

# Virtual car models for handling and ride bridging off and on-line simulations

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## Executive Summary

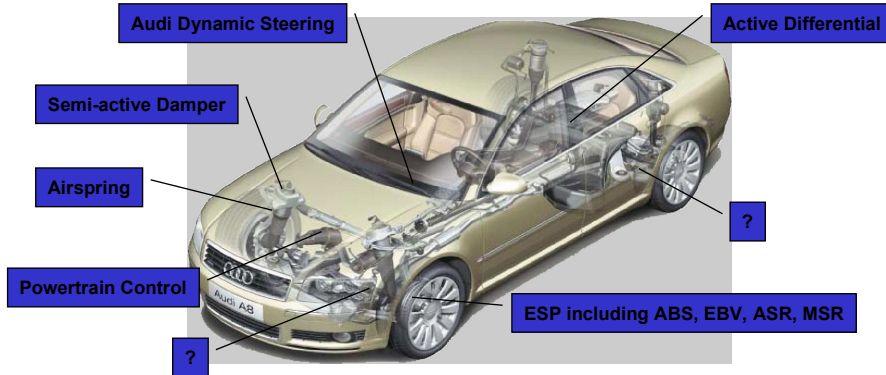
- AUDI AG
  - Current Simulation Strategy for Virtual Handling and Ride Dynamics
  
- VI-grade
  - Current Tools and Development Strategy for bridging off-line and on-line Simulation

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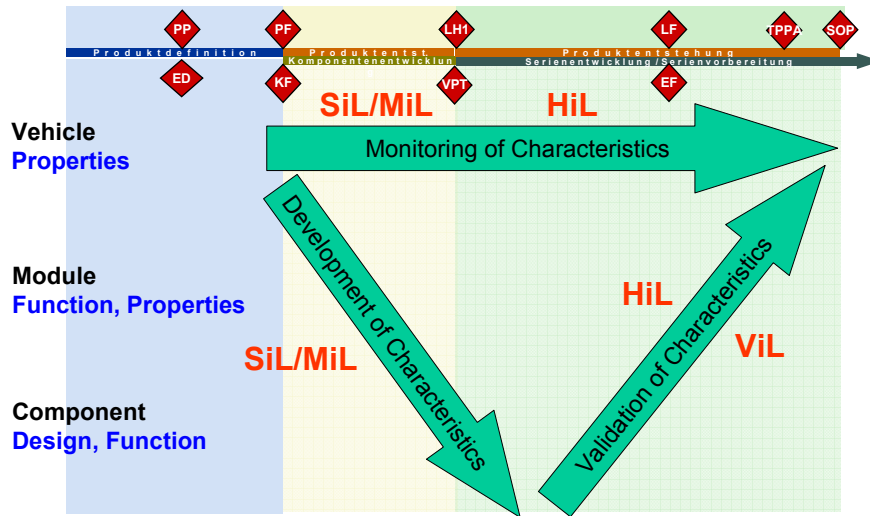
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# Chassis Control Systems

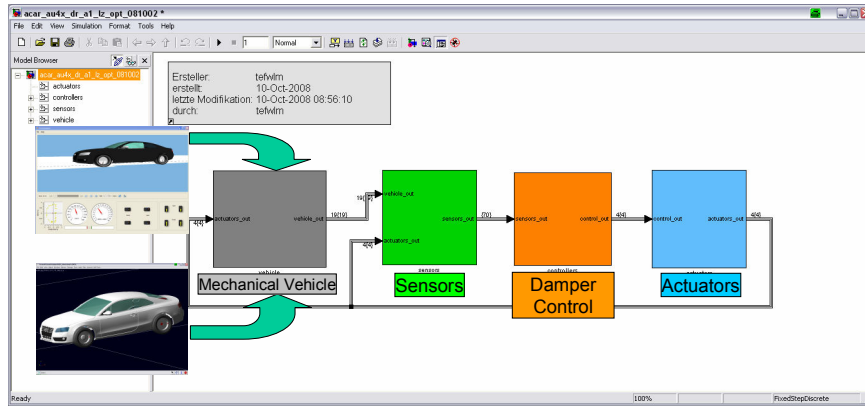


⇒ interaction must be represented in simulation model

# Tasks of Simulation Environments



# MATLAB Integration Model (MiL&SiL)



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## Mechanical Vehicle Modeling

Complex **Reference** Model:

- ADAMS/Car **Handling** Model
  - (Pac2002, Non-Lin Bushings, Flex Bodies ...)
- ADAMS/Car **Ride** Model
  - (FTire, Hydro&Freq Bushings, Flex Bodies ...)

