E-Works 2011
济南, 2011/11/24~25

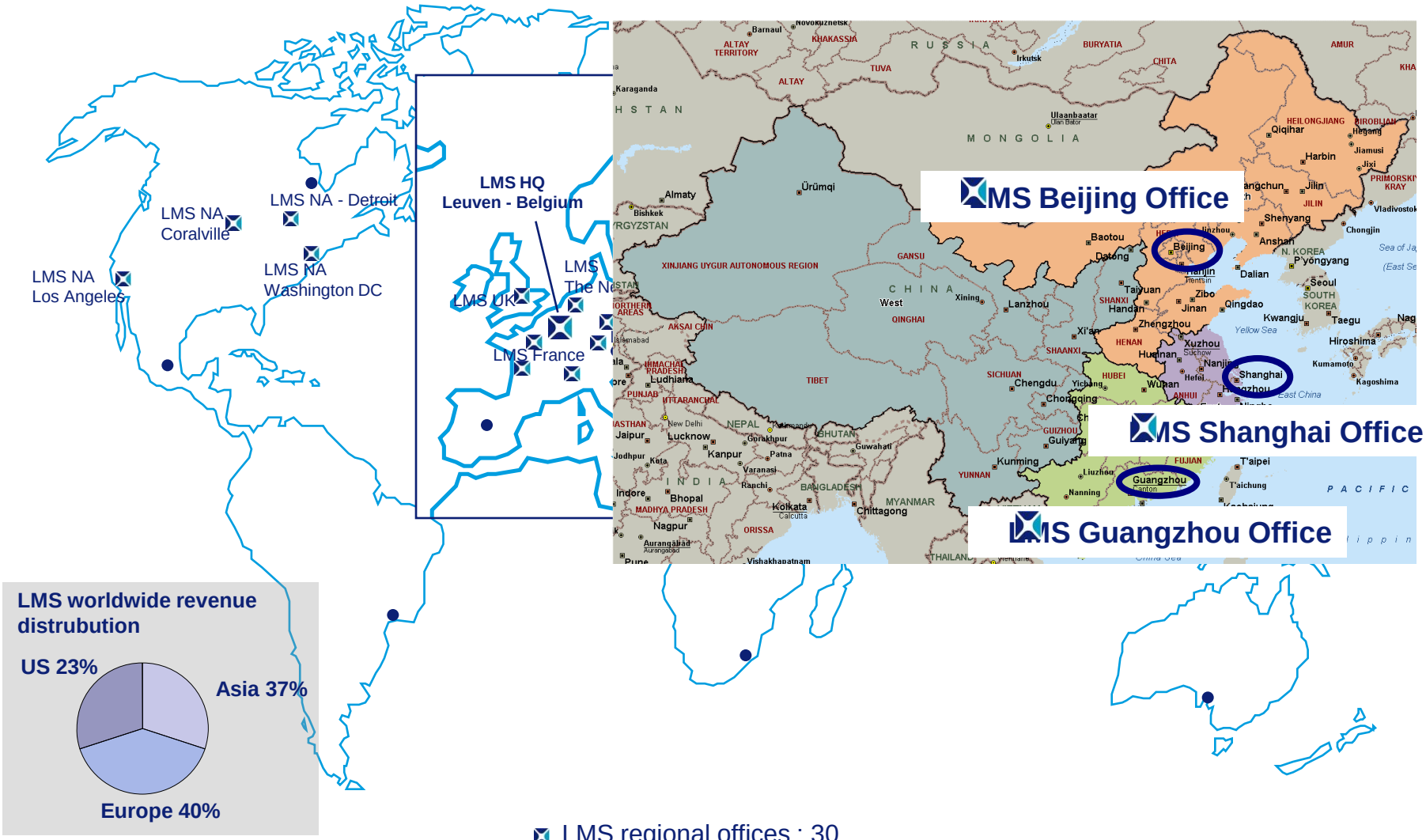
LMS完整集成解决方案

石银明博士

技术总监 LMS中国

LMS ENGINEERING INNOVATION

LMS, a global response to customer needs



LMS worldwide revenue distrubution

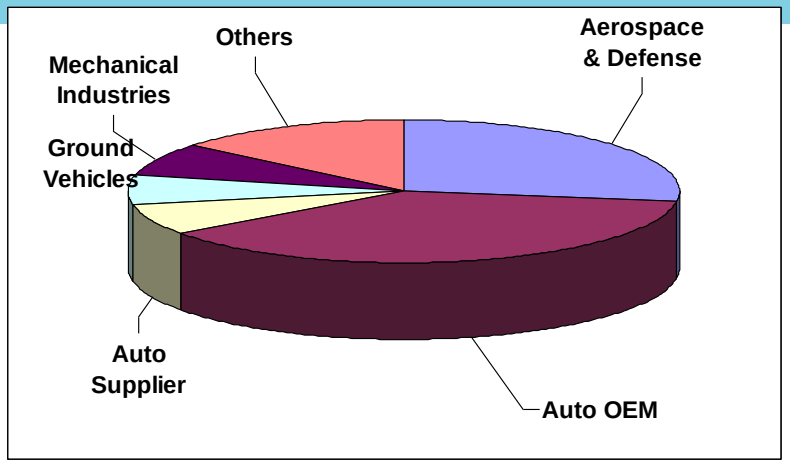
- LMS regional offices : 30
- LMS representatives offices : 25

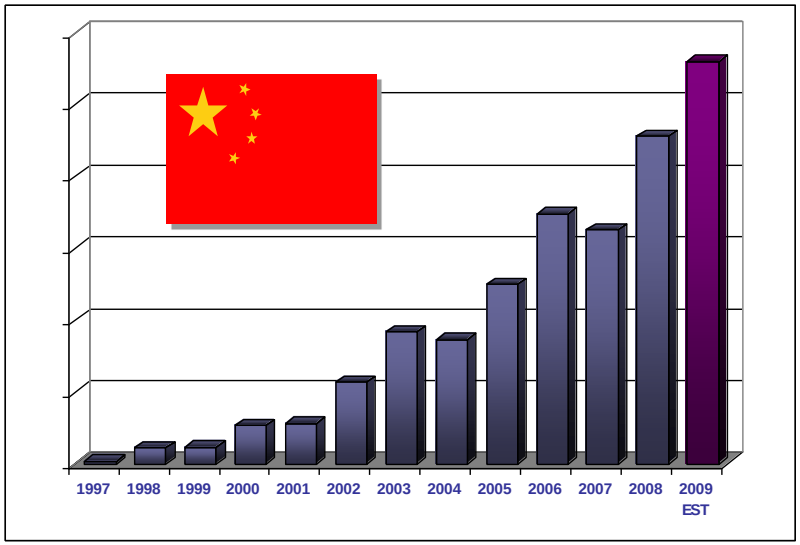
 Copyright LMS International - 2008

LMS® ENGINEERING INNOVATION

LMS 中国区，强大的本地团队

+15% of LMS WW New business





LMS ENGINEERING INNOVATION

LMS, a track record of Transformational Solutions

LMS 2011

Leading partner in Test & Mechatronic Simulation

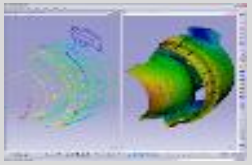
Product Innovation	Process Innovation
More Composite Aircraft More Electrical Aircraft	Achieve earlier aircraft maturity
Sustainable Environment	Process efficiency & Productivity

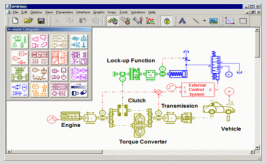
Supporting Model-Based System Engineering

