SIMULIA for the Automotive Industry

September 2011

Outline

- Introduction
- Products
- Automotive Applications

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SIMULIA - The Dassault Systemes brand dedicated to making…

Realistic Simulation
an integral
business practice
to Explore,
Discover,
Understand,
Improve

product, life, & nature

Explore

Discover

Understand

Improve

# …to **Reduce** Physical Testing, and **Save** significant **Time** and **Money**

Courtesy Mechanical Design and Analysis Corporation, 2010 SCC

Global Presence – Local Support

- Brand headquarters in Providence, RI
  - 300+ in RI, 800+ Worldwide
  - 30+ Centers for Simulation Excellence
  - Expansion through Dassault Systèmes Offices and Channels
- Strong focus on R&D
  - 7 R&D labs
- Dedicated to:
  - High-quality products and support
  - Innovative technology
  - Customer satisfaction

Providence
Velizy
Cincinnati
Fremont
Cary
Chennai
Santa Monica
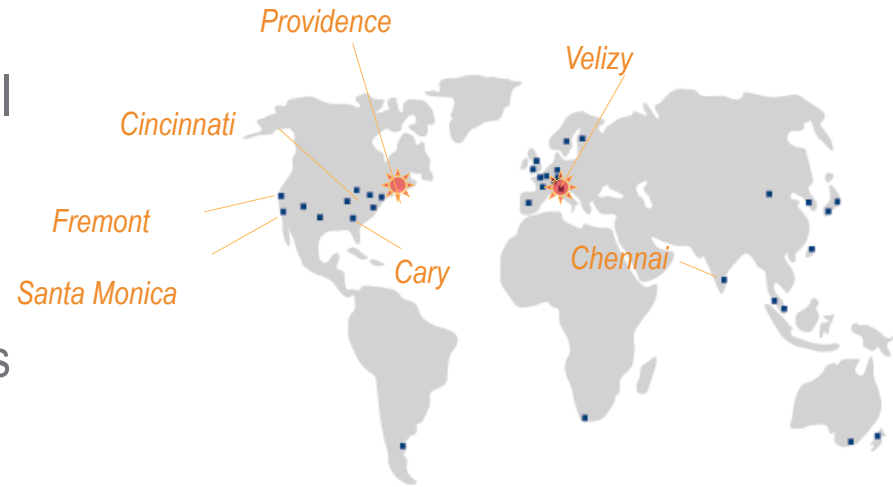
Global Presence – Local Support

Dedicated support staff in Plymouth, MI

- Local sales and support office
  - Dedicated Support Staff
  - Dedicated Consulting Staff (for overflow work and methods development)
  - Regionally-located strategy and operations staff focused on automotive & transportation