Simplified Model:

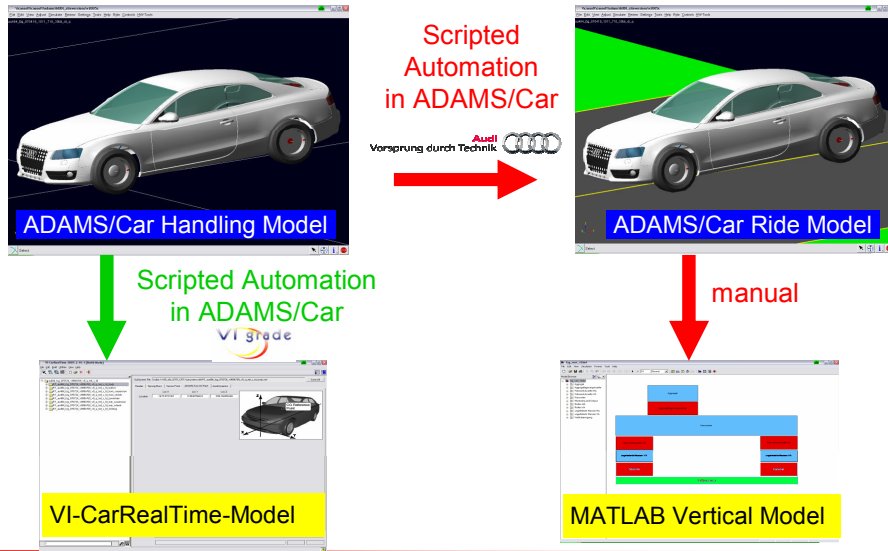
- VI-CRT Model for **Handling**
- MATLAB Model for **Ride** (AUDI development)

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# Mechanical Vehicle Preprocessing



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# Examples of Simulation Tasks

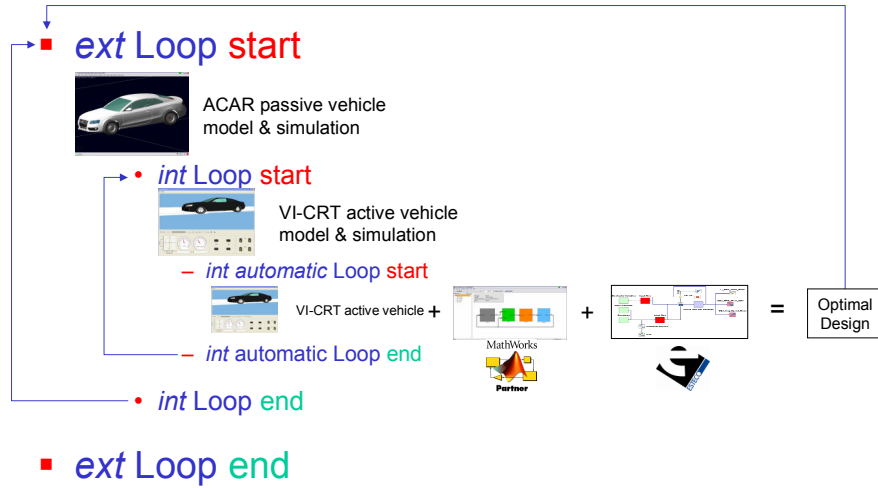
Task	Reference Model	Fast Model
Handling Development	X	X
Ride Development	X	
Powertrain Effects on Handling&Ride	X	X
Durability	X	
Design of Control Algorithms		X
Body-To-Ground Clearance	X	
Specifications for Actuators and Sensors	X	
Support of Component Parametrization	X	X
Robustness Check of Vehicle Configurations	X	
Lap Time		X

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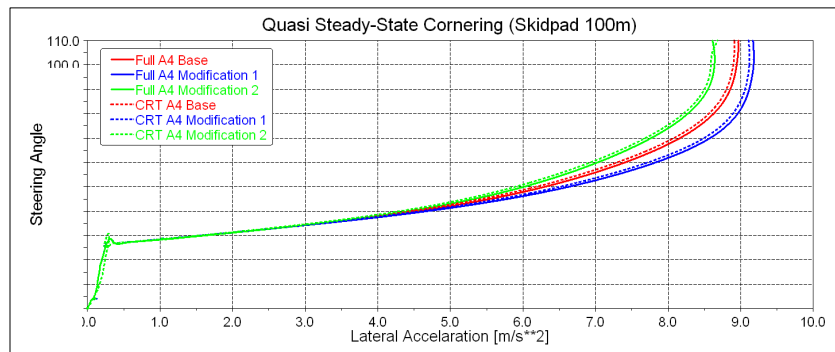
# Development Loops