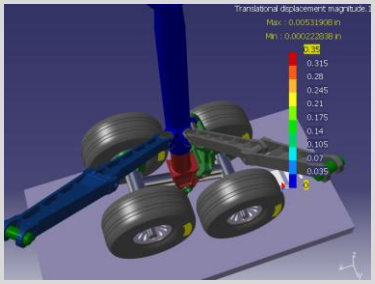
LMS 2010

Hybrid TEST/CAE Partner

1.000 people





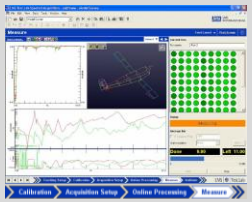


1995 **2010**

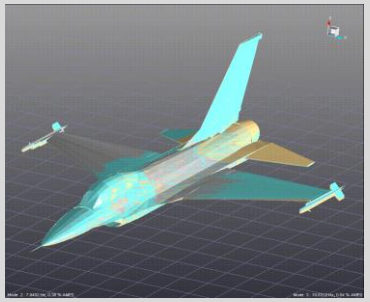
LMS the Roots

TEST-NVH Partner

200 people

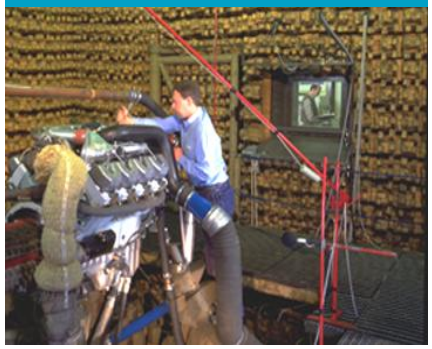


1980 **1995**

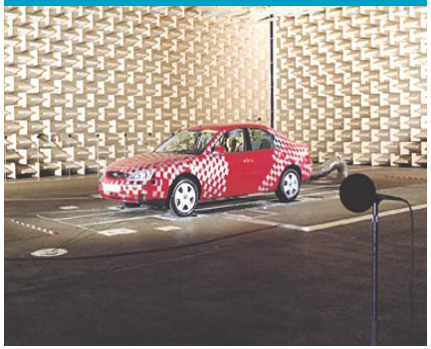


LMS Test.Lab
集成的振动噪声测试试验室

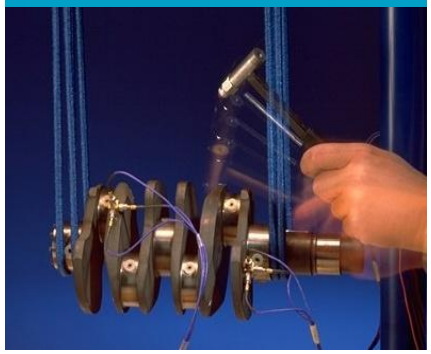
旋转机械



声学



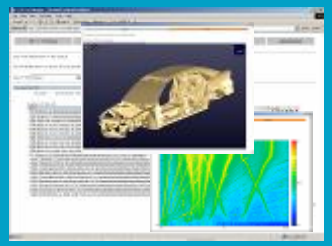
结构测试

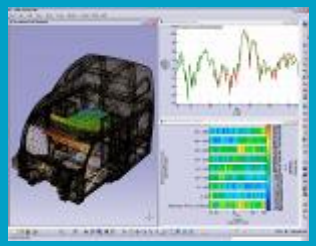


环境和疲劳试验

- 测量和分析的创新
- 充分利用设计和专家系统，提高效率
- 完整的开发流程，试验数据集成到CAE

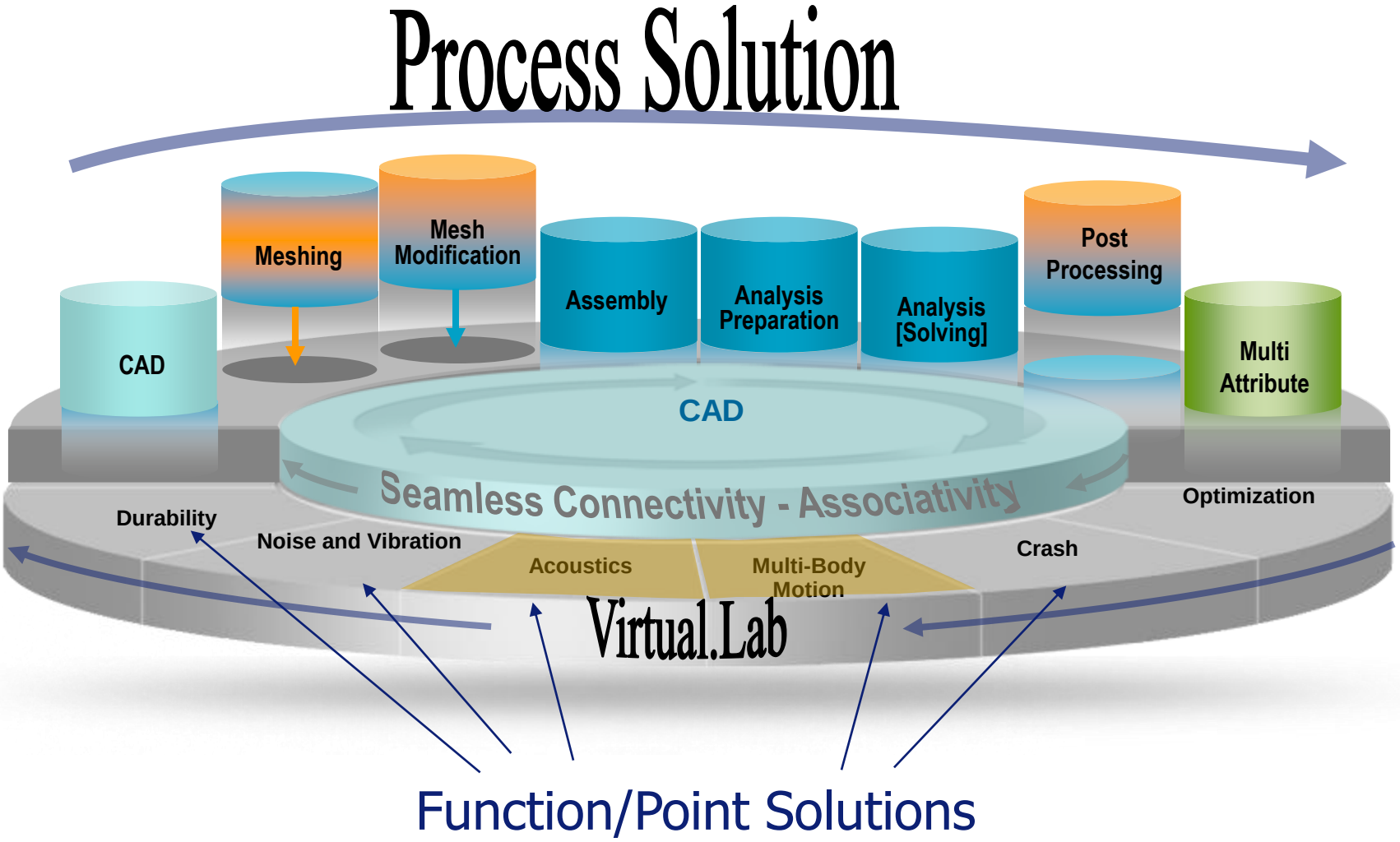
报告
数据分享
高级分析





LMS ENGINEERING INNOVATION

The CAE Based Design Process – Virtual.Lab Positioning



LMS ENGINEERING INNOVATION

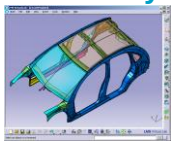
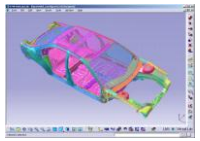
Unified Modeling – Addressing End to End Process for Multiple Simulation Attributes

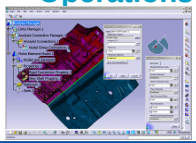
LMS Virtual.Lab

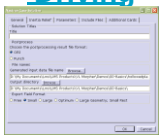
ONE CAD

Geometry | CAD-Assembly | Meshing | Mesh Operations | FE-Assembly | Analysis Definition | Solver Driving | Post Process

Acoustics/NVH…
Crash/Safety
Structural analysis
Cross-Attribute Optimization

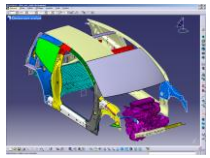





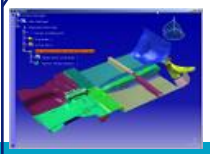


ANSA Batch Meshing **Services** in Virtual.Lab

μETA PostProcessor Post-Processing **Services** to Strengthen LMS Virtual.Lab for structural analysis post-processing



CATIA V.5 Associative Meshing



Externally Meshed Parts

LMS ENGINEERING INNOVATION **Solvers: Acoustics, Motion, NVH, Durability**

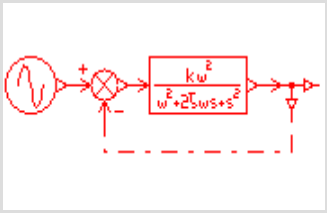
MSC Software | LSTC | DASSAULT SYSTEMES | esi | tass

NASTRAN, ABAQUS, CATIA CAE, LS-DYNA, RADIOSS, MADYMO

LMS ENGINEERING INNOVATION

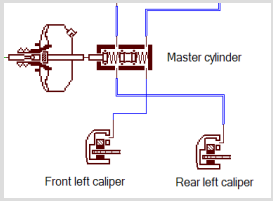
LMS Imagine.Lab AMESim：应用库

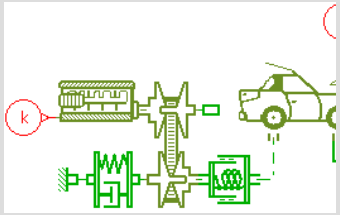
40个 应用库
4500 多个多领域模型



控制
控制系统
实时，SiL – Hil

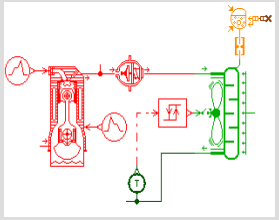
液压 & 气动
车辆，航空航天，
重工，船总
液压

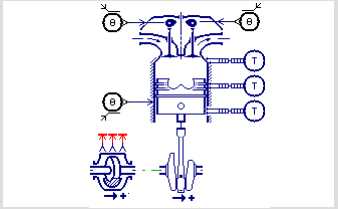




机械
1D 机械系统
传动
车辆动力学

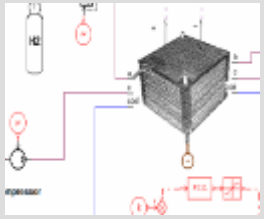
热
车辆热管理
冷却系统& A/C 系统
环境控制

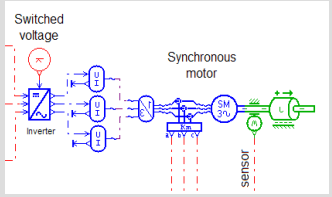




发动机
发动机控制，混合动力
燃烧， 气道

能源
燃料电池，电池
电站



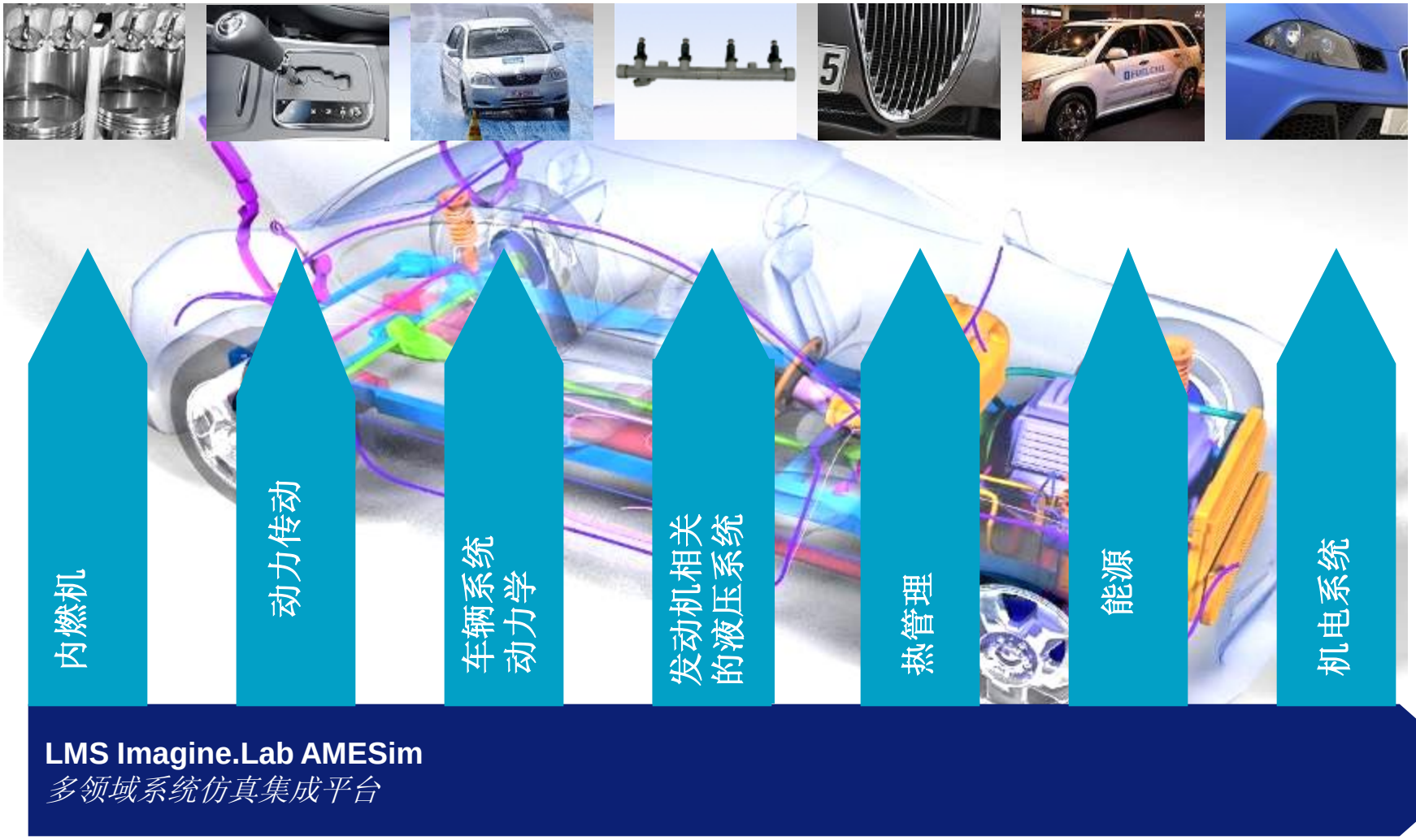


机电
机电转换器
元件 & 网络

LMS ENGINEERING INNOVATION

LMS Imagine.Lab AMESim

车辆方面的解决方案 - *1D 系统成型（System Mockup）*



LMS ENGINEERING INNOVATION

LMS Imagine.Lab AMESim

航空航天方面解决方案 - *1D 系统成型（System Mockup）*

飞行控制

地面负载

发动机装备

环境控制系统

火箭发动机

特种车辆

燃料电池

机电系统

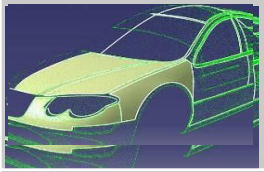
LMS Imagine.Lab AMESim

多领域系统仿真集成平台

LMS ENGINEERING INNOVATION

LMS, a unique Portfolio of Engineering Innovation Solutions Platforms, Mission Critical Applications and Best Practices

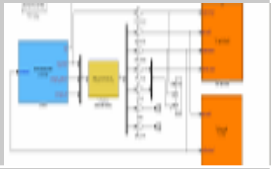
Design - CAD



LMS Virtual.Lab
3D Performance Simulation

LMS Samtech
Structural Analysis

Controls

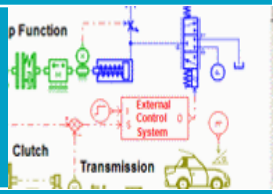


LMS Imagine.Lab – Mechatronic System Simulation

System Synthesis

SysDM
System Data Management

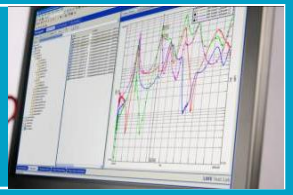
AMESim
Multi-physics Modeling

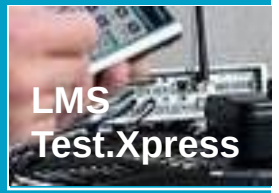


LMS Test.Lab – Test Based Engineering

Laboratory
Mobile

LMS SCADAS





Modal – NVH – Acoustics – Durability

Engineering & Deployment Services

Leading Partner in
Test & Mechatronic Simulation

LMS ENGINEERING INNOVATION

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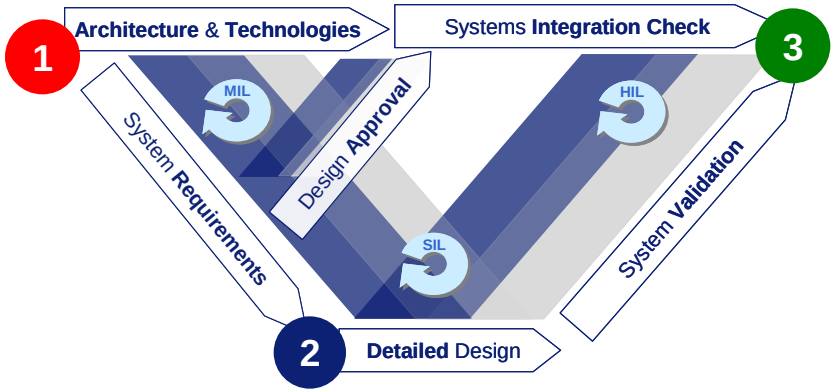
LMS and Samtech Solutions, deployed to achieve Breakthrough Innovation throughout the entire development cycle