- Support is part of the licensing
  - On-line support and help
  - Live telephone support with local staff
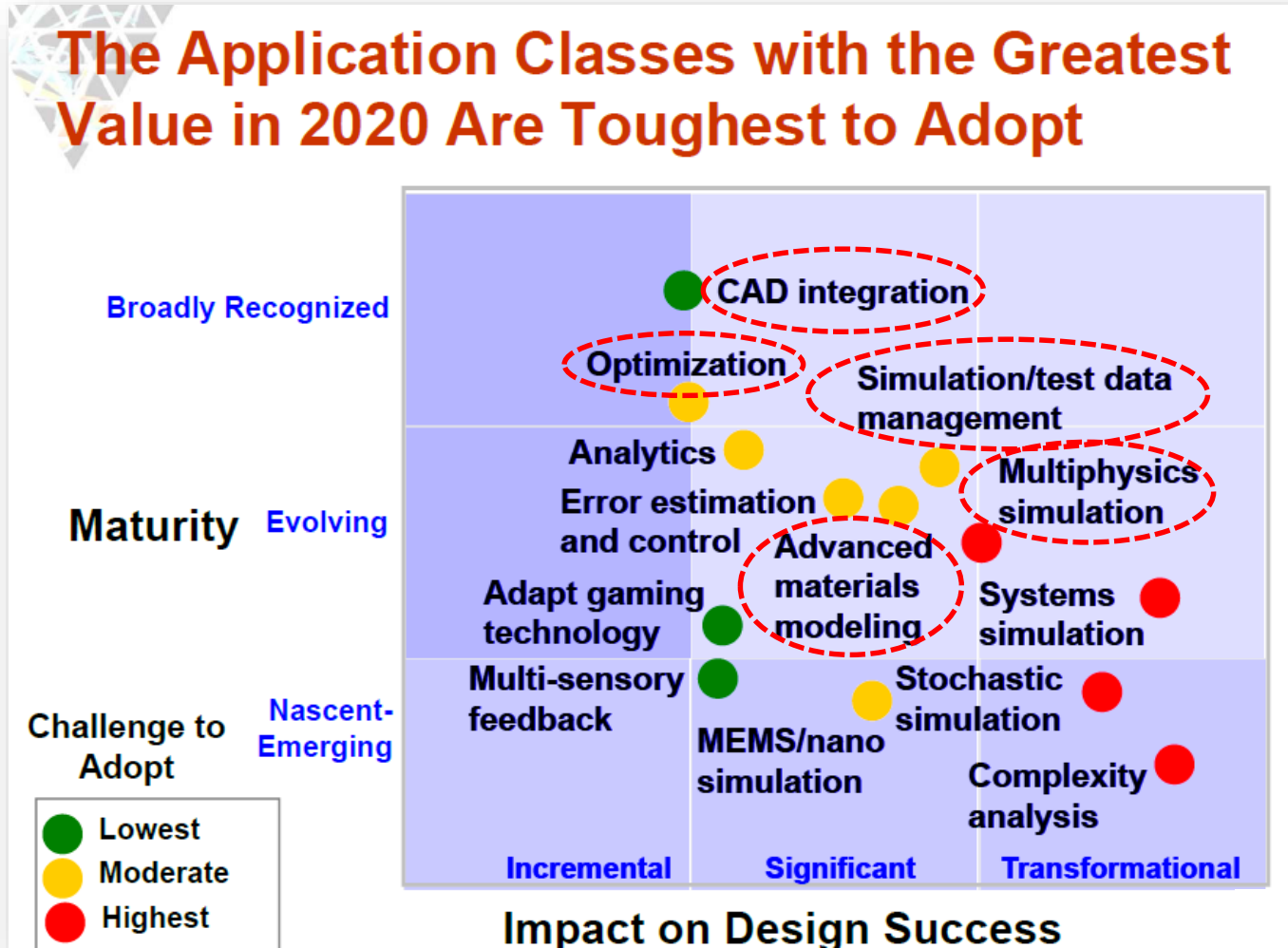   - Extensive automotive and powertrain domain knowledge

Products

Gartner: Applications with Greatest Value

The Application Classes with the Greatest Value in 2020 Are Toughest to Adopt

Source: Gartner Group

DS SIMULIA
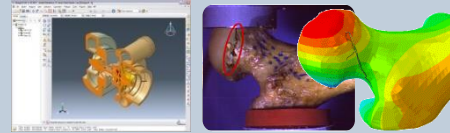
SIMULIA Product Portfolio

Abaqus Unified FEA
- Abaqus/CAE
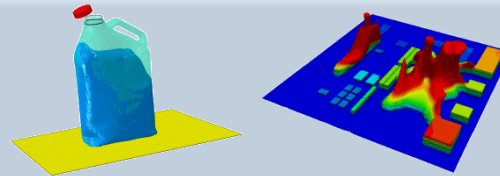- Abaqus Standard/Explicit
- Abaqus for CATIA V5

Continued technology leadership & innovation

Advanced Materials
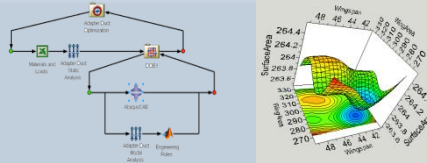
Multiphysics
- Fluids (CEL, CFD)
- FSI
- Co-simulation

More physics, open co-simulation

Multiphysics

Isight
- Design/Runtime Gateway
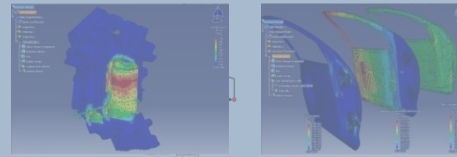- Application Components
- Process Drivers

Design exploration & optimization

Optimization

V5 Design Analysis
- Non-Linear Analysis
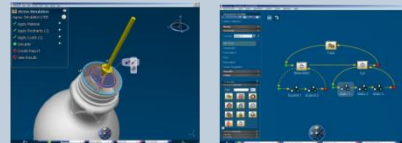- Thermal Analysis
- Advanced Meshing

