NA Regional Summit 2008 NAFEMS

2020 Vision of Engineering Analysis and Simulation

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The next revolution in simulation

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Executive Vice-President, CTO
LMS International

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The industry is facing faster and broader change (IBM CEO Survey 2008)

Sustainability

Radical new product concepts

"80% of the future innovation will be software-driven or electronics-based"

McKinsey & Co

Business Globalization

"Work will move where the talent is"

"The opportunity is in the raising buying power of 1.2 billion new consumers by 2030."

Expansive growth of web applications

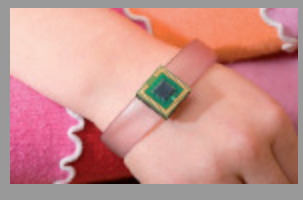
1 million businesses

...1 billion users

...1 trillion devices

New technology

- New materials
- Nano technologies
- Adaptronics



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The “Next” product innovation agenda

Engineering the “passion” in a “green” environment

“ZERONIZE”

Minimal energy consumption

Reduced emissions

95%+ recyclable

Close to no casualties

Smart systems drive 80% of the future innovations

“MAXIMIZE”

Full driving pleasure

Optimal comfort

Distinct sound quality

Power and speed

Demands for a “Next” generation development process
Based on 1D, 3D CAE and Test

Ref. TOYOTA “zeronize / maximize”

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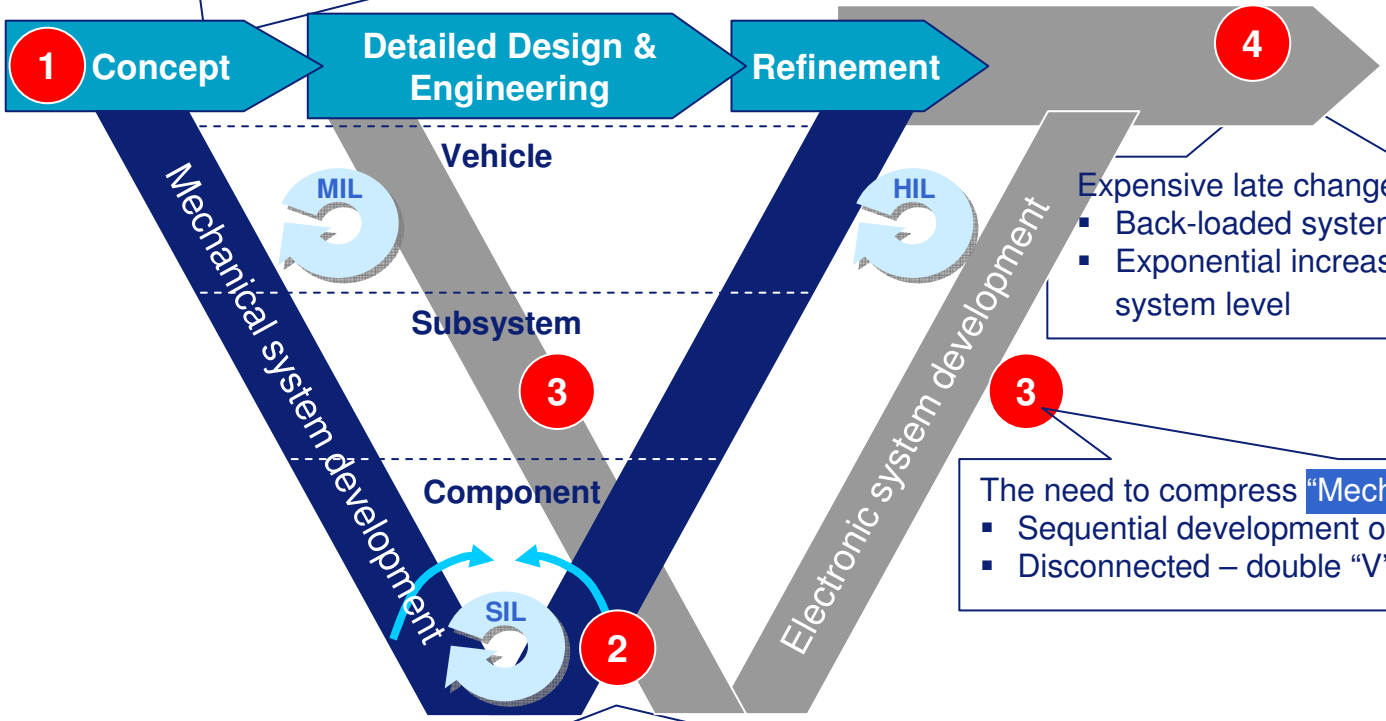
Major pain points in the current development process

Development process "front-end" facing major challenges
- Semi-empirical translation of multiple conflicting requirements and desired customer experiences into physical system specifications
- New customer – environmental – business drivers require new formal architecture design approaches



Expensive late changes and major delays in "back-end"
- Back-loaded system-level integration
- Exponential increase of customer usage validation at system level

3

The need to compress "Mechanical plus Electronics/Controls"
- Sequential development of mechanics/electronics
- Disconnected – double "V"

The need to accelerate, extend and enhance 3D CAE for detailed design
- Traditional 3D-CAE bottleneck by availability of 3D-design
- 3D-CAE stretched and technology curve flattening out

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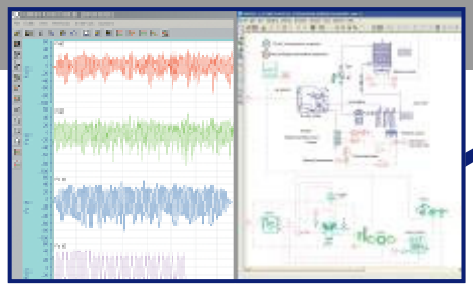
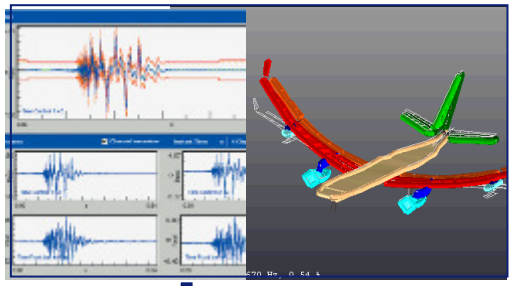
Redefining system-level simulation with the based on Multi-Functional System Mock-Up