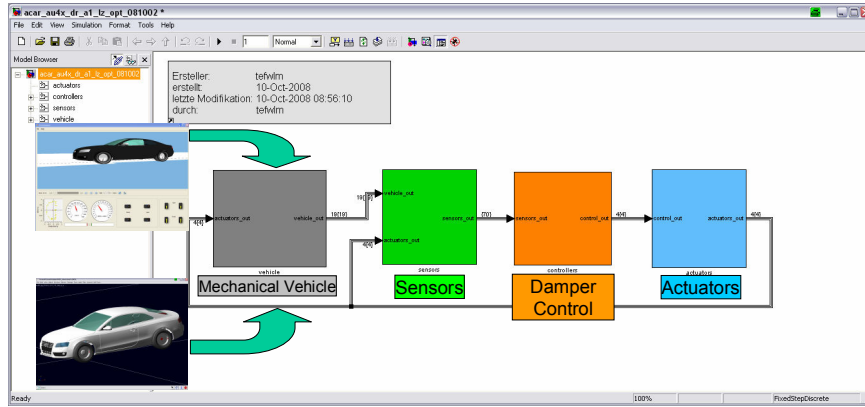
# Comparison ADAMS vs. VI-CRT

## Setups Anti Rollbars

Outer Diameter	Front [mm]	Rear [mm]
Base	12.8	9
Modification 1	12	11.3
Modification 2	13.6	8



# Damper Control System Example

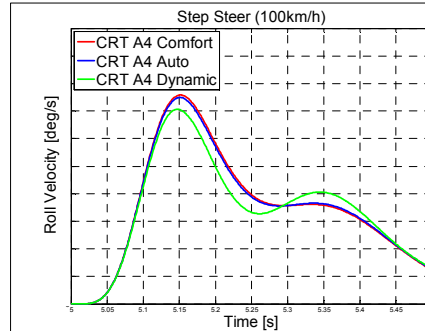
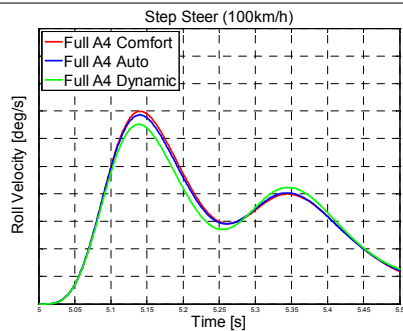


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# Settings of the Controlled Damper

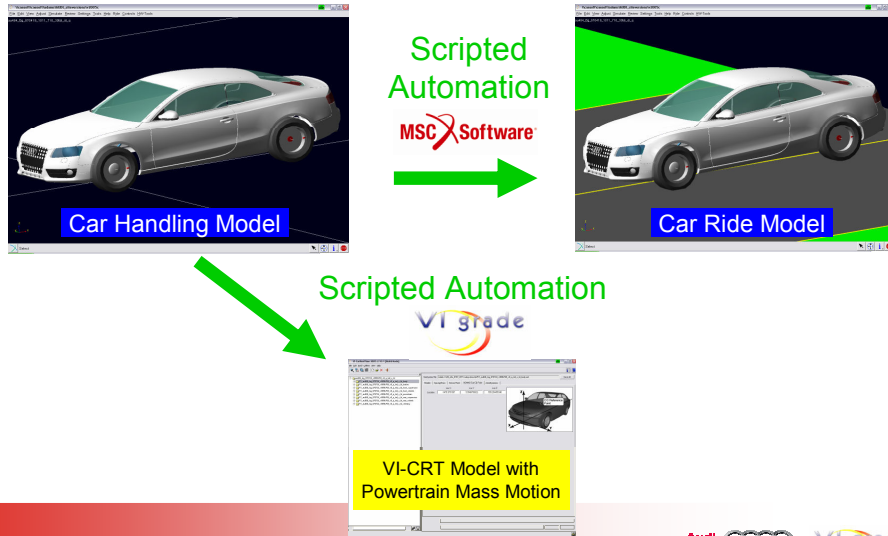
Mechanical Car: ADAMS

Mechanical Car: VI-CRT



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## SimXpert and VI-CarRealTime: future