Simulation for designers using V5

CAD Integration

SIMULIA V6
- DesignSight
- General Purpose Products
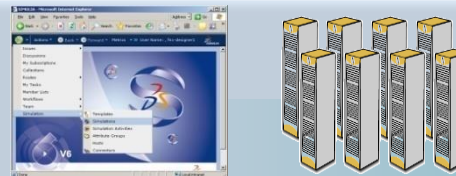- Open Scientific Platform

Next-gen tools for designers & Abaqus users

Simulation Management

SLM
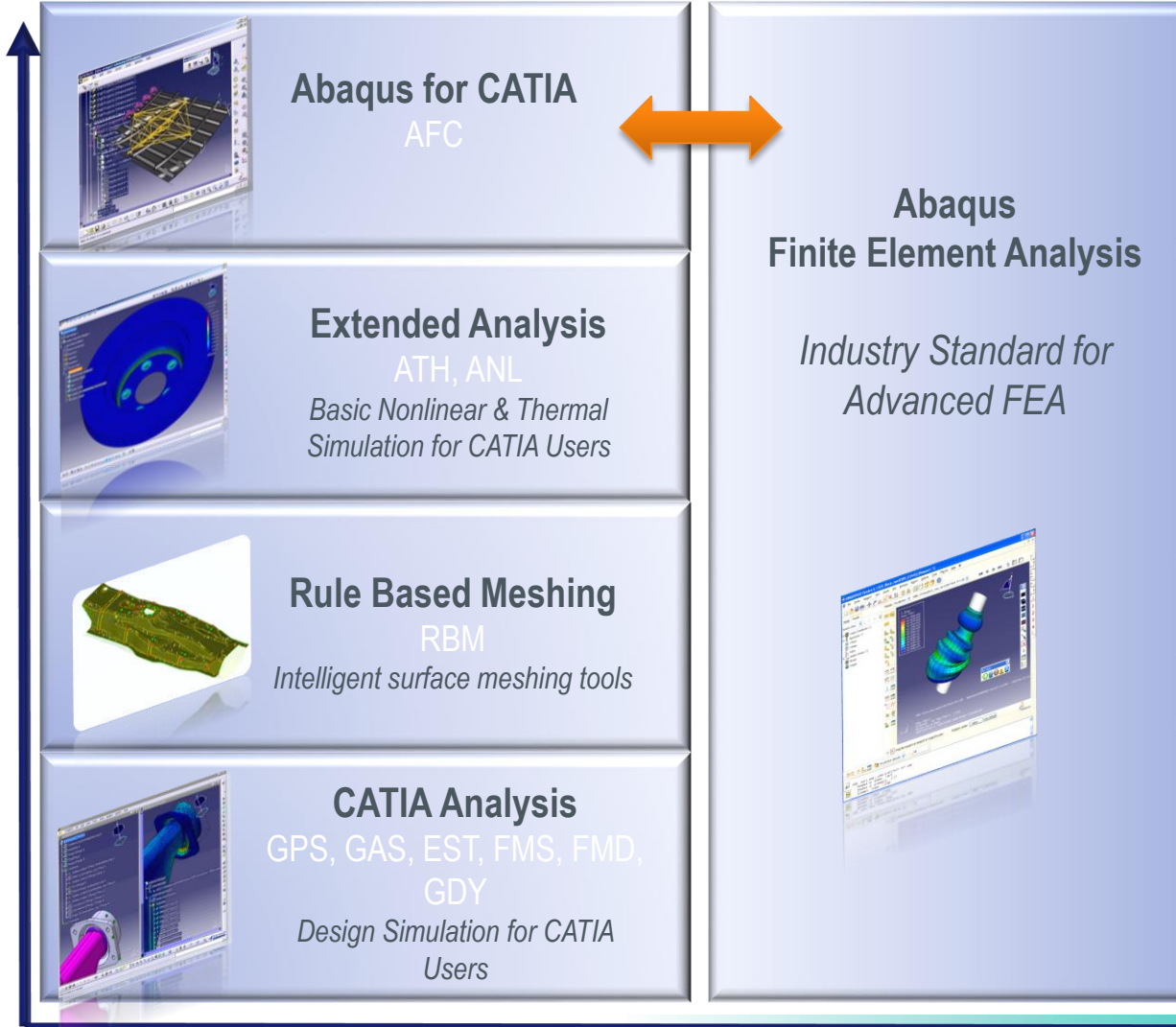- Scenario Definition
- Live Simulation Review
- Execution Engine