Scalable 1D-3D Simulation supported by Test

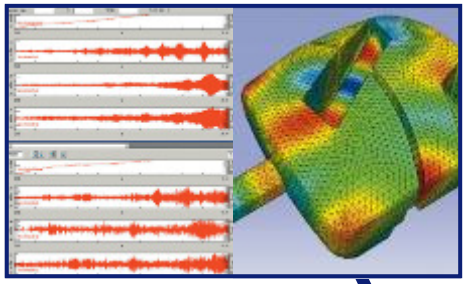


Models & Loads

1D



Models & Loads



Models & Loads

Multi-functional System Mock-up

3D

Test

Controls

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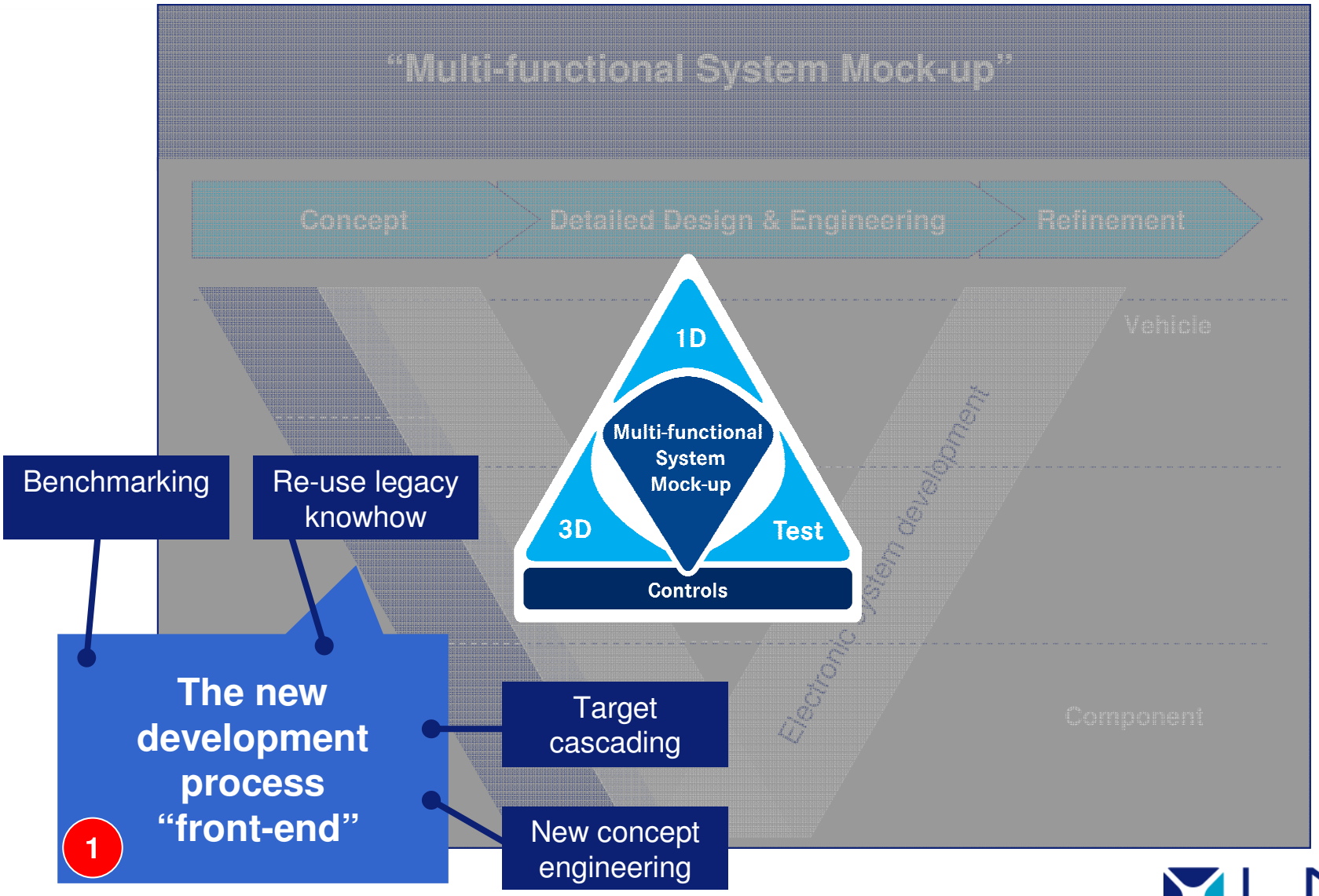
The next generation development process “front-end”



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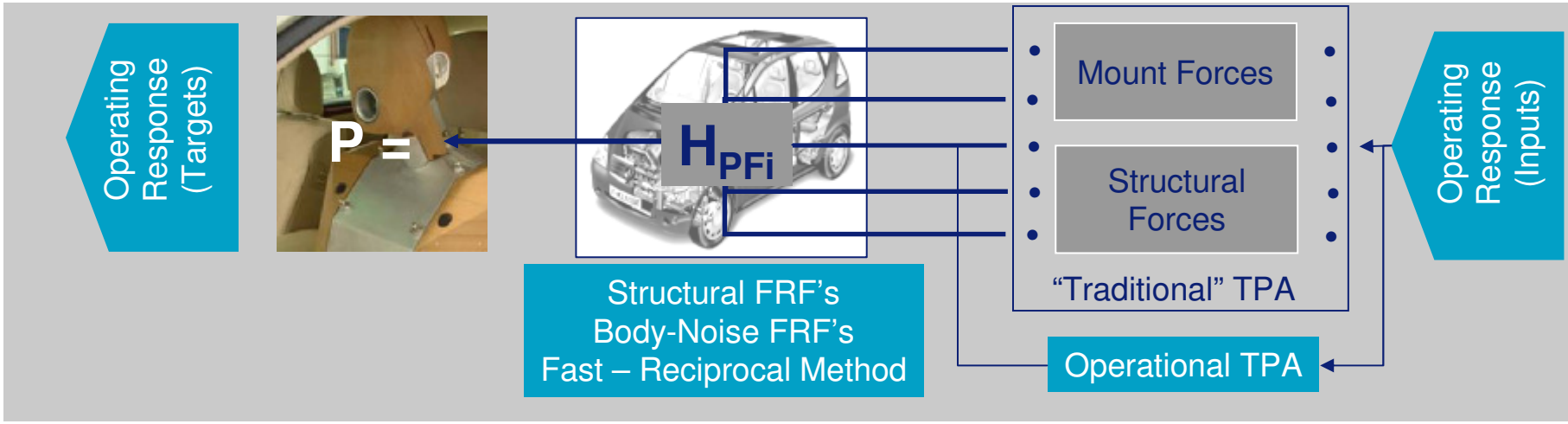
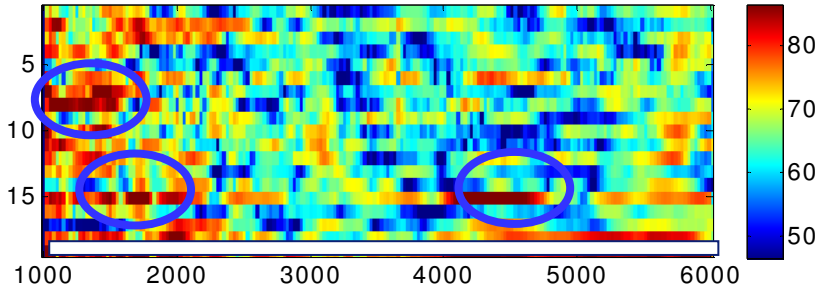
Benchmarking and Test-Based "front-end"
Target setting and target cascading – Transfer Path Analysis