Transformational Solutions



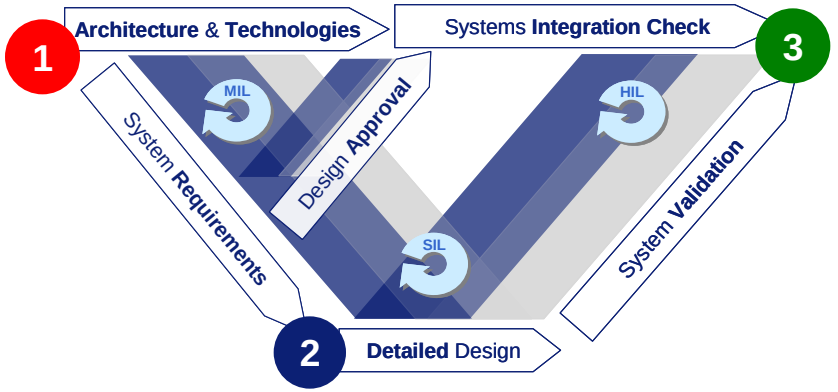
1 **Better & early choices / Early integration validation**
"System-Level Multi-Domain Engineering"

2 **Engineering Insight & Risk Mitigation**
"Scalable Physical Model Fidelity & Realism"

3 **Test & Validation Process improvement**
"Virtual Testing enabling improved Physical Testing"

LMS and Samtech Solutions, deployed to achieve Breakthrough Innovation throughout the entire development cycle

Transformational Solutions



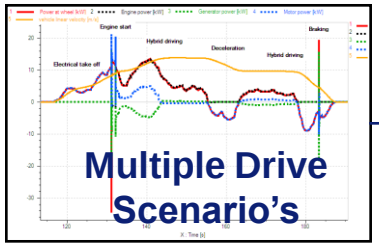
1 Better & early choices / Early integration validation
"System-Level Multi-Domain Engineering"

2 Engineering Insight & Risk Mitigation
"Scalable Physical Model Fidelity & Realism"

3 Test & Validation Process improvement
"Virtual Testing enabling improved Physical Testing"

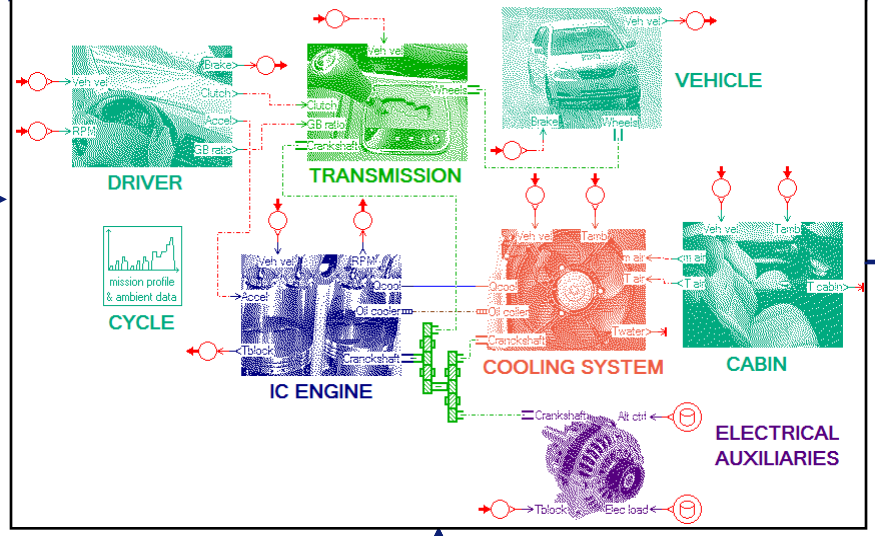
Concept Phase – Vehicle Energy Management
Optimization of hybrid vehicle architecture for fuel economy

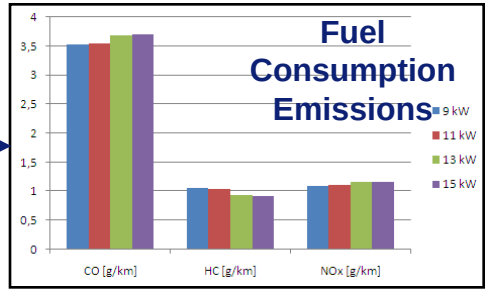
Example

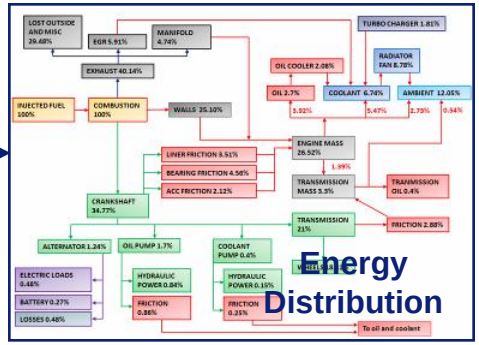


Tip-in, Tip-out
Gearshift, WOT, Stop & Start
Incidental maneuver
Std & Realistic cycle
…

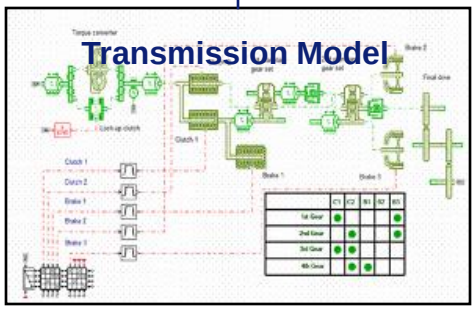
Vehicle Architecture – Synthesis & Analysis

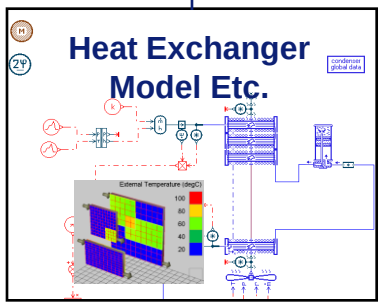


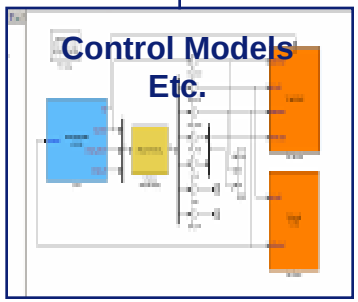




Sub-Systems Models







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LMS Imagine.Lab Selected to support Integrated Vehicle Energy Technology (INVENT)

"We've defined the **concept of the energy-optimized aircraft**, which **steps above more-electric systems and sets goals at the vehicle level**."

Steve Iden, INVENT Program Manager

Aviation Week, Oct 27, 2008; Aviation Week, Jul 12, 2010

Scope

Implement system engineering solutions for energy-optimized design of Vehicle & Systems

Expectations

1. Energy optimized aircraft to have **50% increased range**
2. System engineering to deliververy significant **schedule compression – up to 5x**

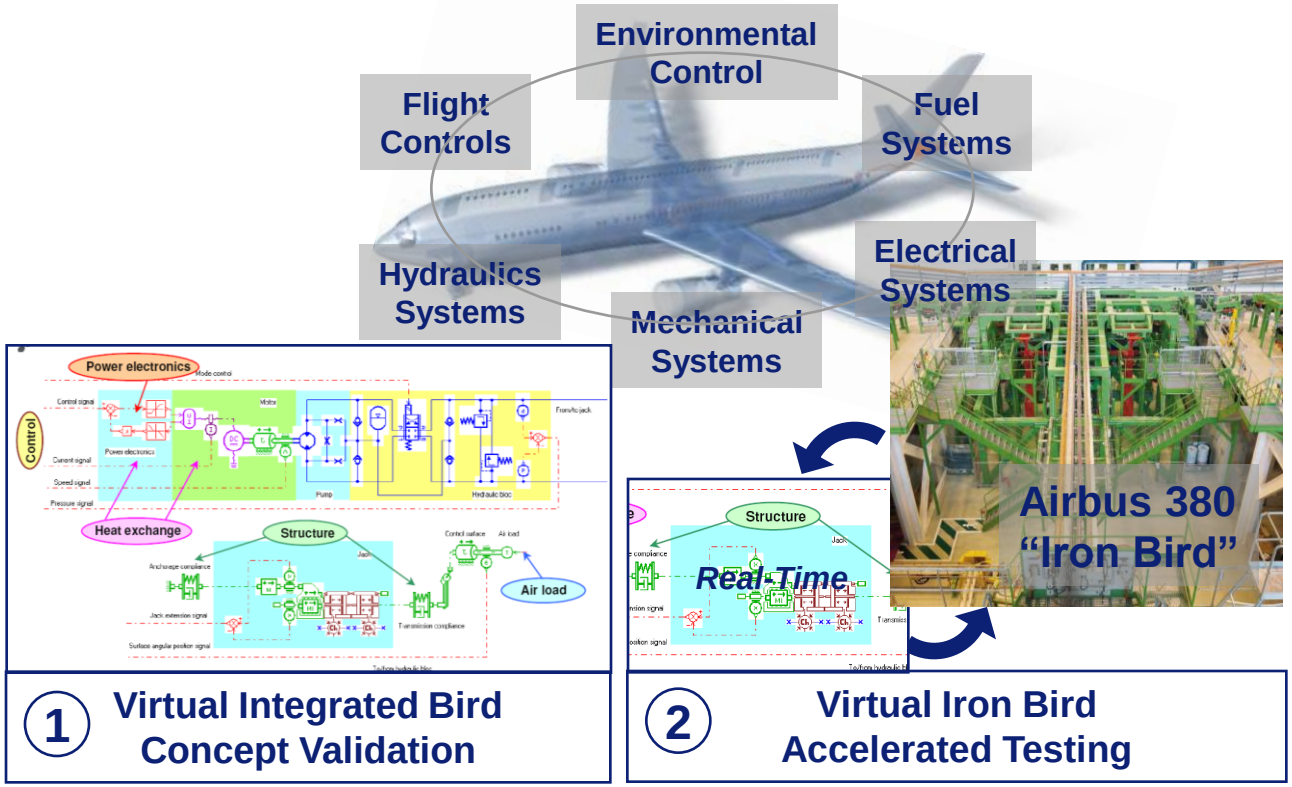
After extensive evaluation of solutions, LMS Imagine.Lab was selected to support the US Air Force INVENT Program

"We are excited about going forward with LMS, PCKA, Boeing, and the growing numbers of INVENT contractors"
Peter Lamm, AFRL

Concept Phase
Virtual Integration for Aircraft Systems Engineering

Example

Frontloading Integrated Aircraft Systems Simulation to Achieve Early Maturity in Aircraft System Concepts



① Virtual Integrated Bird Concept Validation

② Virtual Iron Bird Accelerated Testing

CLEANSKY

CRESCENDO

AIRBUS

60 M€ - 2010-2013

- 10% reduction of development lifecycle time/cost
- 50% reduction in rework
- 20% cost reduction of physical tests

LMS ENGINEERING INNOVATION

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Aircraft Power Systems
HYDR system Network modeling

A/C Power Systems

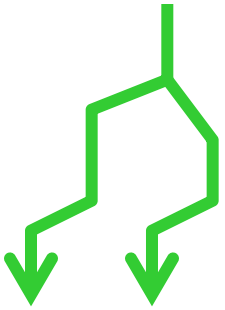
HYD A Green

Component, Subsystem Modeling – "Authoring"

Power Generation

LEP1 **REP2**

Power Network



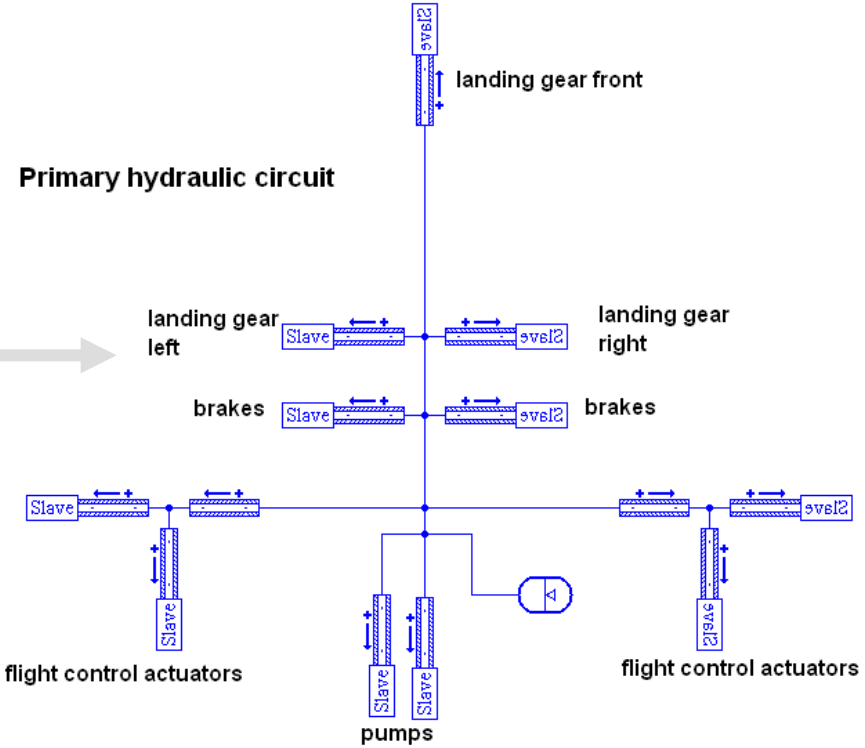
Power Consumption

ELEV

Brake

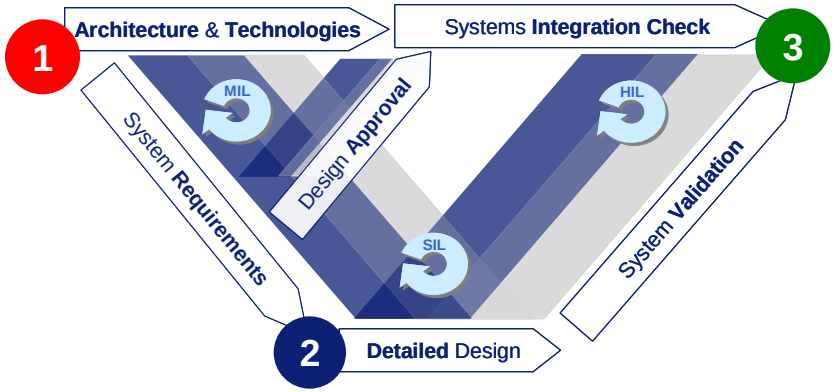
Rudder

LG



LMS and Samtech Solutions, deployed to achieve Breakthrough Innovation throughout the entire development cycle