Manage simulation data, processes & IP

simuleon

DS SIMULIA

SIMULIA Product Portfolio: Unified FEA
Scalable solutions

Technology Sophistication (vertical axis)

Abaqus for CATIA
AFC

Extended Analysis
ATH, ANL
Basic Nonlinear & Thermal Simulation for CATIA Users

Rule Based Meshing
RBM
Intelligent surface meshing tools

CATIA Analysis
GPS, GAS, EST, FMS, FMD, GDY
Design Simulation for CATIA Users

**Abaqus
Finite Element Analysis**

Industry Standard for Advanced FEA

Designers   **Engineer**   **CAE Specialist**

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Isight: Automation & Optimization

- Create simulation process flows
- Execute multiple simulation studies automatically
- Distribute simulations across multiprocessor compute resources
- Evaluate multiple design options in one step
- Find the Best Design
  - Design-to-target for simulation attributes and quality
  - Manage variations in materials, loads and tolerances

Components

Isight
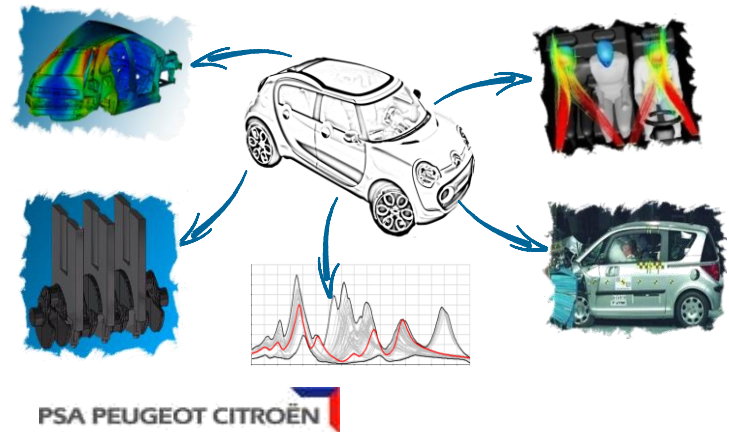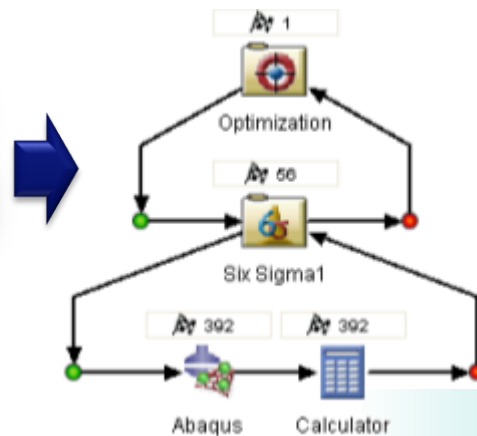
PSA PEUGEOT CITROËN

Automotive Applications

SIMULIA in Automotive

30-year history in the Automotive industry

Nonlinear FE Calculations: A Progressive Trend in the Automotive Industry.

E. Schelkle, Dr. Ing.
PORSCHE R&D Center
Porschestrasse

D-7251 Weissach. FRG

Abstract

The present article describes the application in automotive development and points out to the increasing need for nonlinear FE calculation. ABAQUS, which has been a General Purpose Program, is used for both linear and structural as well as temperature and acoustic calculations. This paper reports on Porsche's 7-year experience with ABAQUS and its use on the CRAY-2 supercomputer and gives some examples of practical use which reflect the wide range of possible applications of ABAQUS in automotive industry. The presentation ends with an outlook on future development and desirable extensions.