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## VI-CarRealTime "ADAMS goes RealTime"

- Full compatibility with ADAMS/Car:
  - Common data model
  - Same driver control file
  - Same data output format
- Vehicle dynamics
  - conceptual
  - multi-objective optimization
- Control systems development
  - Software, Hardware and Model in-the-loop
- VI-grade
  - 20+ years experience with ADAMS development
  - Great understanding of vehicle dynamics
  - Collaboration with major international OEM's

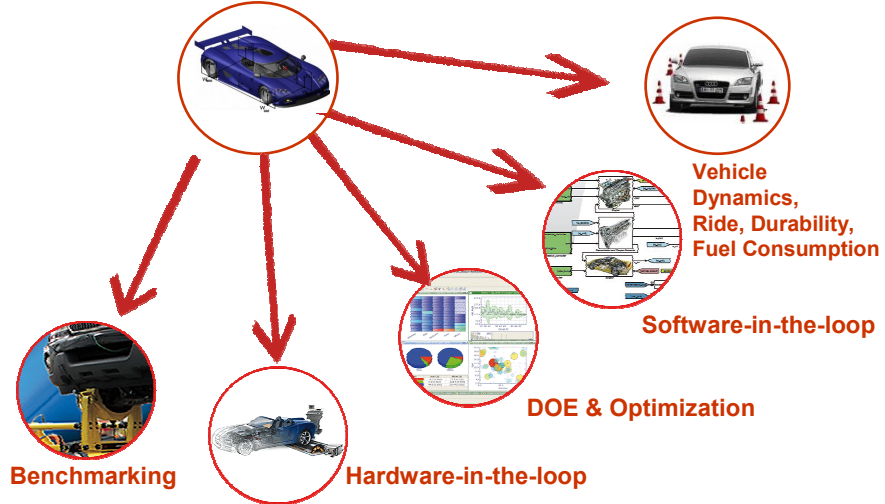


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# VI-CarRealTime Product Strategy