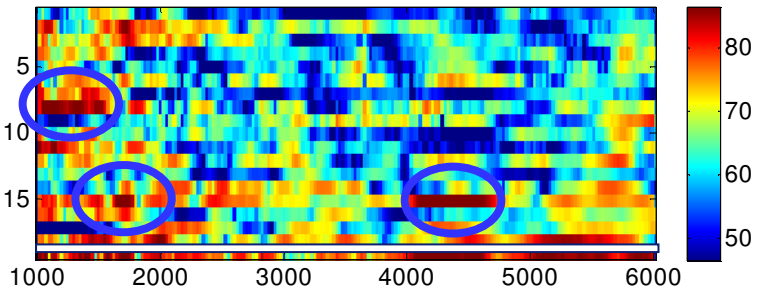
Traditional TPA

- Requires force transmissibility functions (mounts, attachment FRF's)



Operational TPA

- Direct estimation of forces based on operational inputs - **Patent Pending**



Operational TPA = same insights as **Traditional TPA**

Time saving: 80%

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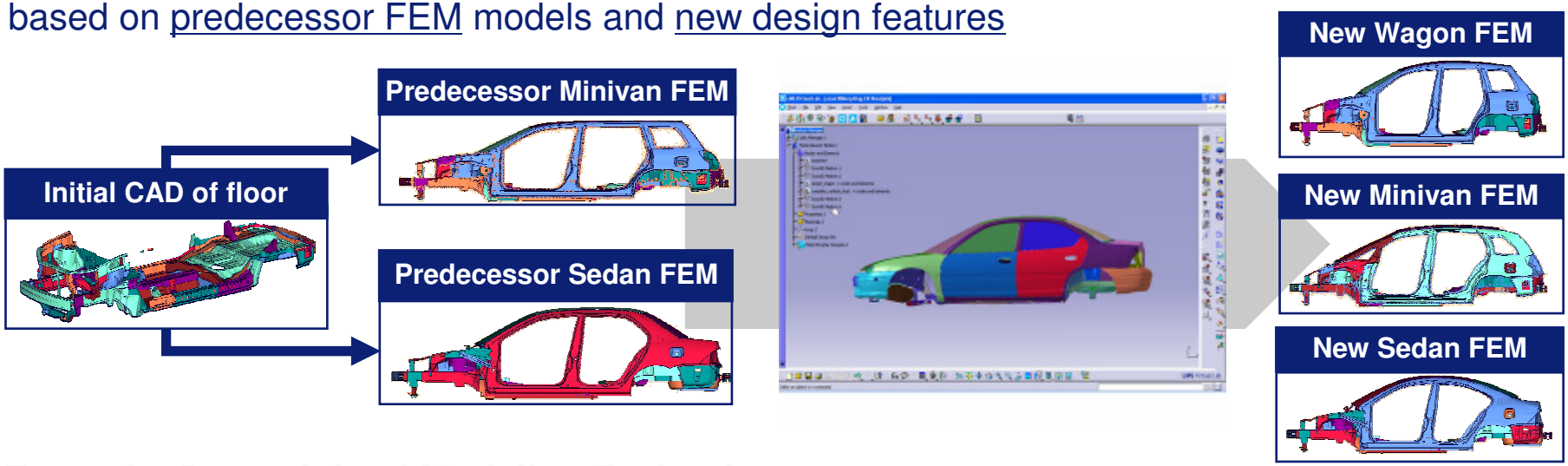
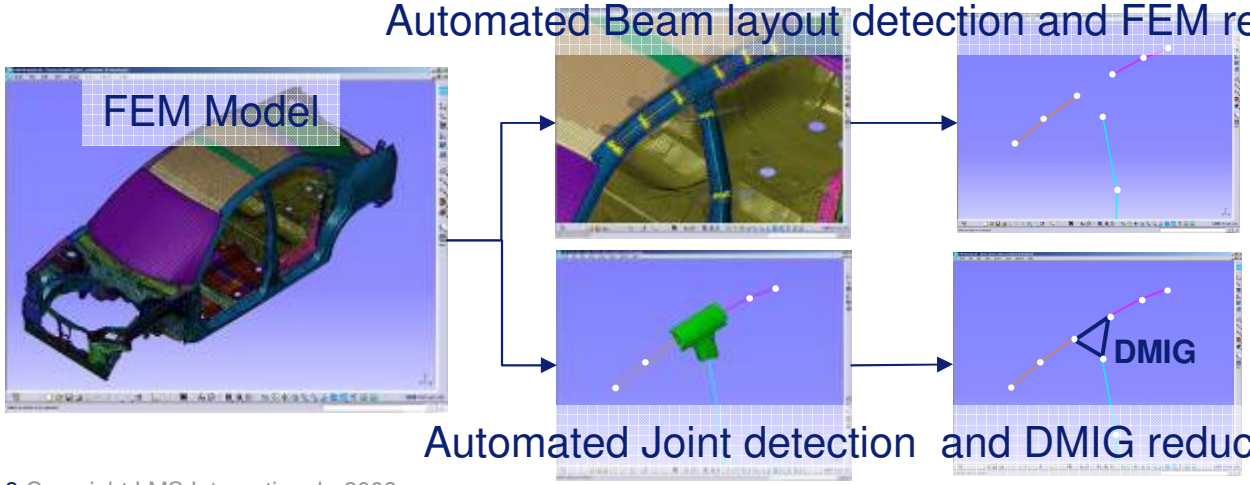
3D-CAE Based “front-end”
Re-use of 3D simulation models for early analysis

Example: FEM Morphing Generate new FEM models
based on predecessor FEM models and new design features



Example: Beam/Joined Modeling Technology

Automated Beam layout detection and FEM reduction



Very fast identification of weak spots (sensitivities) and very fast optimization

Automated Joint detection and DMIG reduction

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The next generation development process “front-end”
System concept engineering – Based on 1D system simulation

Example: study of new concepts for engines/powertrains
Based on multi-functional system mock-up and simulation