1988 ABAQUS Users Conference

- **SIMULIA presence at large majority of Automotive OEMs and suppliers**
  - Automotive represents largest SIMULIA industry segment

- **Extensive functionality to address wide range of structural workflows**
  - Nonlinearity (Materials, Contact, Large Deformations,…)
  - Linear, Advanced Linear; High Performance
  - Accuracy, Quality

- **Strong technical support and customer relationships**
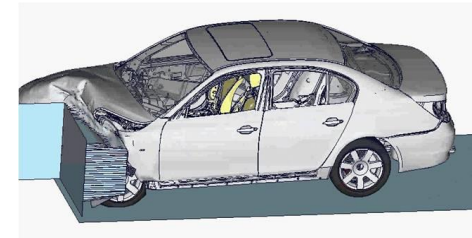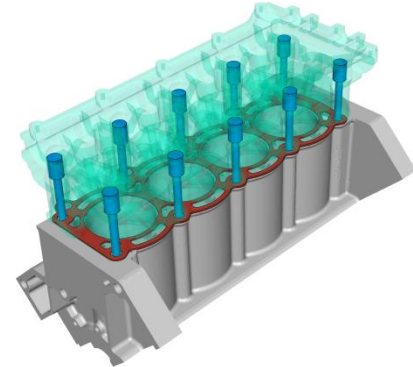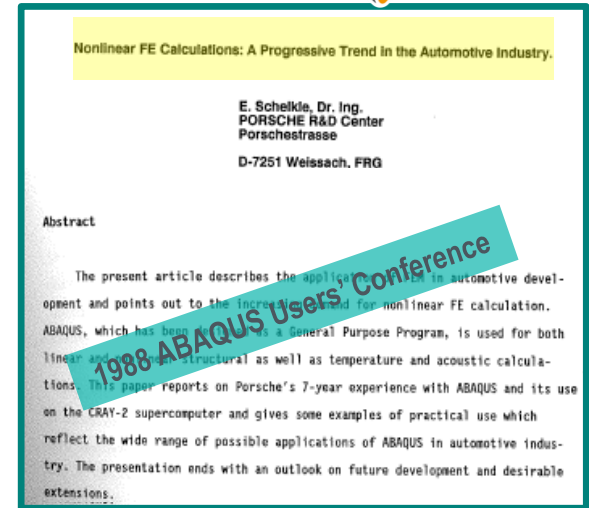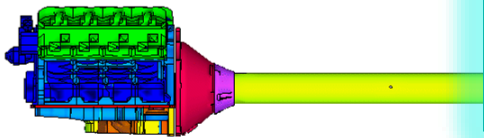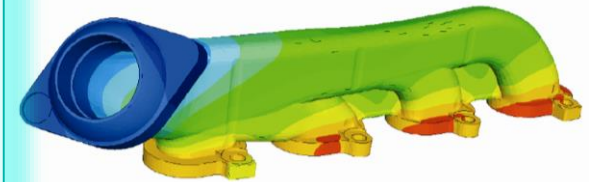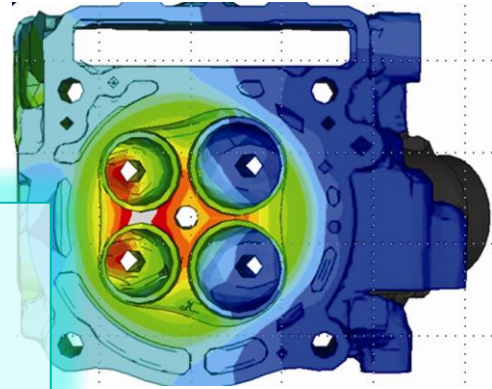
Key Automotive Simulation Solutions