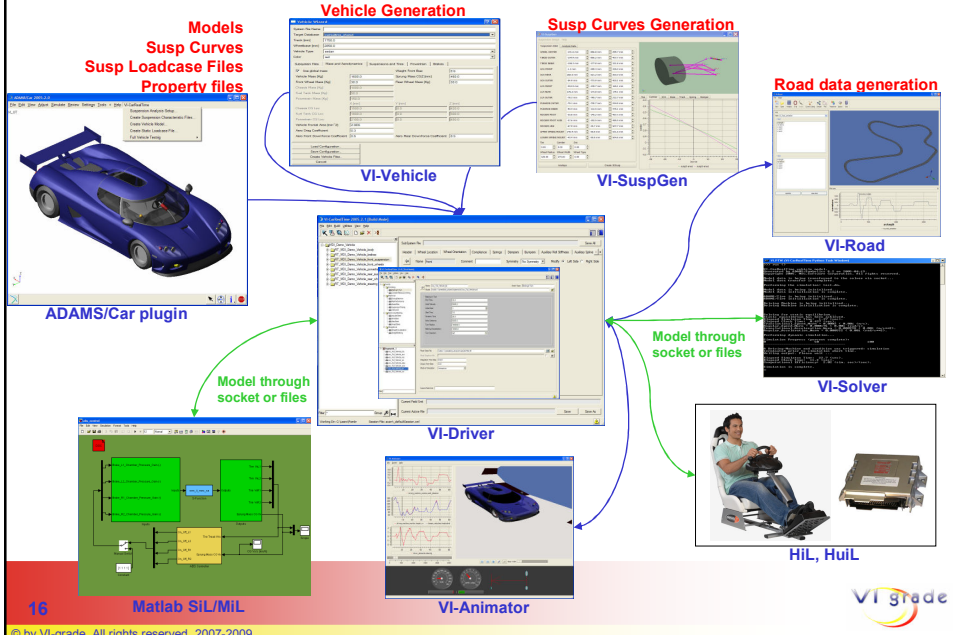


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# VI-CarRealTime Components



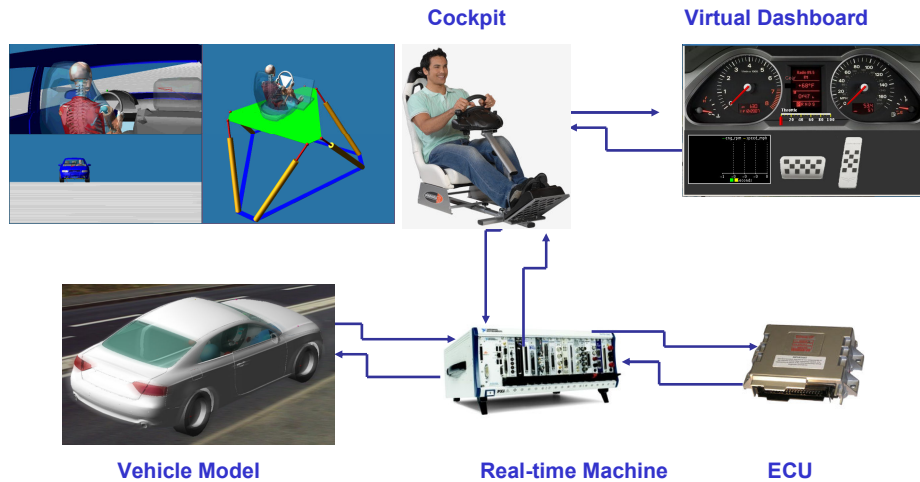
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# VI-Grade HIL&Driving Simulator



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## Human-in-the-Loop

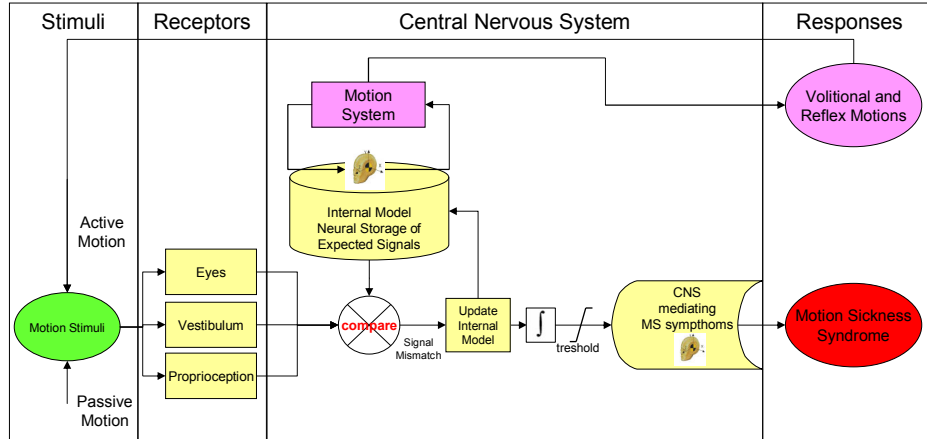
- More and more control systems are included in a car to facilitate drivability, safety and comfort
- Numerical modelling of these systems has reached unprecedented levels of accuracy
- Some vehicle control systems require the human-in-the-loop (ABS, ESP, ASP)
  - how does the **human** perceive, memorize and *learn* the system control actions?
  - Are those controls action *suitable* for the **human**?
  - Can we include a virtual **human** model in the DS platform to understand all that?

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# Sensory Conflict Theory



adapted from: Benson C.M., "Motion sickness", in K. Ernsting (Ed.) Aviation Medicine, Second ed., Butterworths, London, 1988

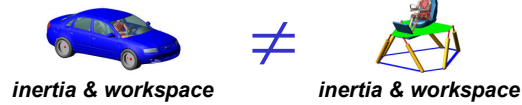
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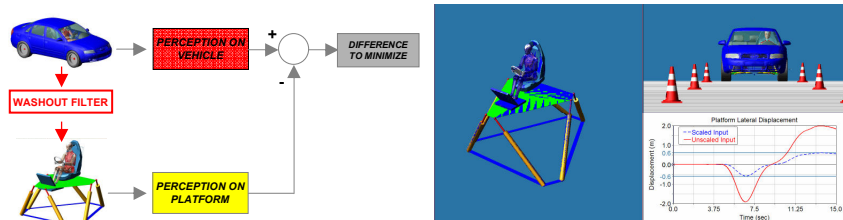


# Simulate the simulator

- A driving simulator has to reproduce the angular rates and forces that the driver would feel if the simulation was real, but ...