Transformational Solutions



1 **Better & early choices / Early integration validation**
"System-Level Multi-Domain Engineering"

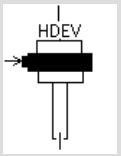
2 **Engineering Insight & Risk Mitigation**
"Scalable Physical Model Fidelity & Realism"

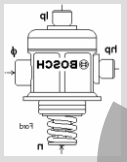
3 **Test & Validation Process improvement**
"Virtual Testing enabling improved Physical Testing"

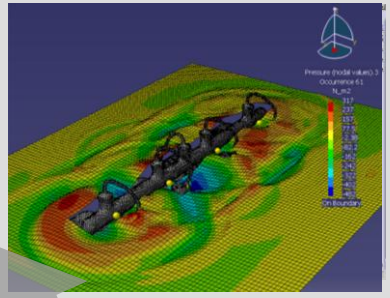
Development Phase - Realistic system simulation
Enabled by combining 1D and 3D simulation technologies

Example

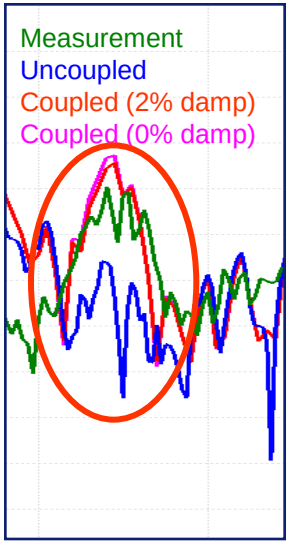
Example: optimize high frequency impulsive noise (Direct Injection) in high efficient Internal Combustion Engine (ICE)

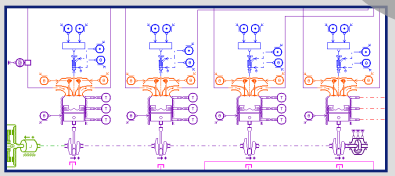




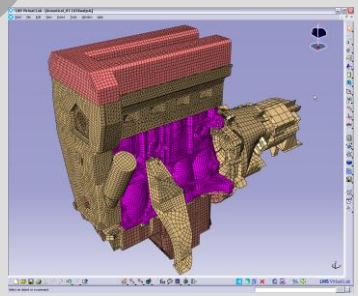


Vibro-Acoustic Model





1D Model
Injection System



Structural FE Model

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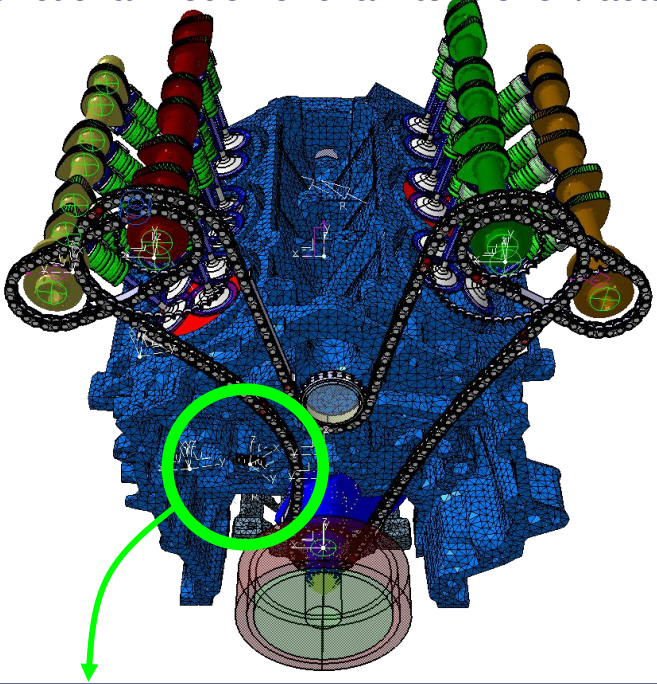
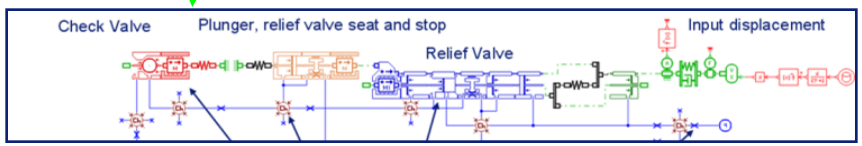
Development Phase - Realistic system simulation
Enabled by combining 1D and 3D simulation technologies

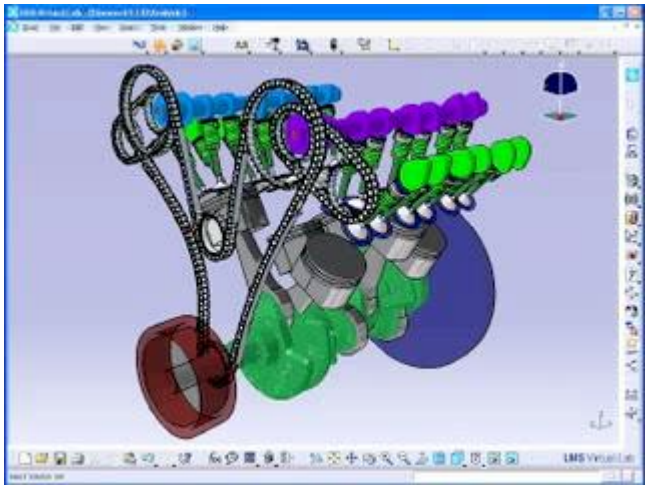
Example

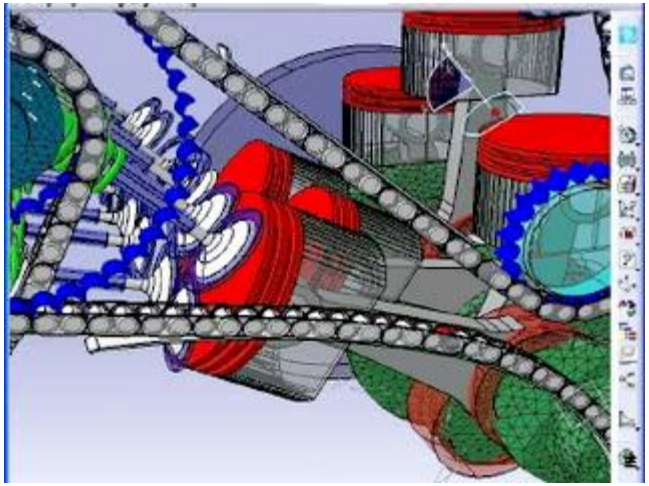
Example: Simulation of chain whine

1. Fully coupled 3D mechanical model
   Upper& Lower Engine - MBD – FEM
2. Coupled 1D – 3D simulation with
   functional model for chain tensioner / actuator









Source: "Utilization of CAE/Hybrid methods as an enabler of up-front design optimization"
Takeshi Abe, FORD
2007 LMS Conference on Virtual and Physical Prototyping

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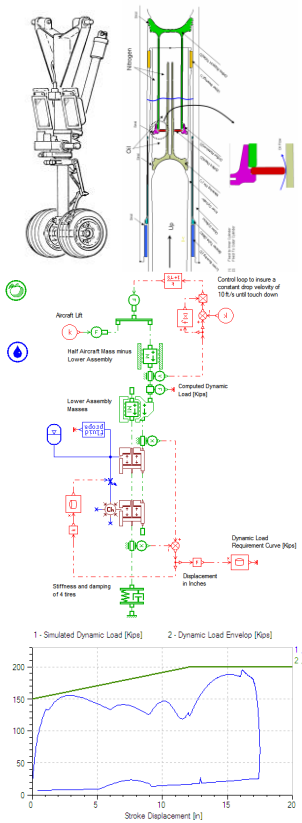
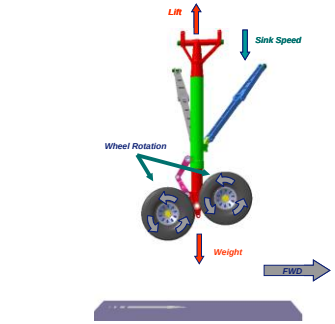
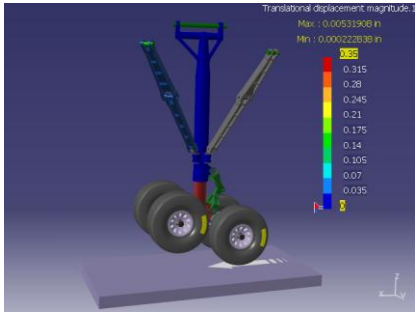
Engineering Mission Critical Systems with Scalable Multi-Physics Simulation & Testing Technology



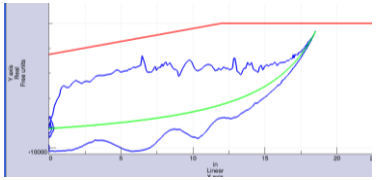
Increasing Model Details



Increasing Model Details



Increasing Model Details



Increasing Model Details

1D Simulation

Oleo-Pneumatic Damper

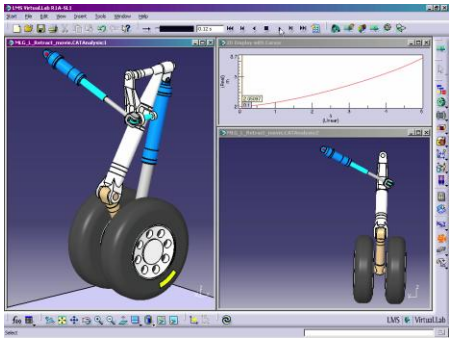
Double Chamber
Orifice Sizing & Optim.
Tire

3D Simulation

Detailed Landing Gear

Detailed Geometry – incl. Flexibility
Detailed Non-linear Behaviour
Tire Models

Aircraft Ground Loads & Handling



Landing Failure Mode Analysis

Landing Gear Dynamics Test

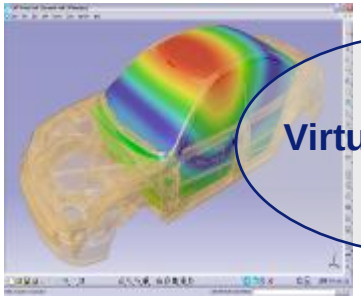
Improving “realism” and “productivity” for system simulation Based on combined use of Test and Simulation