Key Automotive Worklfows
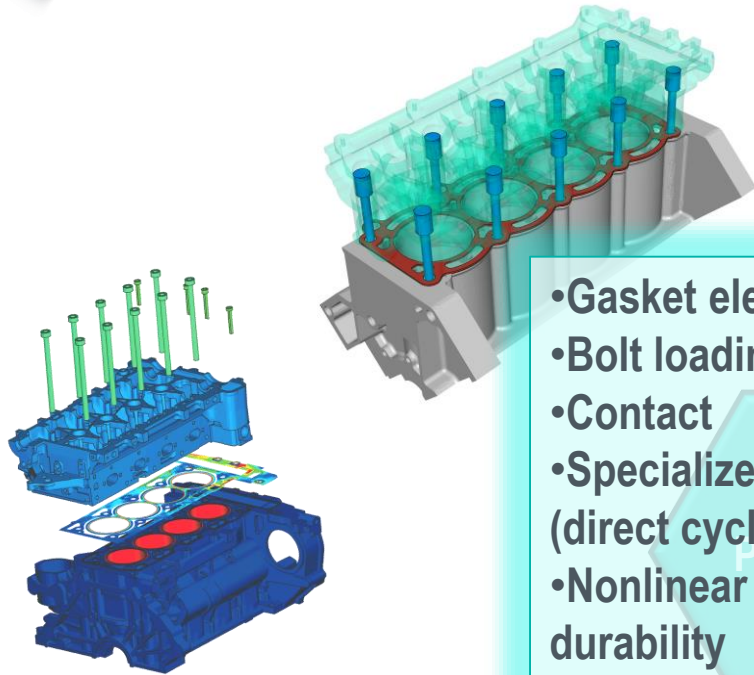
- Gasket elements
- Bolt loading
- Contact
- Specialized procedures (direct cyclic,…)
- Nonlinear thermomechanical durability
- Performance/parallelization
- Direct and iterative solvers
- Full N&V capabilities
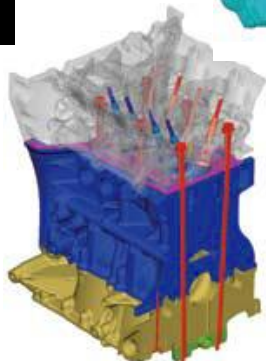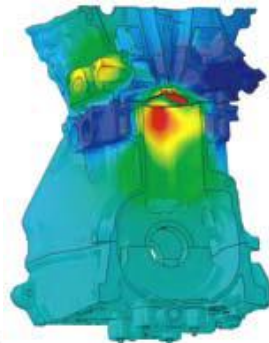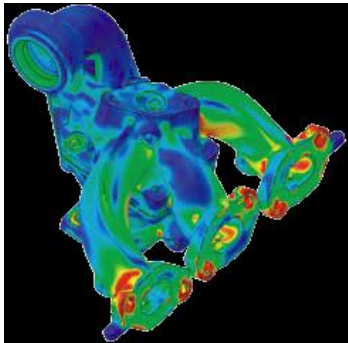- Coupling with AVL Excite

Powertrain

3
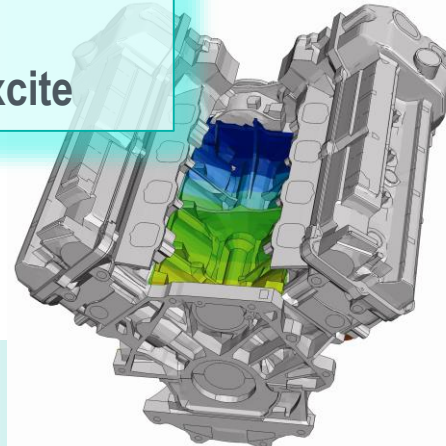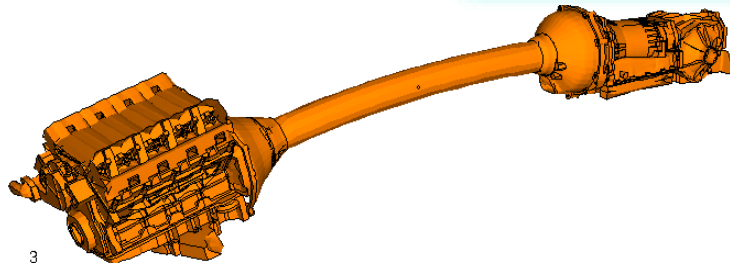
Powertrain

MAHLE Powertrain

- ### Engine downsizing
  - Meeting stringent emissions requirements
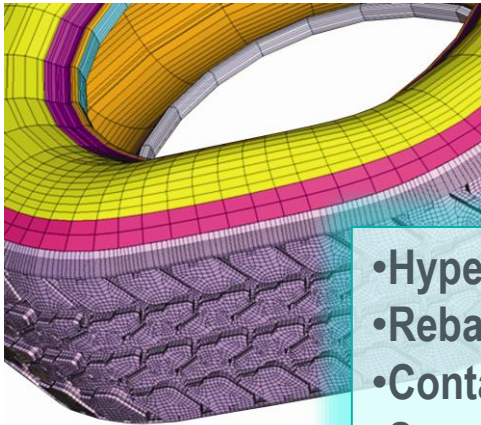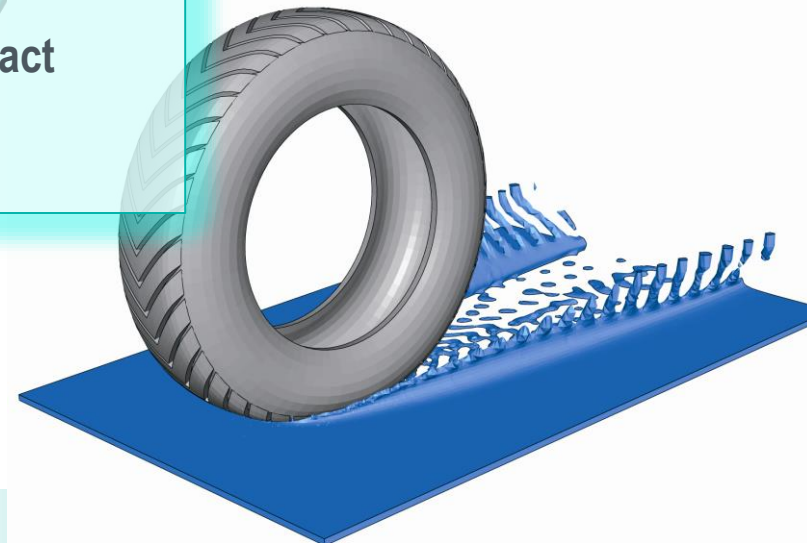 - While maintaining strong performance characteristics