- The vehicle dynamics signals have to be filtered due to limited workspace  
**WASHOUT FILTER** needed



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# Integrated Simulation Solution

- Consistent framework for the development and execution of multiple, multi-rate, real-time simulations for:
  - “legacy code” models (VI-CRT)
  - MATLAB/SL
  
- Flexible Integrated Simulation Solution:
  - for all Concurrent iHawk 32-bit Multiprocessor Systems with RedHawk Linux
  - relies on RedHawk Real-Time features
  - supports large selection of COTS I/O boards

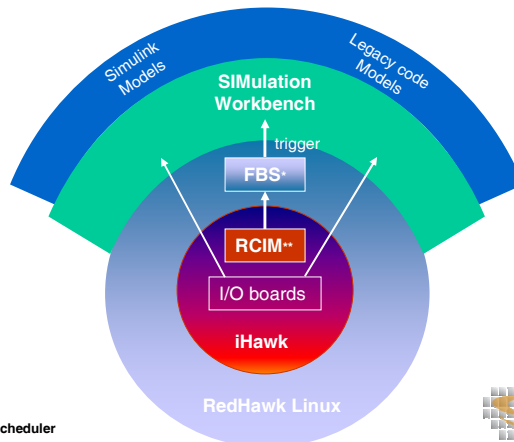


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# Integrated Simulation Solution



\* FBS = Frequency Based Scheduler  
\*\* RCIM = Real-Time Clock and Interrupt Module

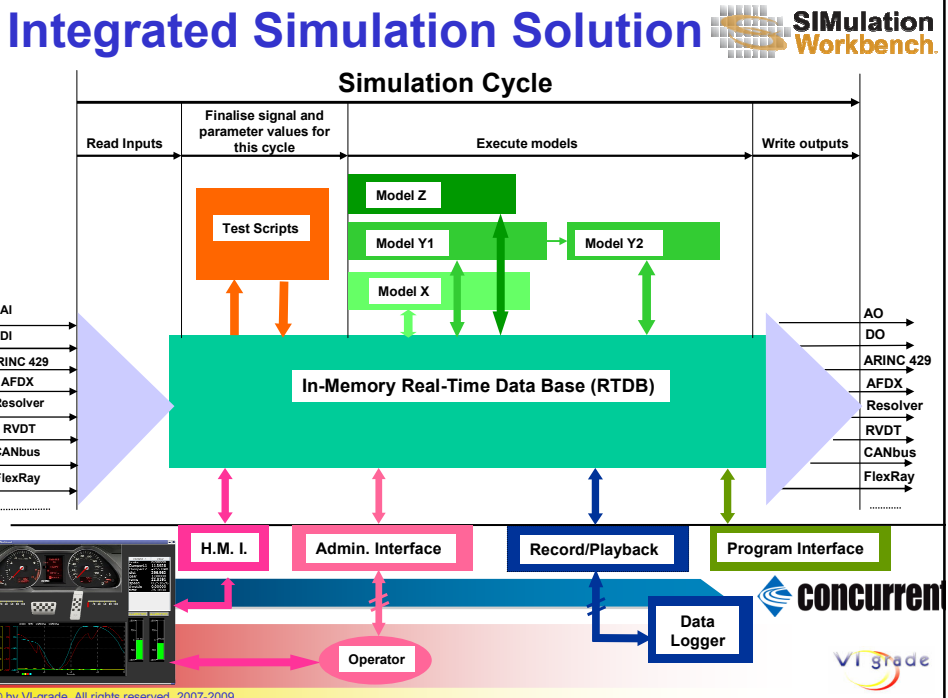
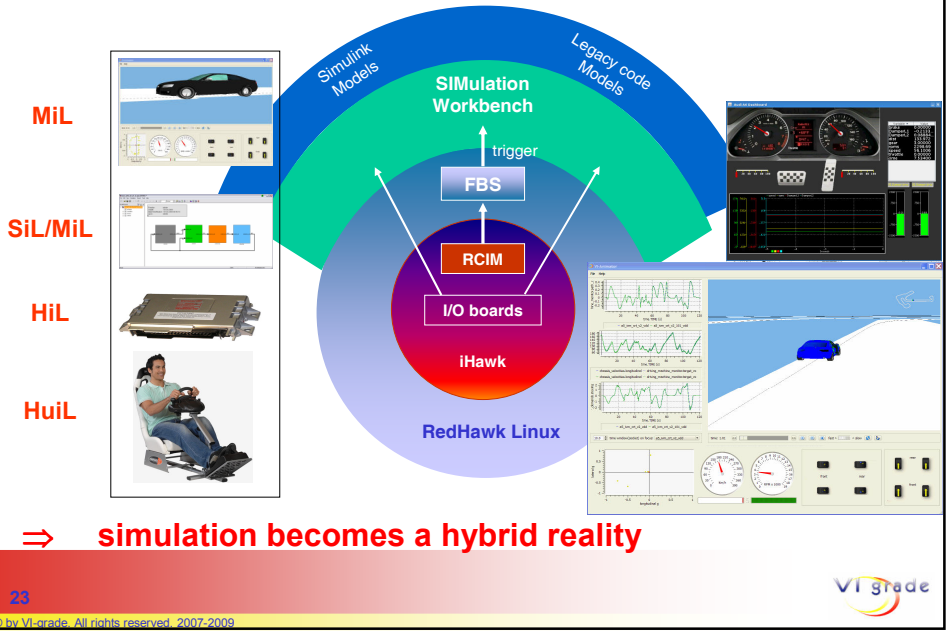