Example

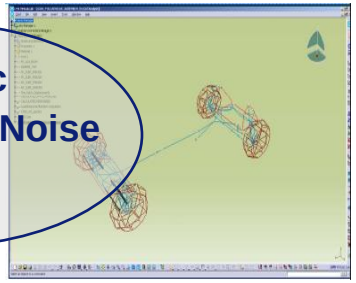
Realistic Simulation

Example: Test Based Tire Model for Road Noise Simulation

Test Based Virtual Tire



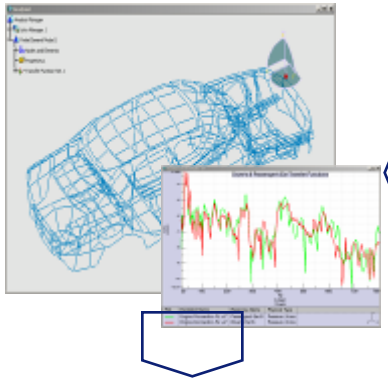
Realistic Virtual Road Noise Model



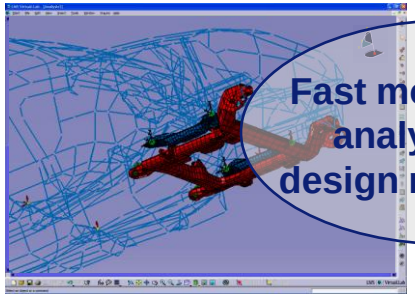
Vehicle Dynamics Model for Road Noise

Accelerated Simulation

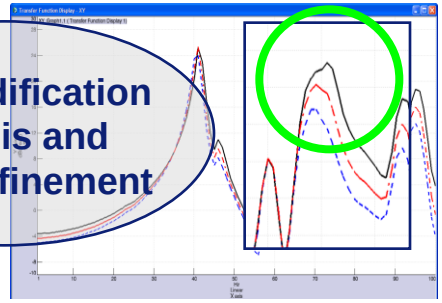
Example: Test Based Trimmed Body Model



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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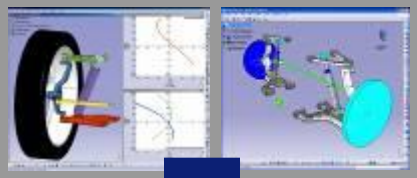
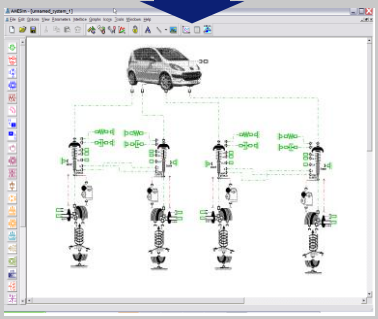
LMS Virtual.Lab Motion - Scalable system simulation
Enables by combining 1D and 3D simulation technologies

Example: Vehicle Dynamics

Component – Subsystem Models





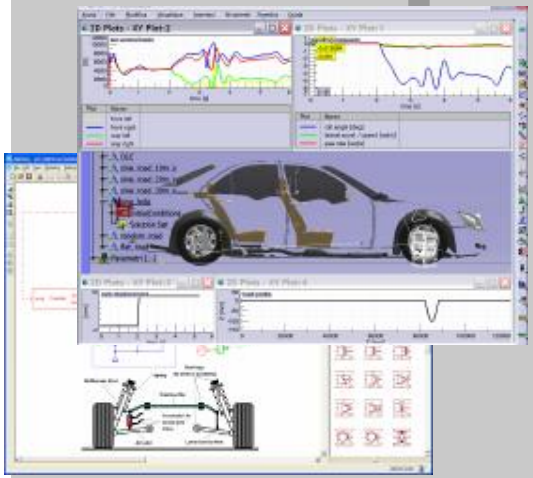
Ride & Handling

1D Simulation
Chassis Concept

Suspension type
Hard points
Bushing, damper settings

Increasing Design Details

Component – Subsystem Refinement

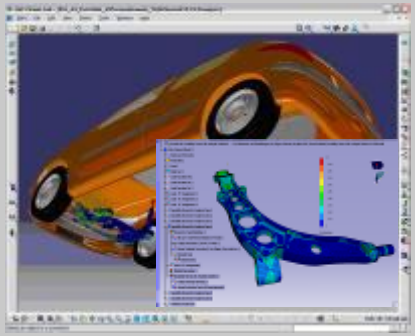


Ride & Handling - Comfort

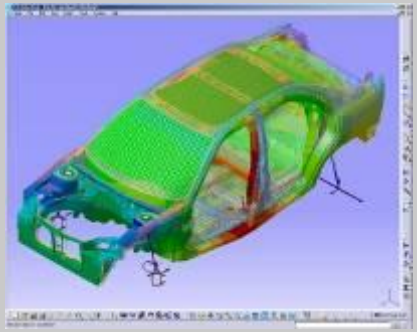
3D Simulation
Chassis Detail – Body Concept

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

Increasing Design Details



Loads for component durability analysis



Road Noise

"A New Library for Vehicle Dynamics Functional Simulation"
B. Parmentier (PSA Peugeot-Citroen) & M. Alirand (LMS)
Vehicle Dynamics Expo 2008 NA

PSA PEUGEOT CITROËN

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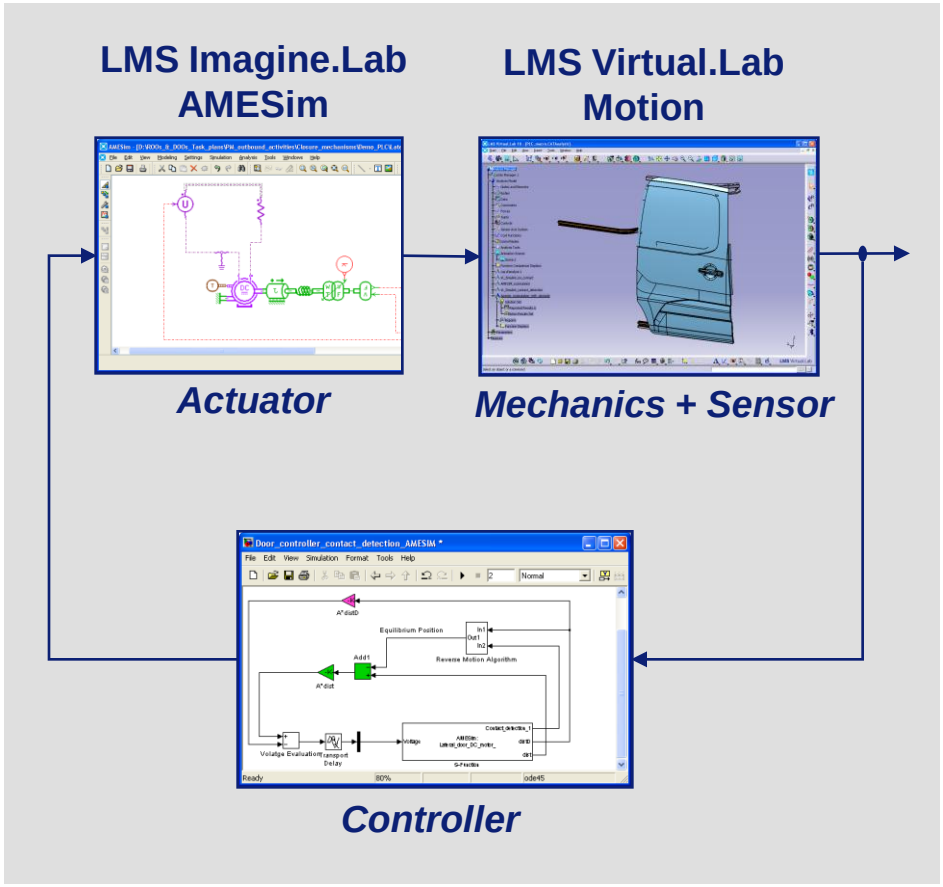
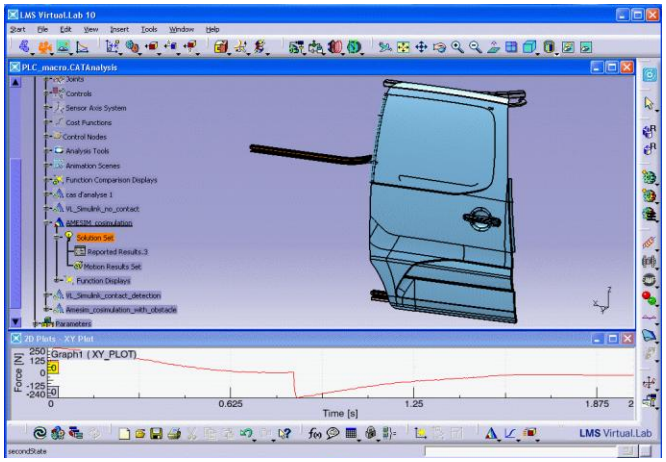
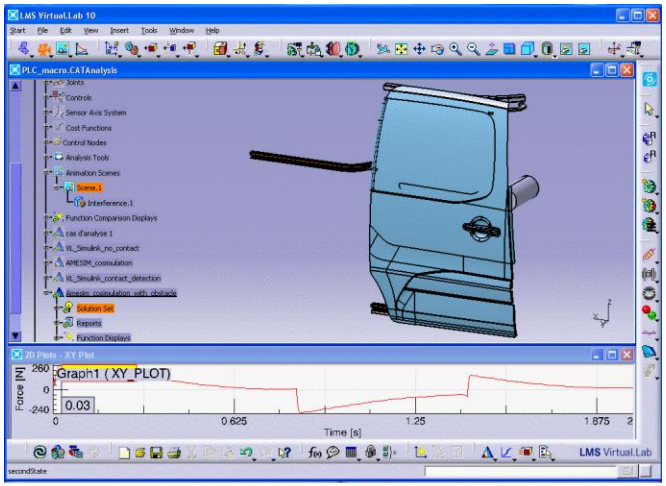
LMS Virtual.Lab Motion
Supporting “System Approach” for Mechatronics





Normal Operation



Obstacle Detection

Mechatronic optimization of controller functions for different operating modes

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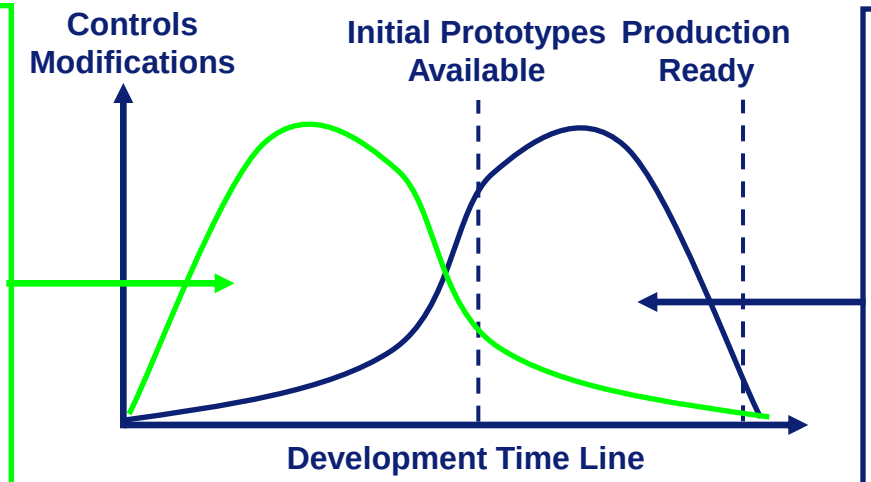
Accelerating Controls Engineering enabled by Model Based System Engineering

Example

Model Driven

- Frontloading controls development
- Mechanical – Controls System optimization

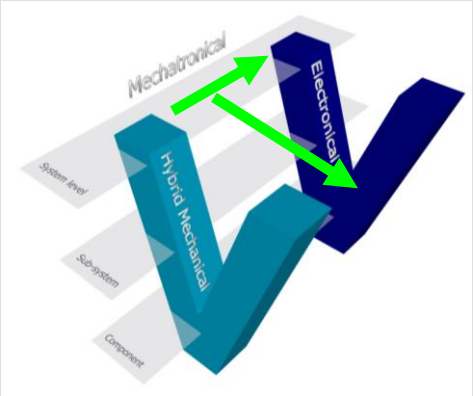


Towards Model Driven Controls Engineering

Prototype Driven

"Rapid Prototyping"

- +50% control modifications after prototypes available
- System optimization driven by control calibration



- **Representative "plant" models for controlled systems**
  - ***Scalable in precision*** – function of design stage
  - ***Off-line to Real-Time*** – to support ***MIL-SIL-HIL***
- **Interconnected "mechanical" and "controls" engineering**
  - ***Collaborative*** 1D (MIL-SIL-HIL) ***system management***