- ### Multiple design simulation applications
  - Crankshaft dynamics
  - Head/Block assembly thermomechanical durability
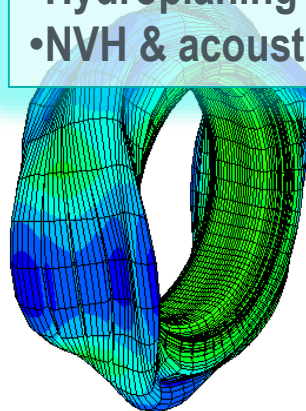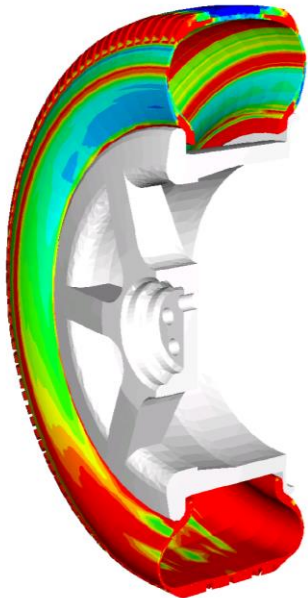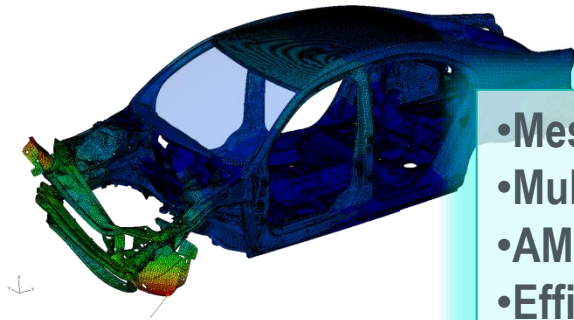 - Exhaust manifold fatigue life
  - …