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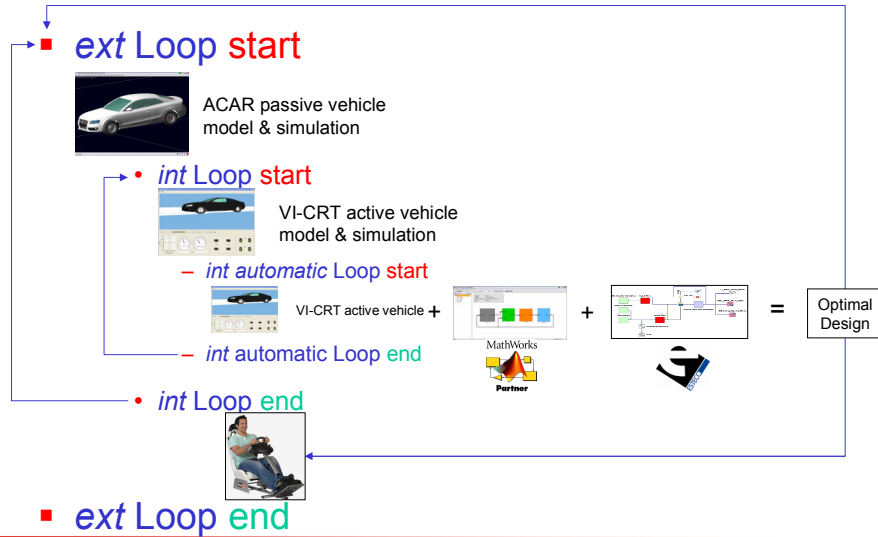
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# Flexible Model-in-the-Loop



# Development Loops

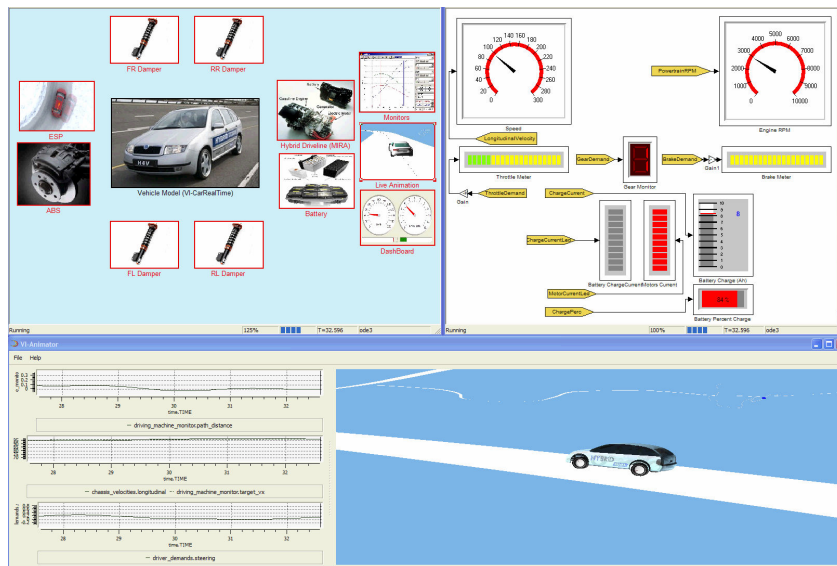


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