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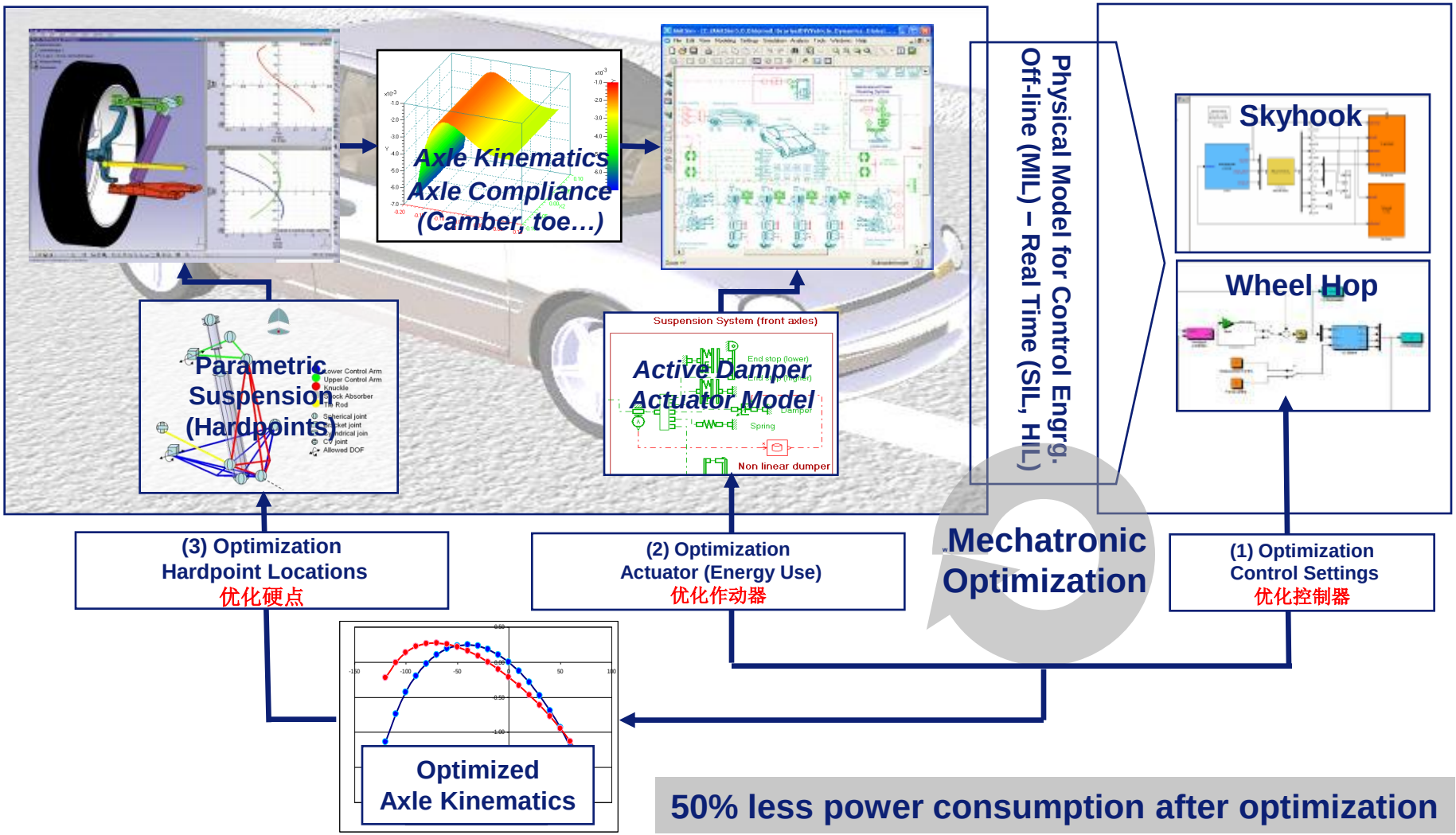
Model Based System Engineering for Mechatronic System Optimization

Example

Example: Joint performance and energy optimization in active suspension



50% less power consumption after optimization

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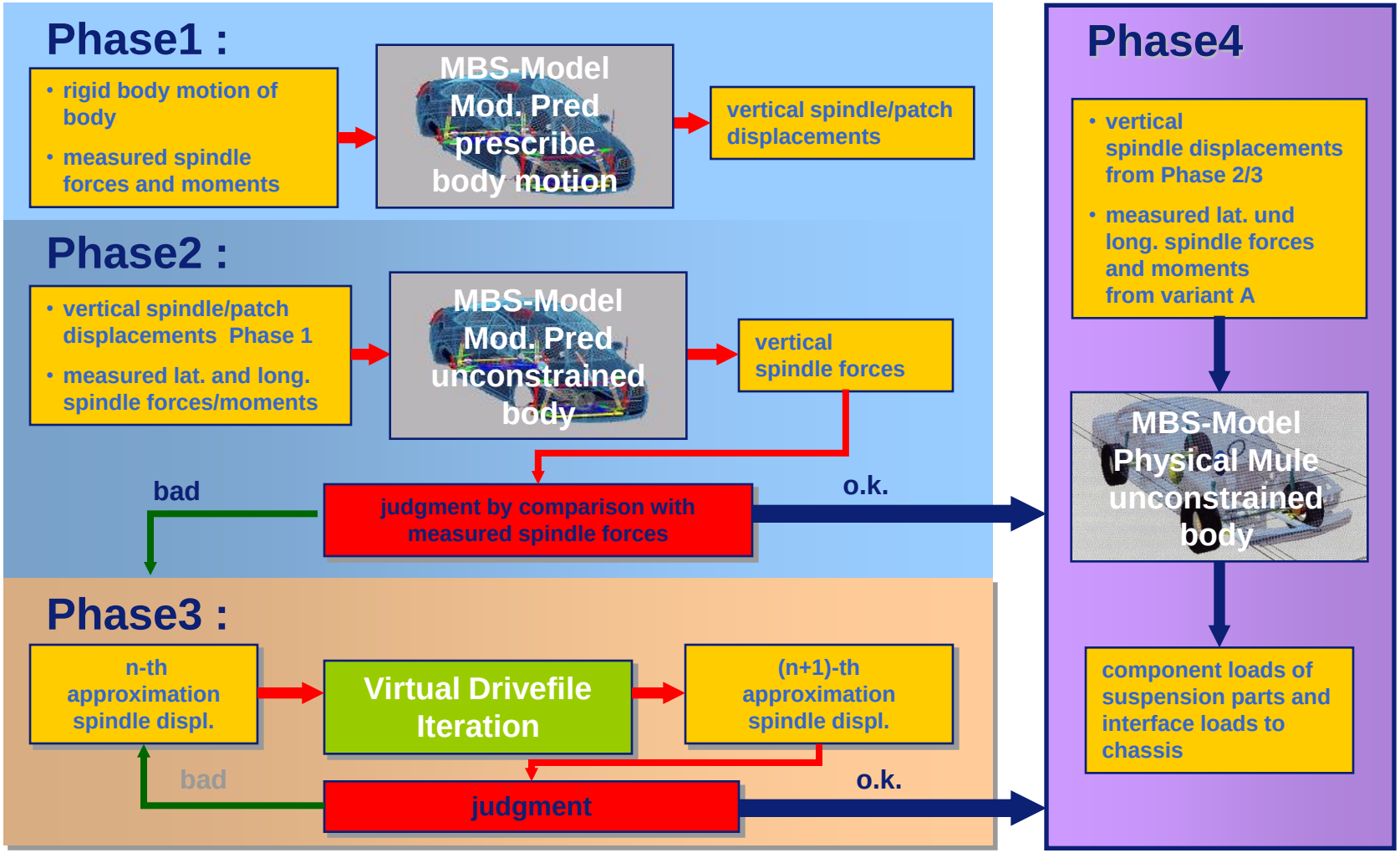
虚拟混合路面的详细流程



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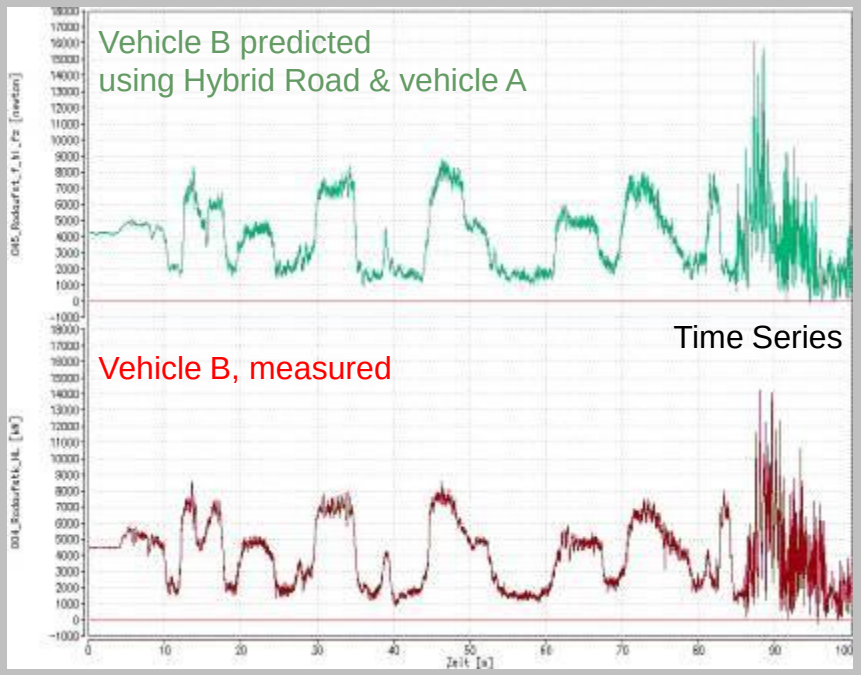
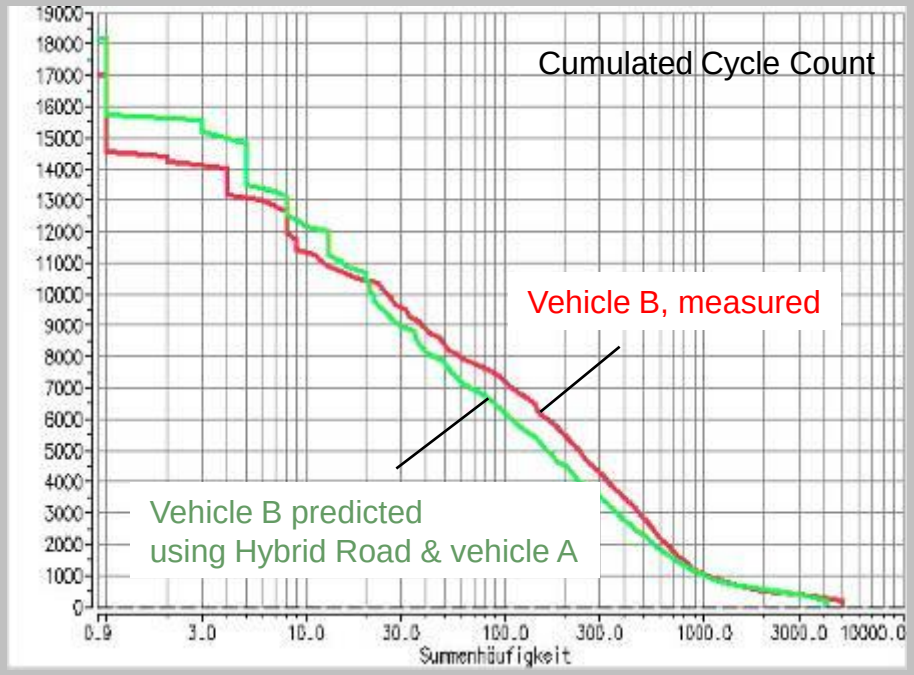
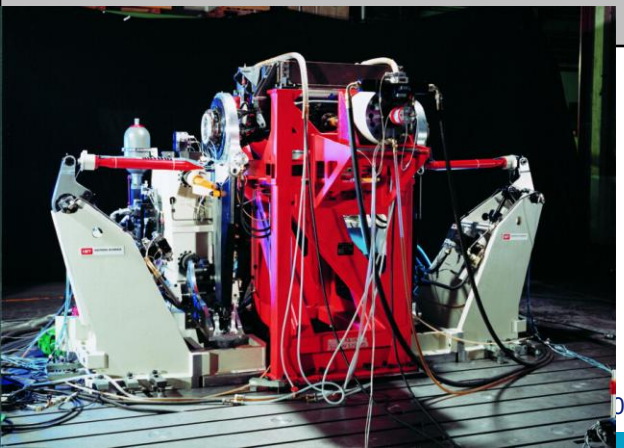
BMW项目结果

