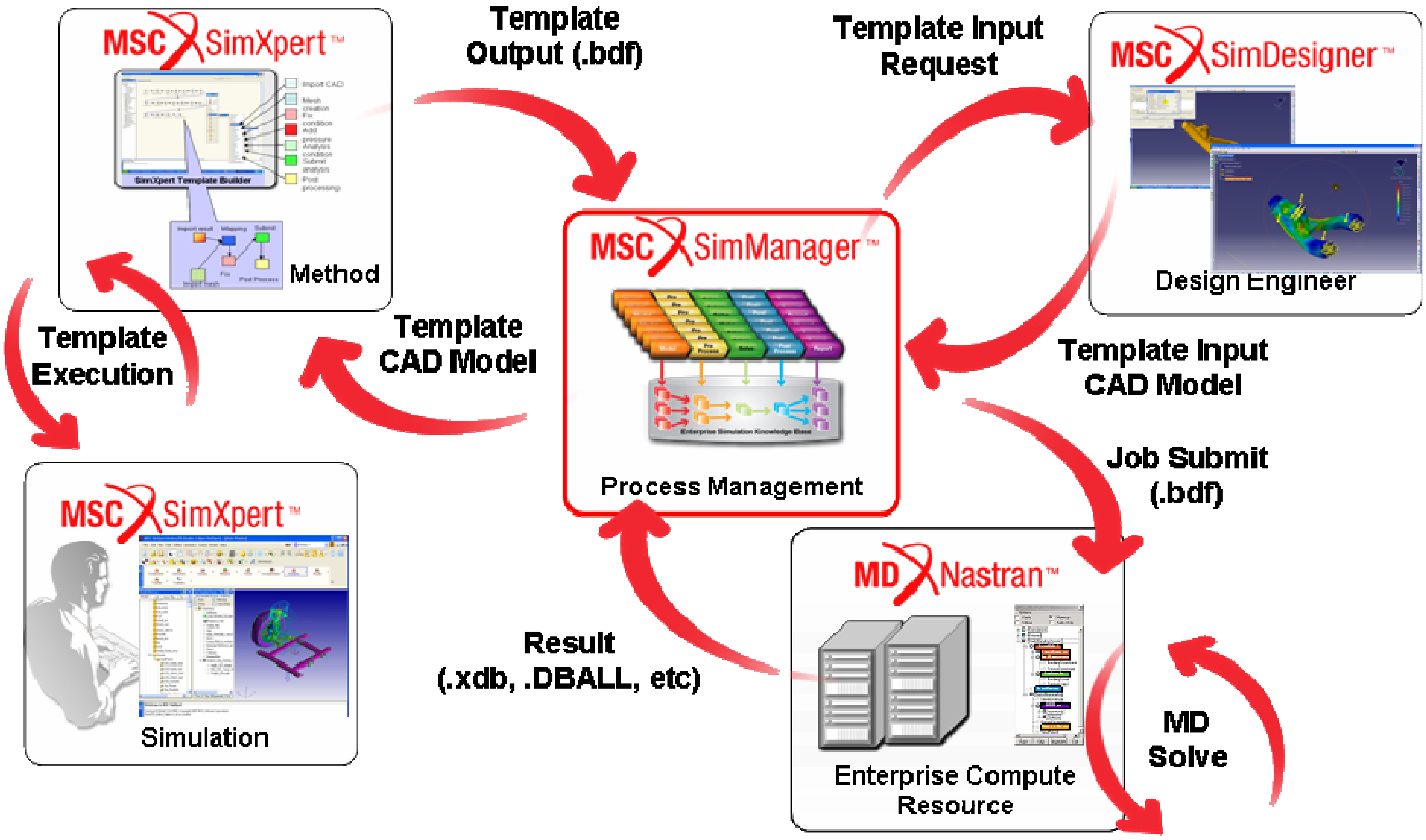


Simulation Revisioning

- **Review Simulation configurations**
- **Instantiate new configurations**
- **Compare configurations**



Knowledge Capture and Reuse



Thank you for your attention !