Cooling

Air path

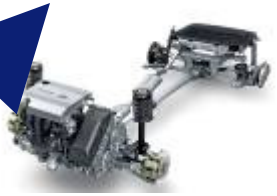
Combustion

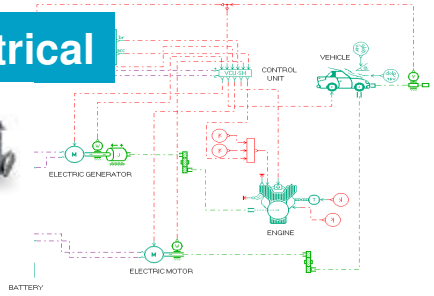
Exhaust

Lubrication

Transmission

Hybrid / Electrical



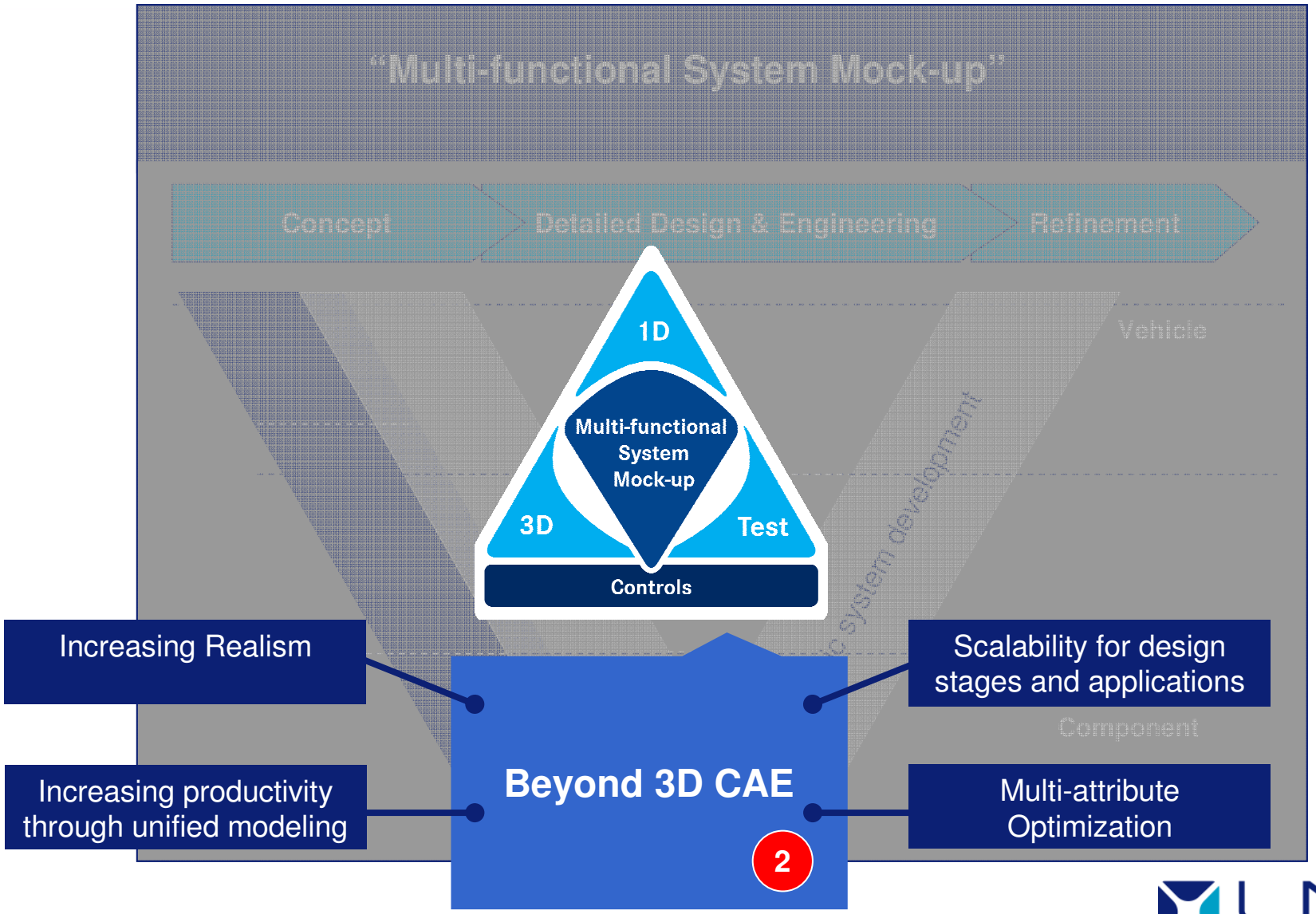


Fuel cells

Engineer to be eco-friendly and to meet “brand” image - performance

SIEMENS VDO
DELPHI
BOSCH
RENAULT
TOYOTA
VOLVO
GM

Beyond traditional 3D CAE



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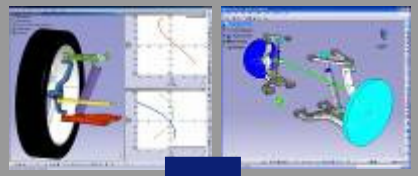
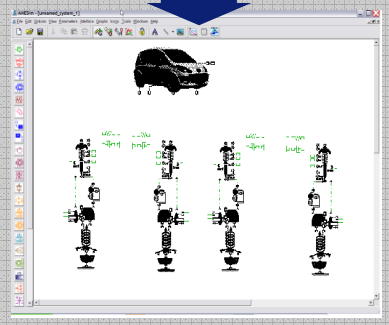
Beyond traditional 3D CAE
Scalable 1D/3D CAE for different design stages & simulation purposes

Example: vehicle dynamics engineering

Component – Subsystem Models





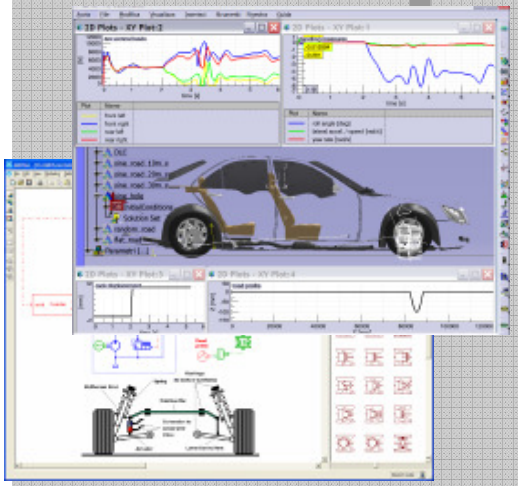
Ride & Handling

1D Simulation
Chassis Concept

Suspension type
Hard points
Bushing, damper settings

Increasing Design Details

Component – Subsystem Refinement

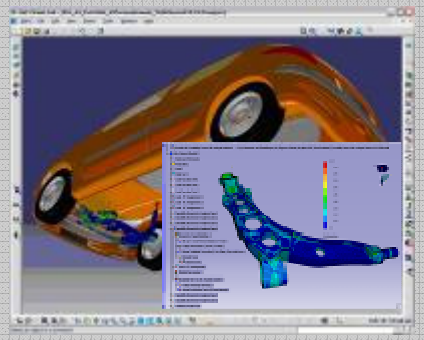


Ride & Handling - Comfort

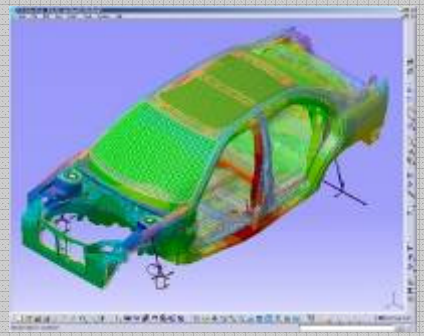
3D Simulation
Chassis Detail – Body Concept

Details subframes – incl. flexibility
Body concept model - incl. flexibility
Tire models

Increasing Design Details



Loads for component durability analysis



Road Noise

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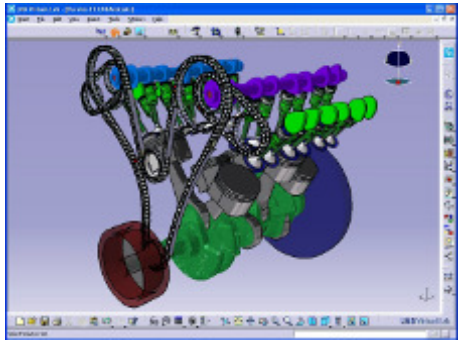
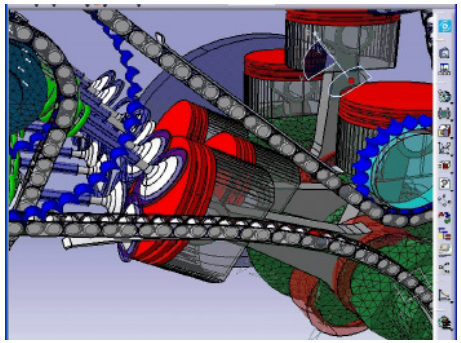
Improving realism for system level simulation
Advancing 3D simulation