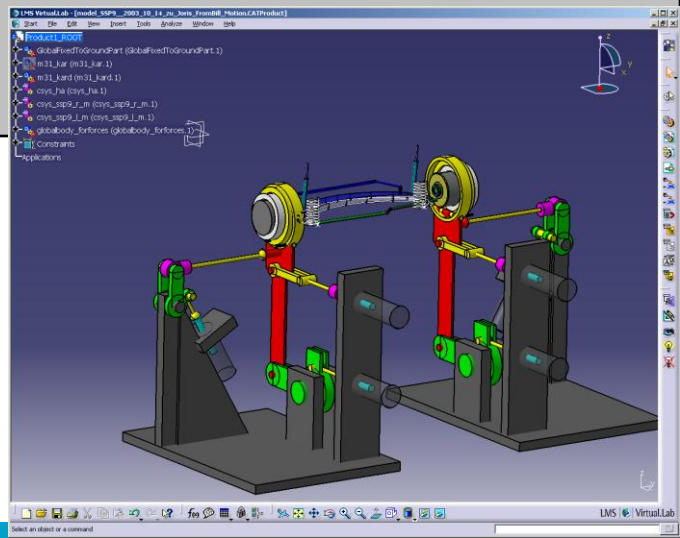




Spindle Force



Source: SAE paper 2005,



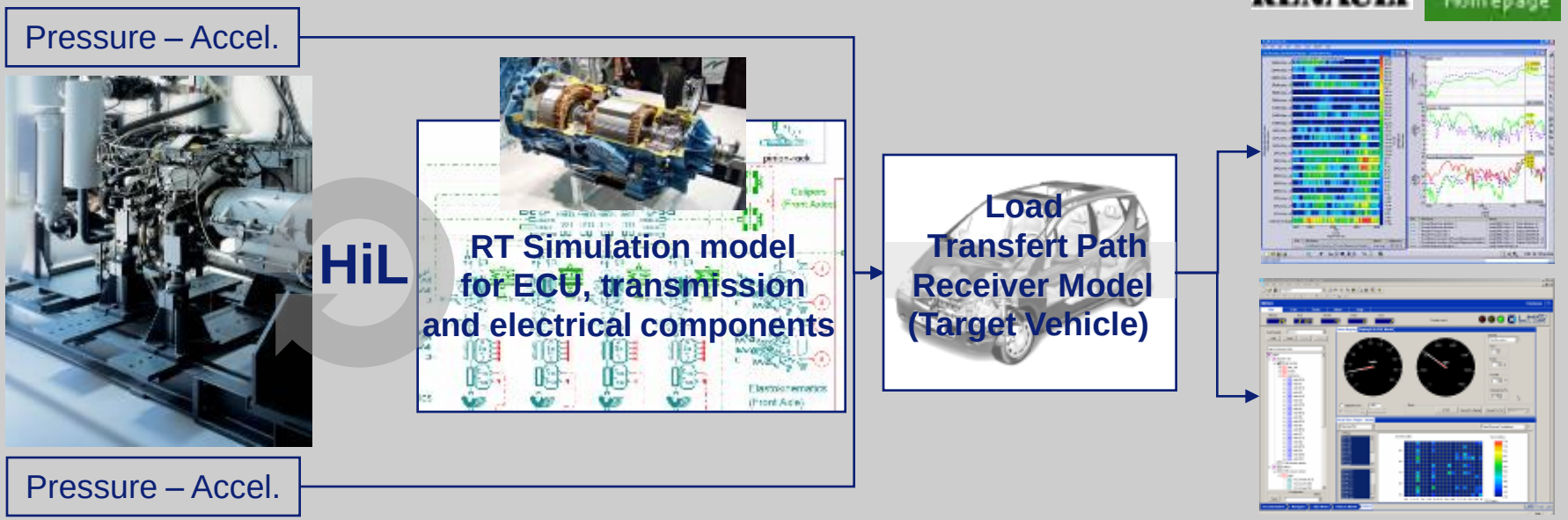
Model Based System Engineering to frontloading physical testing and validation

Example

- 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: Hybrid Powertrain Development

Testing and calibration of ICE to be used in hybrid powertrain



Simulation is key to enable frontloading of testing and validation

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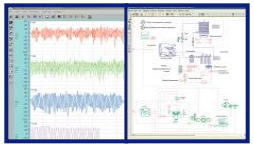
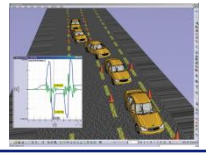
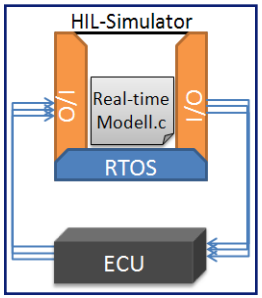
Virtual.Lab Motion Real-Time

“Multi-physics” models
Mechanics, Electrics, Hydraulics…





HIL Testing



“Controls” models, hardware
Electrical, Electronics, Software…

- ✓ **More realistic SIL / HIL testing**
  - by using 150-DOF multi-body models,
  - without model simplification,
  - valid until 20 Hz,
  - with industry-proven, robust and accurate solver
- ✓ **Re-use existing MBS models**
- ✓ **Optimize the complete mechatronic system**

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OPAL-RT

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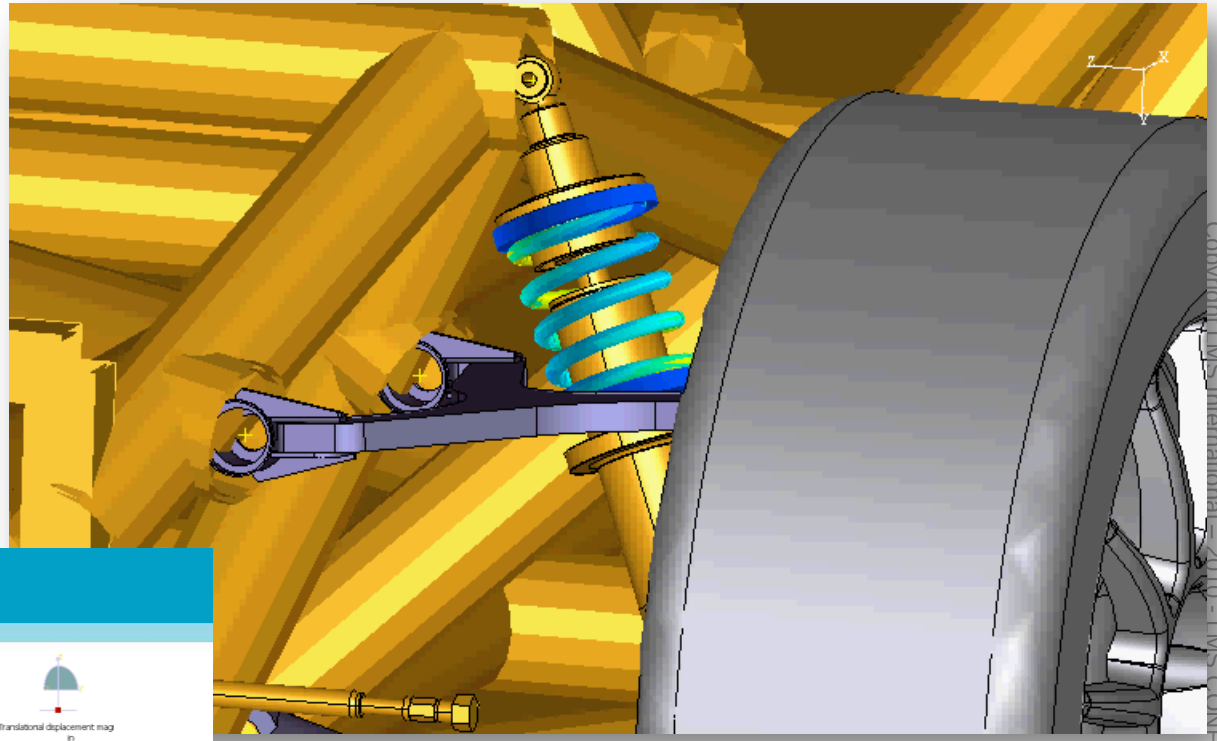
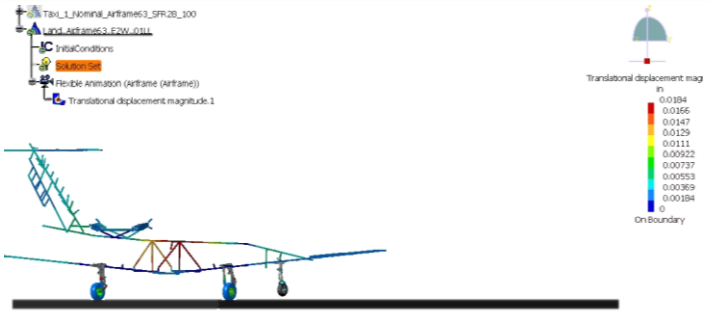
Virtual.Lab Motion – SAMCEF MECANO
Example: Vehicle Dynamics with Local Non-Linearities

Rev 11



Cessna GUI for Landing & Taxi Analysis



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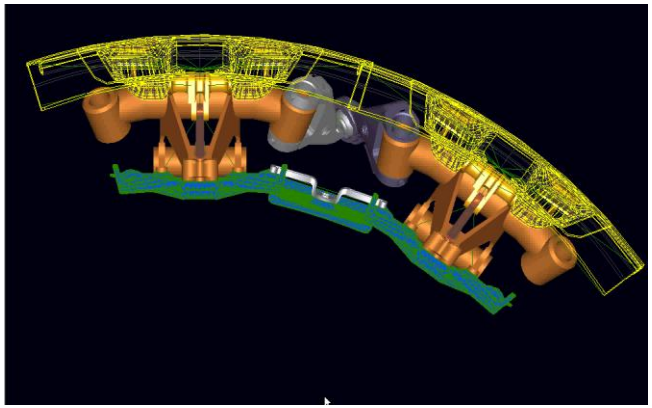
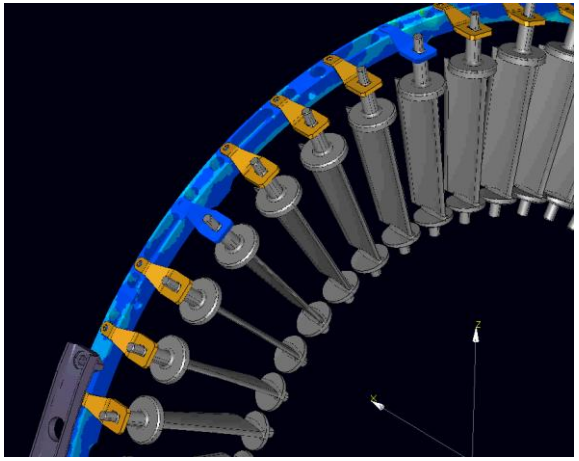
Advancing Simulation Realism & Physical Model Fidelity to Gain Precise Insight in Complex Aircraft Performances

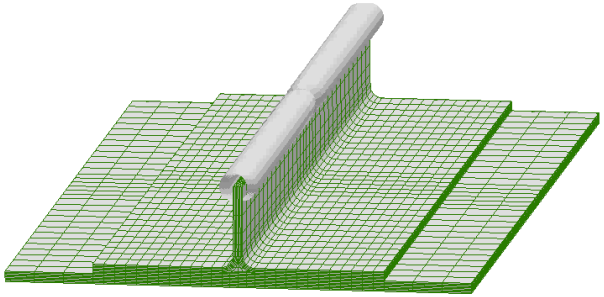
SAMTECH

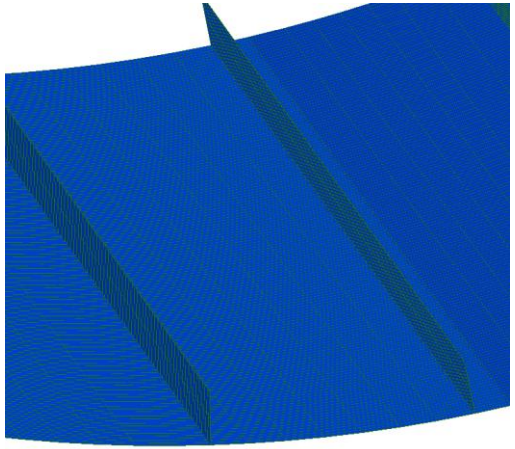
3D Mechanism Simulation
with Highly non-linear effects
Thermal – Material - ...





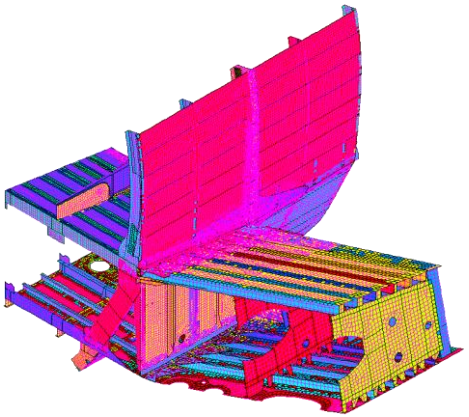
Advanced non-linear analysis
(post-buckling, composite delamination…)

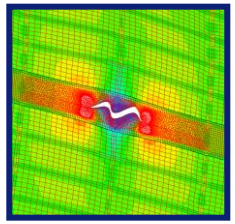


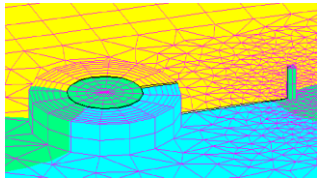


Virtual Testing

Fatigue & damage prediction by simulation







Advancing Simulation Realism & Physical Model Fidelity to Gain Precise Insights in Complex Space Systems

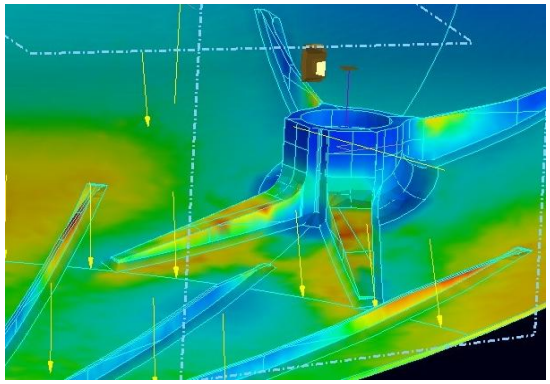
SAMTECH

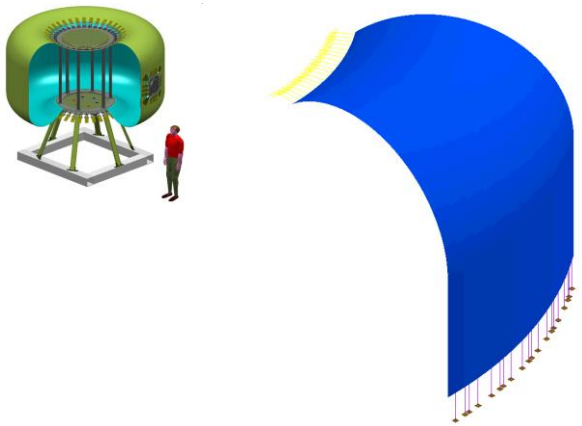
Structural analysis
with Highly non-linear effects
Thermal – Material - ...

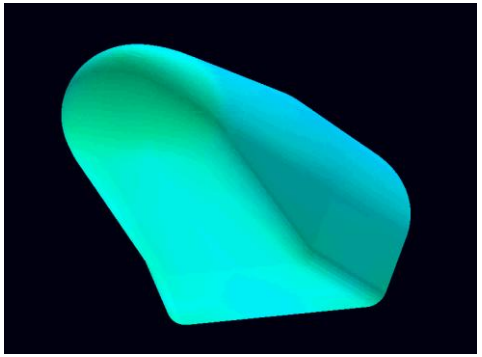
Complex Systems
Mechanisms & Inflatable structures, ...

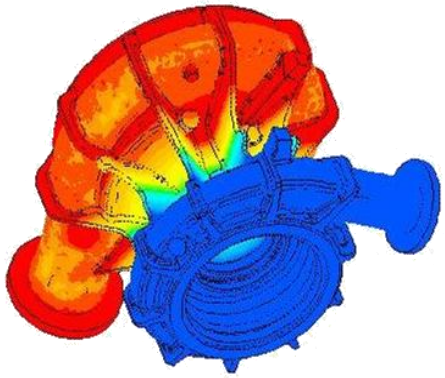
Thermal

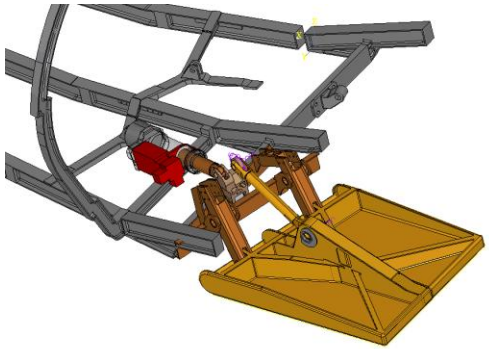
Thermal – Structural analysis, ablation.…

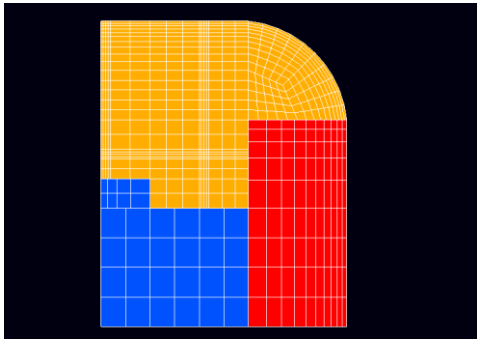




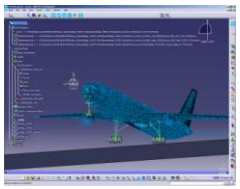






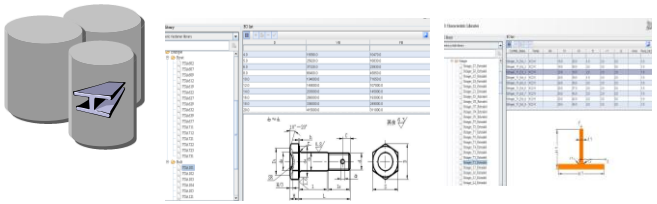


Advancing Process Efficiency with Unified & Integrated Analysis Platform

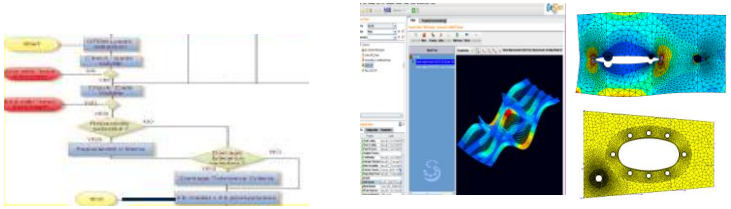


NASTRAN
CATIA
...

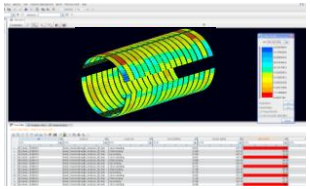
Links to CAD / FEM / Loads …



Materials / Fasteners / Profiles Data Base



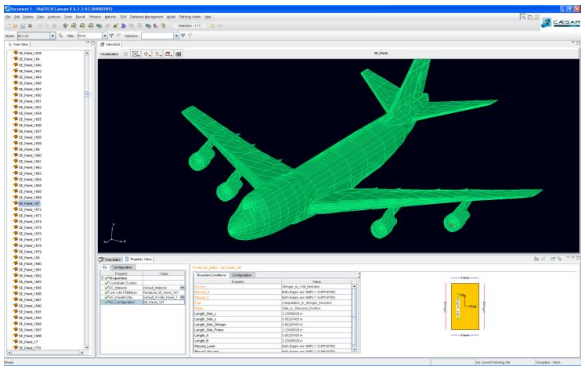
Analysis Process, methods (metallic/composite)



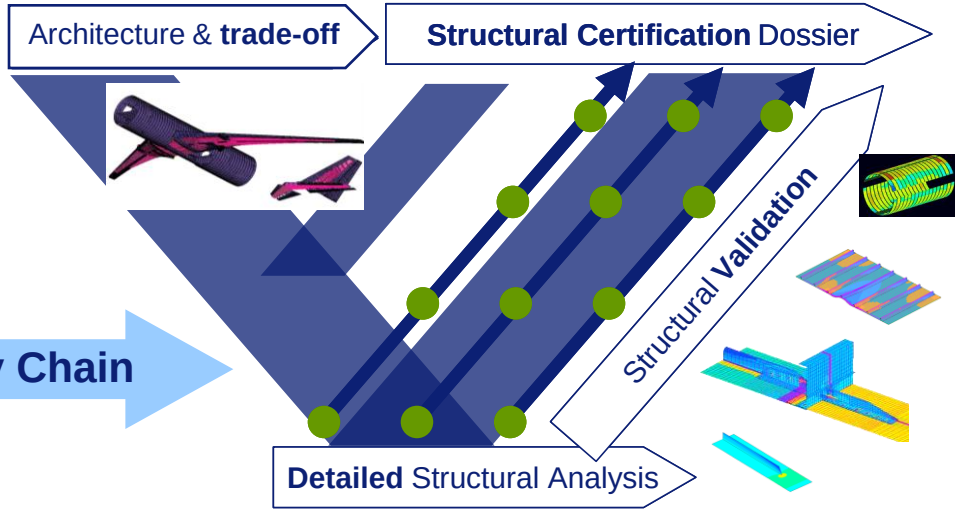
Stress analysis -RF/margin

CAESAM - Analysis & Process Platform

Integration platform for Aircraft Structural Certification File



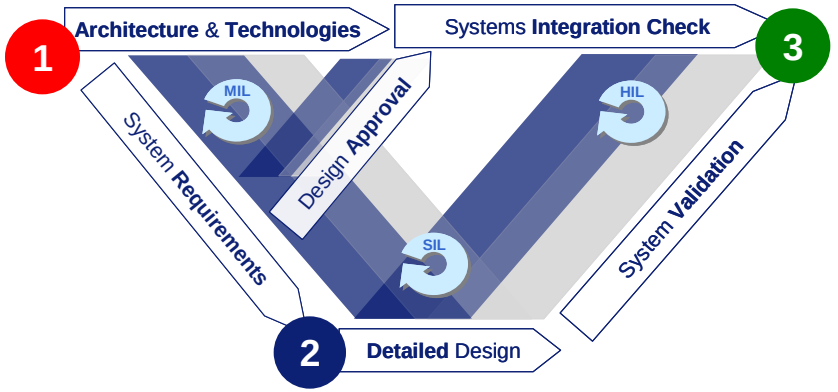
Deployed on Airbus A350 Program



Supply Chain

LMS and Samtech Solutions, deployed to achieve Breakthrough Innovation throughout the entire development cycle

Transformational Solutions



1 **Better & early choices / Early integration validation**
"System-Level Multi-Domain Engineering"

2 **Engineering Insight & Risk Mitigation**
"Scalable Physical Model Fidelity & Realism"

3 **Test & Validation Process improvement**
"Virtual Testing enabling improved Physical Testing"

LMS Solutions for Aircraft System Engineering
Virtual & Physical Ground Vibration Testing (GVT)

Feasibility → Concept → Definition → Development → Test & validation → In service

First Flight | Certification

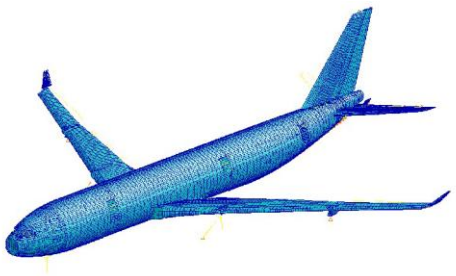
Ground Vibration Testing Campaign

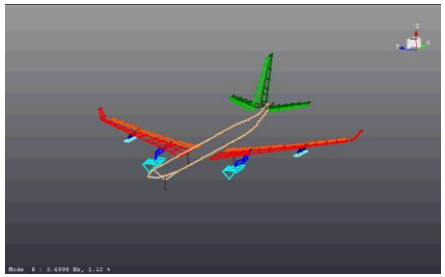
1 Virtual Ground Vibration Test

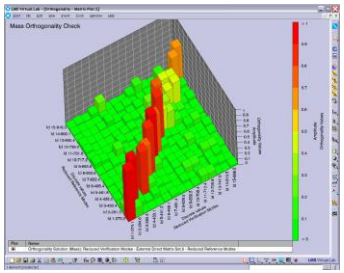
2 Physical prototype available Ground Vibration Test (GVT)

3 Engineering Insights

Pre-Test & De-Risking → Prepare Instrumentation → Instrument Aircraft Validate Set-up → **Ground Vibration Test** Identify Modes & Validate Modes → Correlate Model GO/NO GO First Flight → Update Refine Models

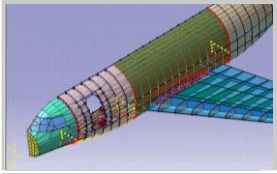






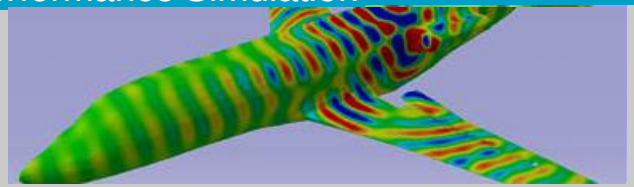
LMS, a unique Portfolio of Engineering Innovation Solutions, Platforms, Mission Critical Applications and Best Practices

Design - CAD

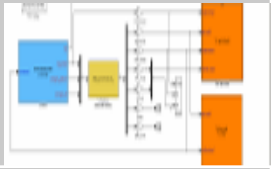


LMS Virtual.Lab
3D Performance Simulation

LMS Samtech
3D Structural Analysis



Controls

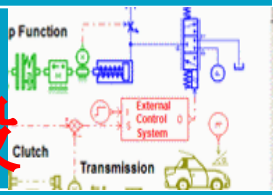


LMS Imagine.Lab – Mechatronic System Simulation

System Synthesis

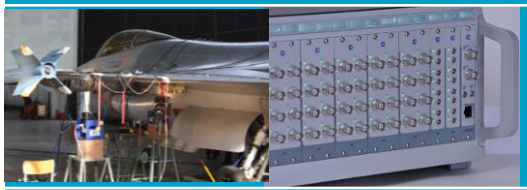
System Data Management

Multi-physics Modeling



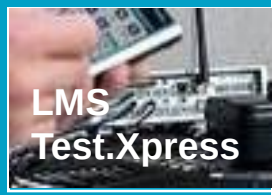
4个平台，涵盖设计各个阶段

LMS Test.Lab – Test Based Engineering



Laboratory
Mobile

LMS SCADAS



Modal – NVH – Acoustics – Durability

Engineering & Deployment Services

谢谢!

LMS®
ENGINEERING INNOVATION