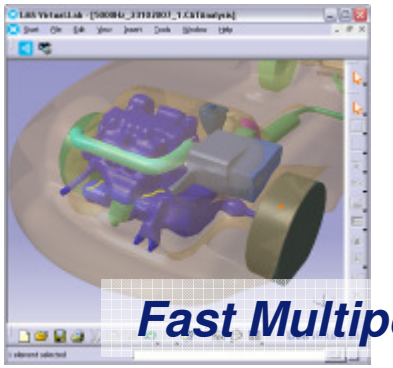


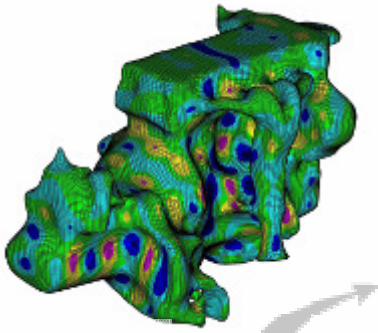


✓Accurate modeling of interaction between subsystems to simulate loads, and load propagation

✓Extending the “frequency” range:

- High frequency noise sources: Injectors, modeling of engine bay
- Higher frequency noise radiation
  Simulation at +500 Hz





Fast Multipole - BEM EADS

SIMDAT **2004-2008**
18.5 MEuro

EC FWP 6 – Grid Computing Initiative
Data Grids for Process and Product Development
using Numerical Simulation and Knowledge Discovery

Audi RENAULT

✓Make use of continuous progress with computing

- Multi-CPU computation
- Grid computing

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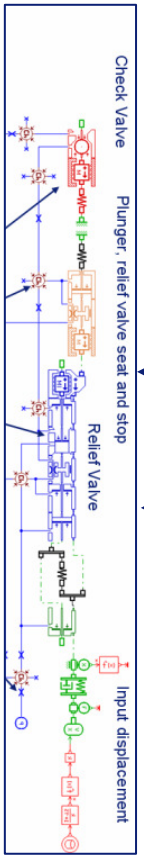
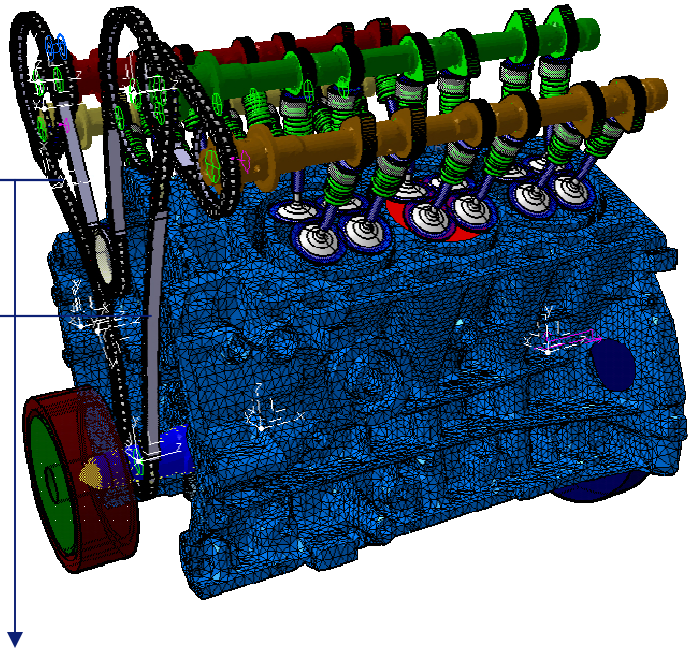
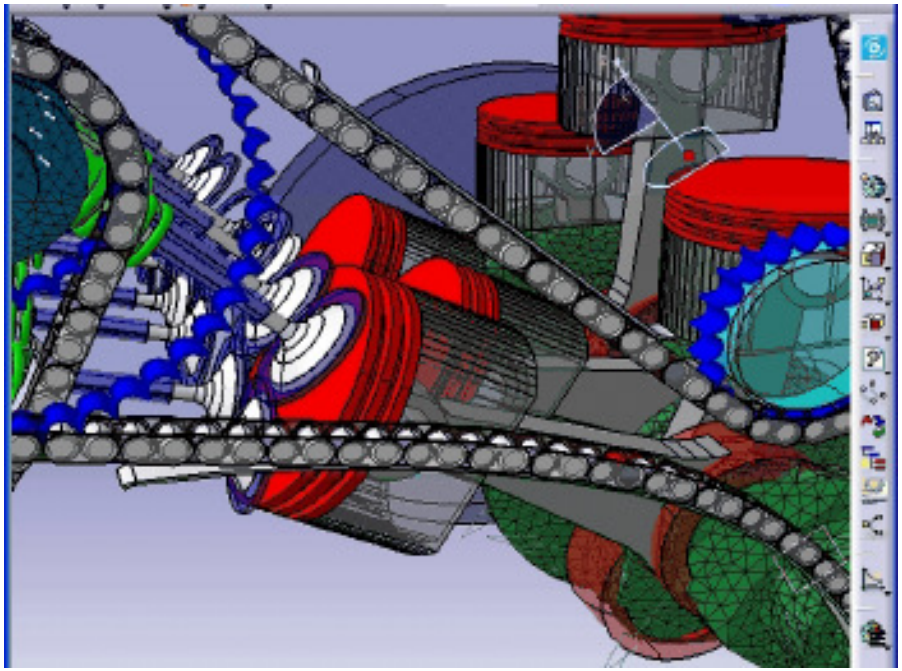
Improving realism for system level simulation
Based on combination of 1D and 3D

Example: chain whine



Coupled mechanical model
Upper& Lower Engine
MBD - FEM





Coupled simulation with
functional model for
chain tensioner / actuator

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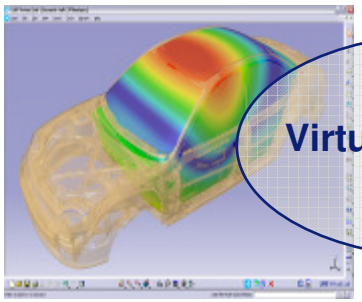
Improving realism for system level simulation
Based on combined use of Test and CAE

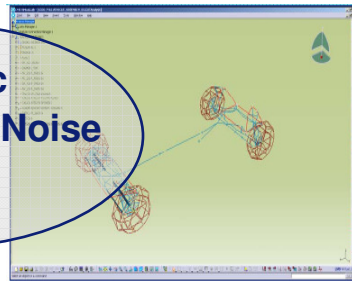
Realistic Simulation

Example: Test Based Tire Model for Road Noise Simulation

Test Based Virtual Tire



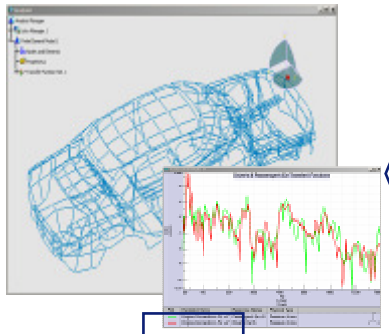
Realistic Virtual Road Noise Model



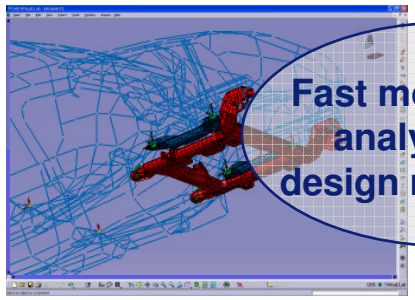
Vehicle Dynamics Model for Road Noise

Accelerated Refinement

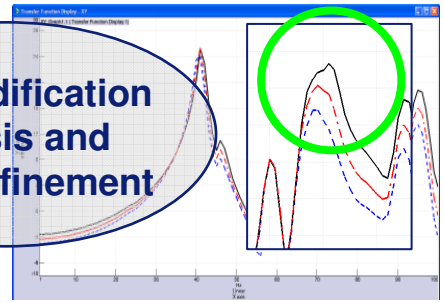
Example: Test Based Trimmed Body Model



Test Based Trimmed Body



Fast modification analysis and design refinement



Test – CAE Substructuring

Measurement and analysis innovation – in support of simulation

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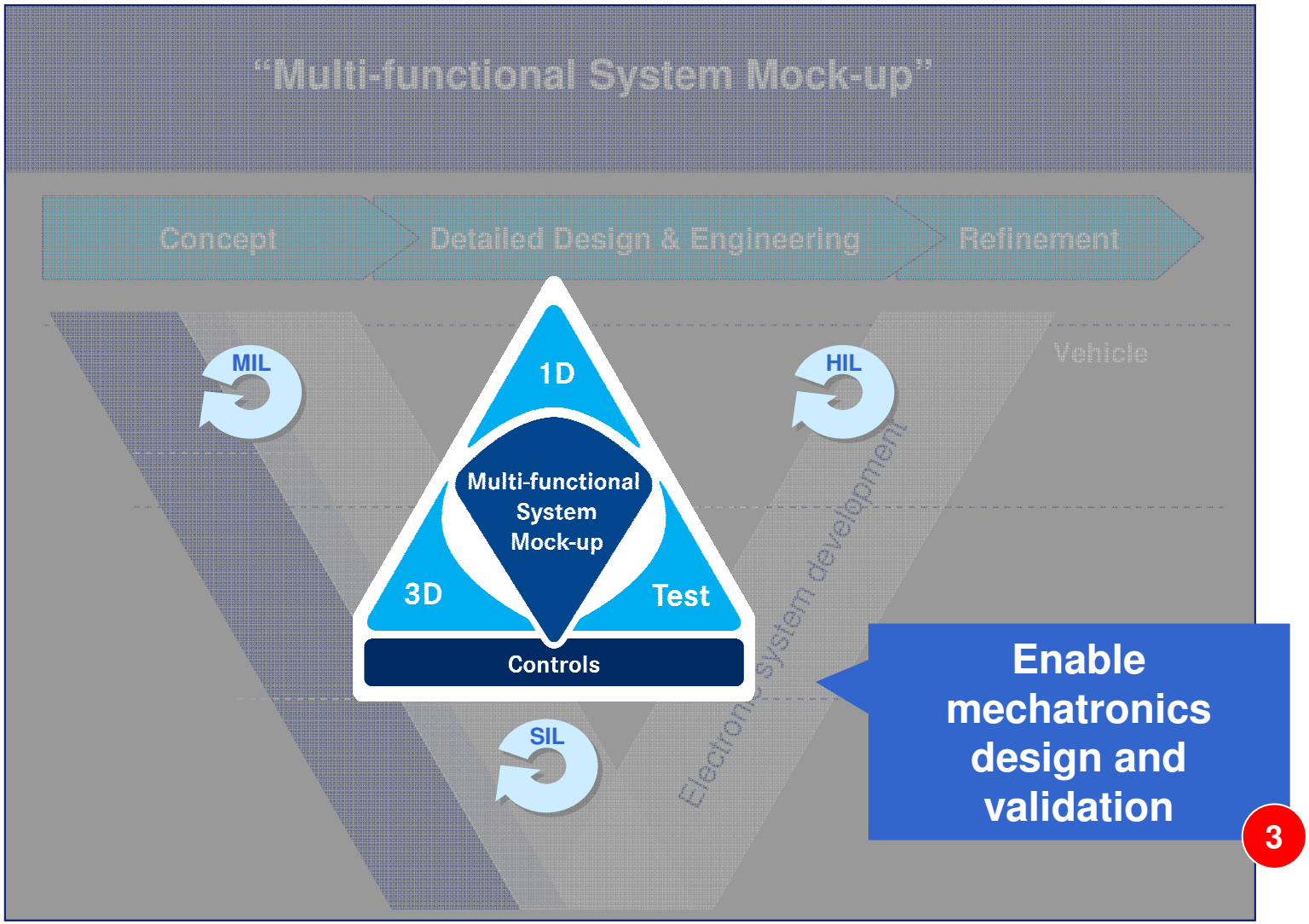
Enabling mechatronics design and validation



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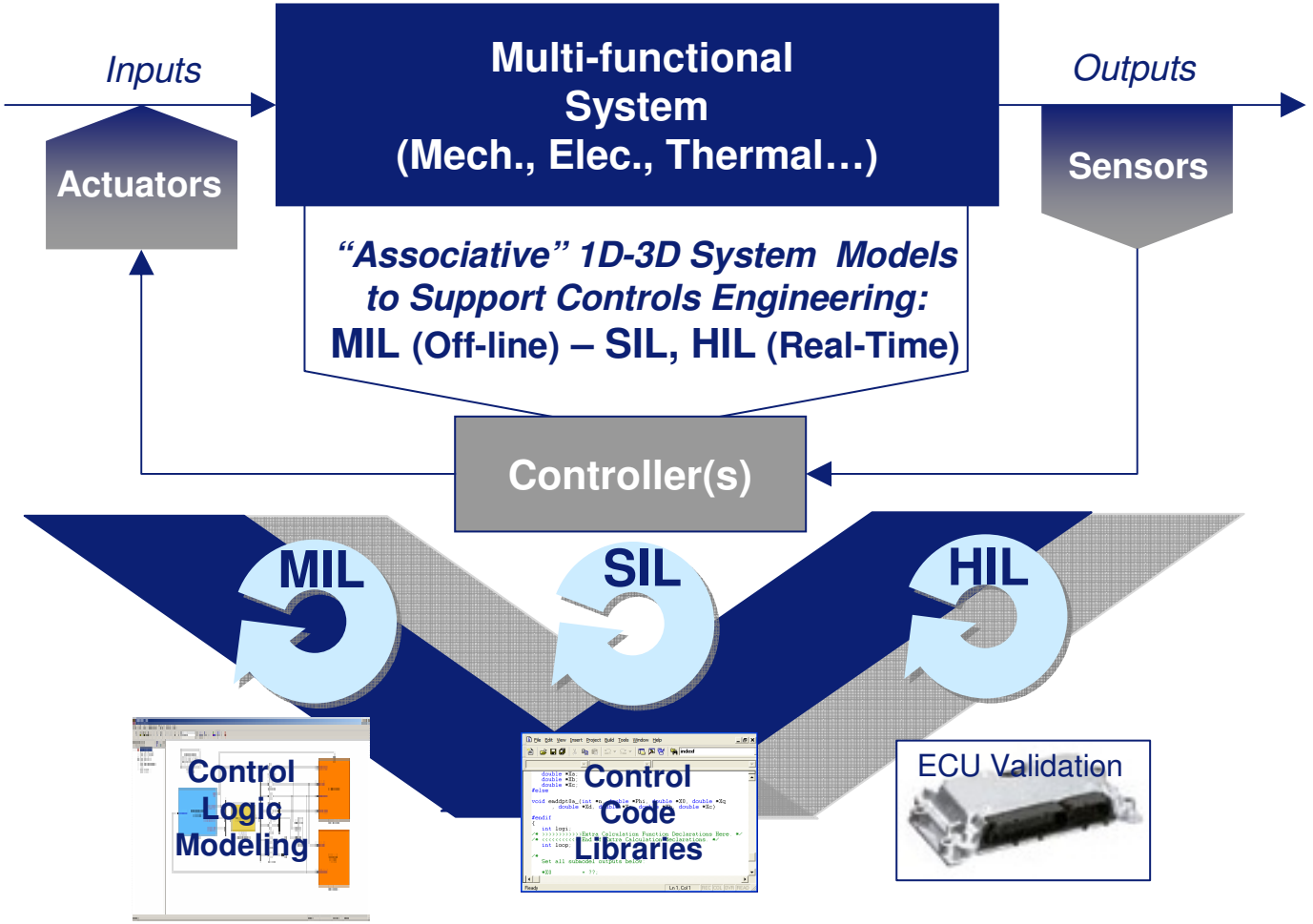
Enable mechatronic design and validation



Associative 1D-3D system models
to interconnect mechanical and electronics/control engineering

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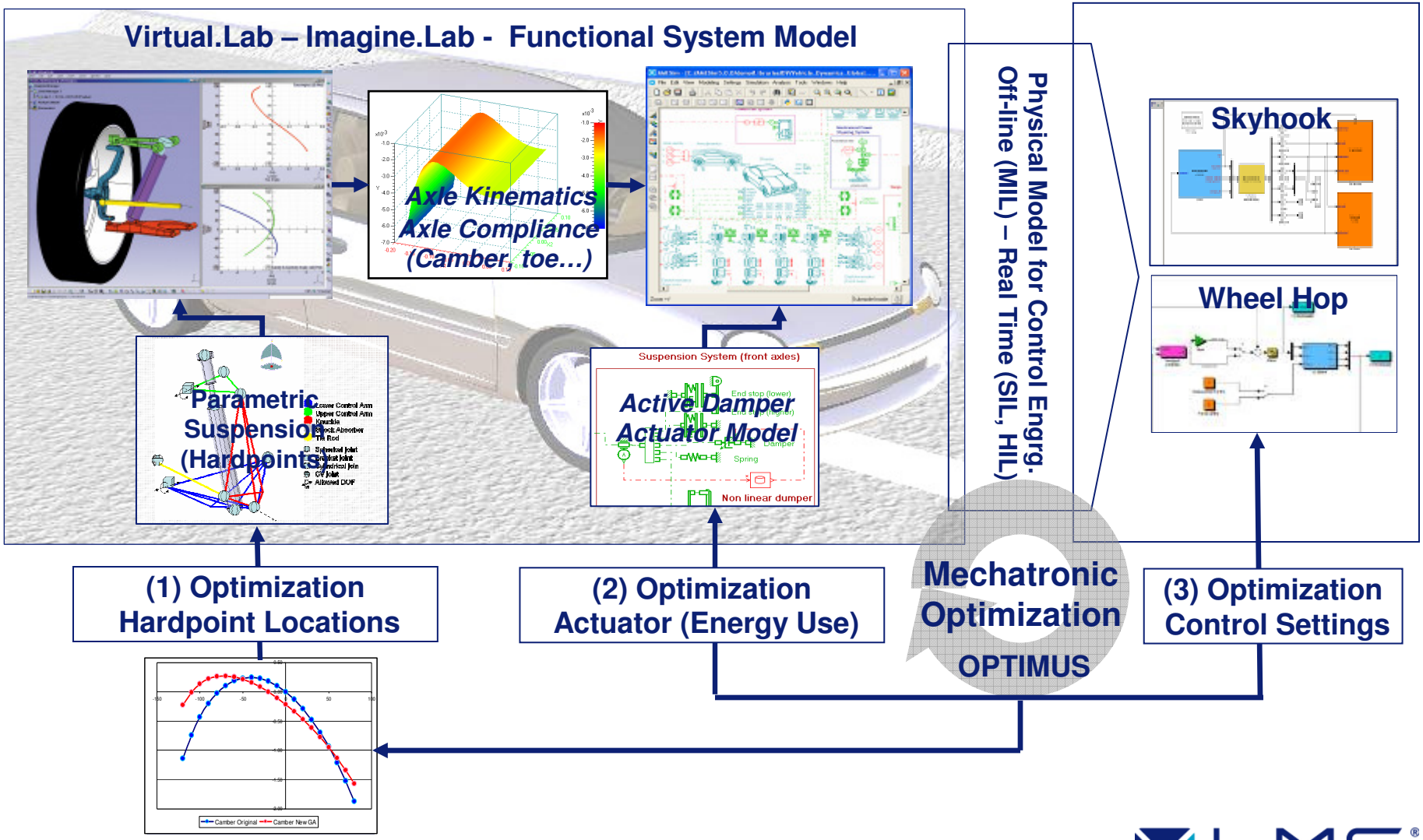
Mechatronic system optimization
Joint performance and energy optimization in active suspension



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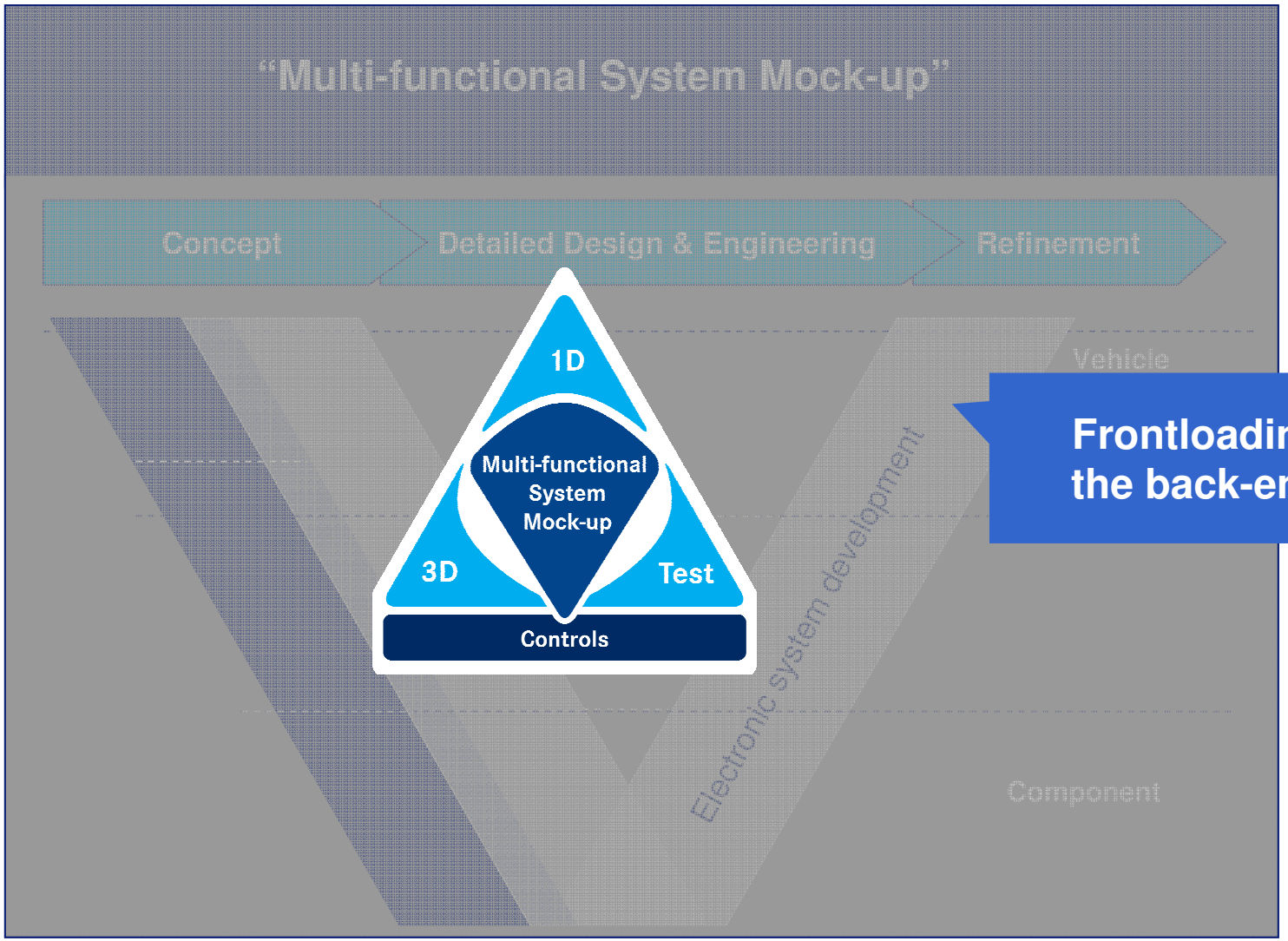
Frontloading the development process “back-end”



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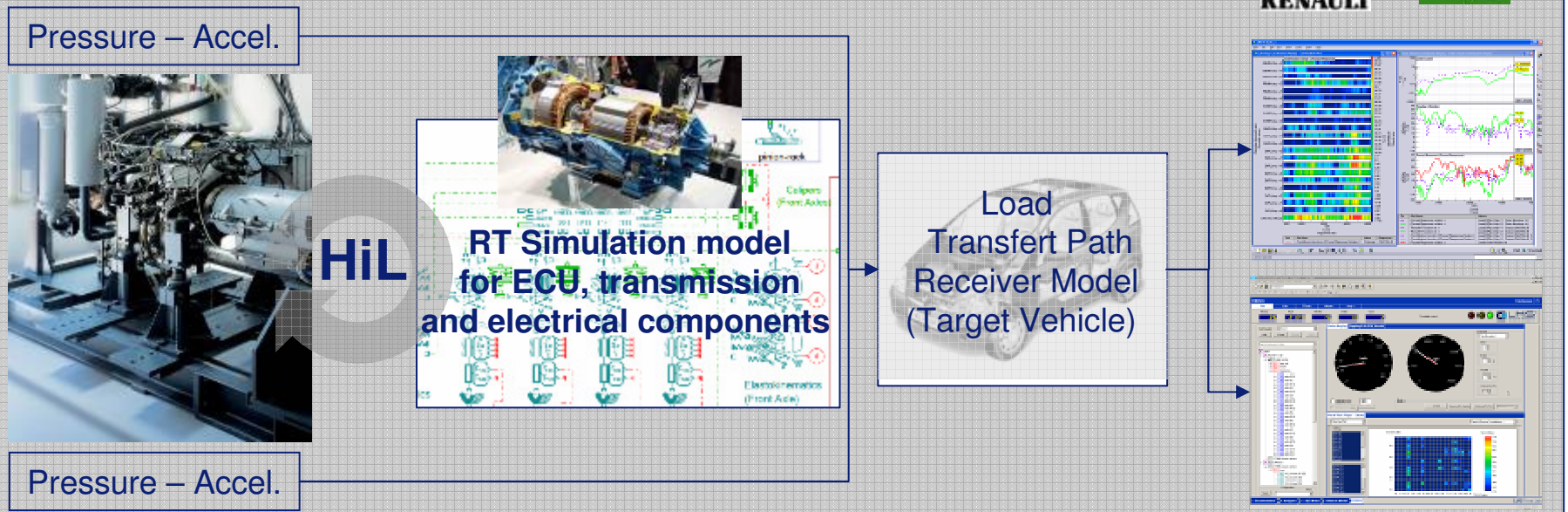
Frontloading validation and physical testing Enabled by the multi-functional system mock up

- Simulate on the test cell the “working” of target build-in environment
- Process and analyze test cell data in context of target build-in environment

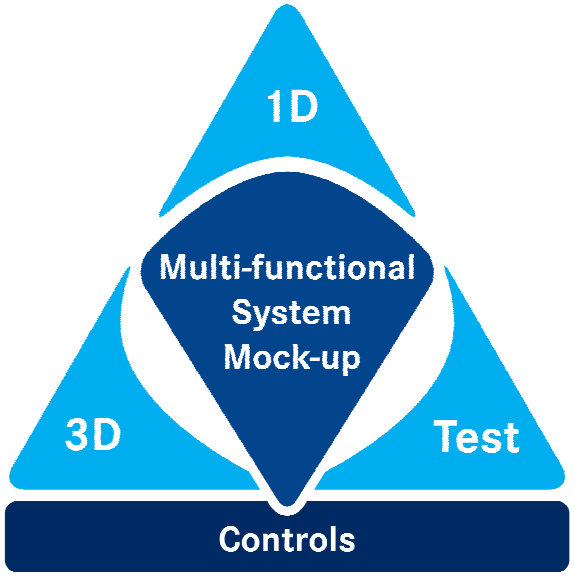
Example: testing and calibration of ICE to be used in hybrid powertrain



Simulation is key to enable frontloading of testing and validation

Conclusion

Increasing the impact of system simulation in all phases of development process based on Multi-funtional System Mock-up



1D, 3D, Test – Functional Domain

- Continuous innovation
  Simulation (1D, 3D) and Test
- Use progress in computing
  Multi-CPU, Grid computing

Multifunctional System Mock-up

- "Combined" solutions
  1D-3D Simulation
  Simulation -Test
- "Physics" Models for Control

Empowering² the Next Generation Development Process

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Thank you

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