Key Automotive Workflows
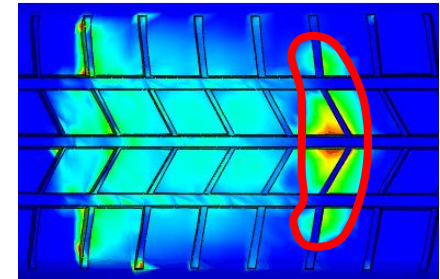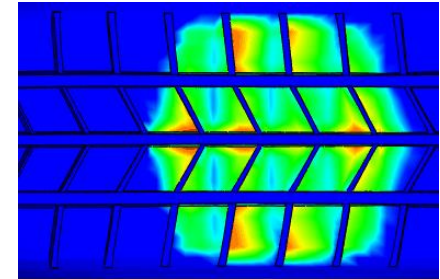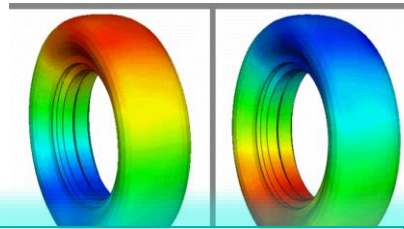
- Hyperelasticity, viscoelasticy
- Rebar (reinforcement)
- Contact
- Symmetric model generation
- Mounting/Inflation/Footprint
- Steady-state rolling
- Durability/wear
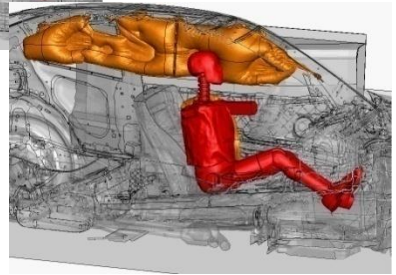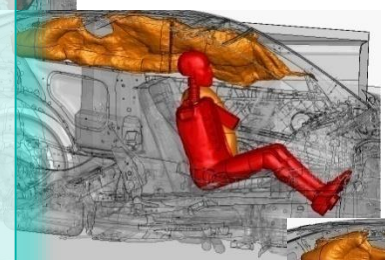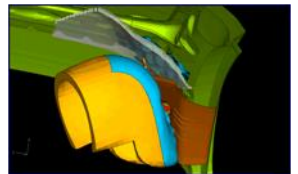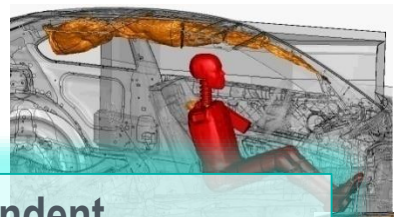- Abusive loading/impact
- Hydroplaning
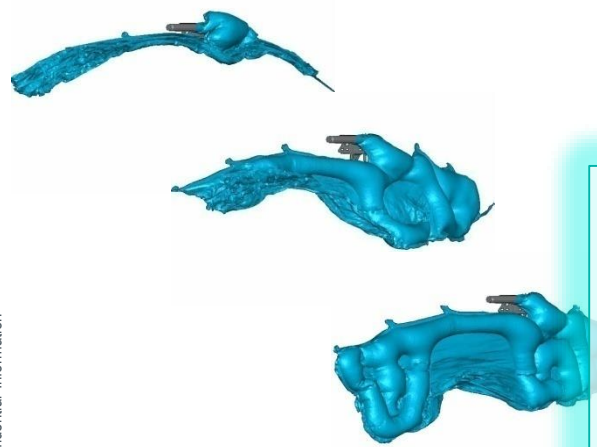- NVH & acoustics

Tires

DS SIMULIA

Key Automotive Workflows

Body N&V

- Mesh independent spotwelds
- Multilevel substructures
- AMS (eigenvalue extraction)
- Efficient linear dynamics
- Acoustics
- Advanced effects (damping, rolling tires, nonlinear preloading)
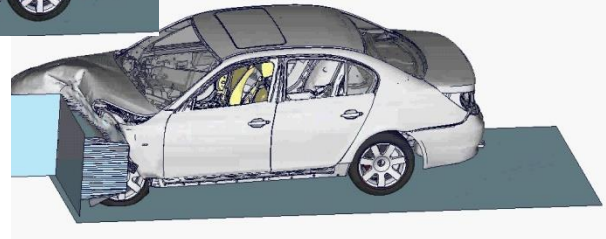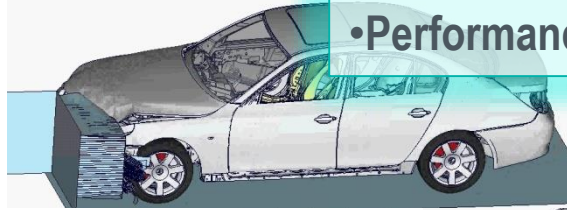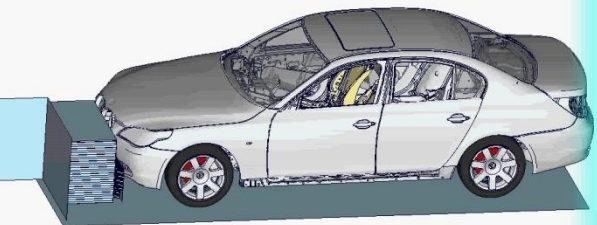- Nastran interoperability
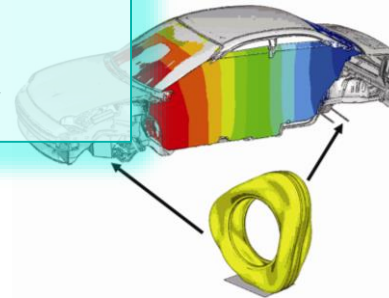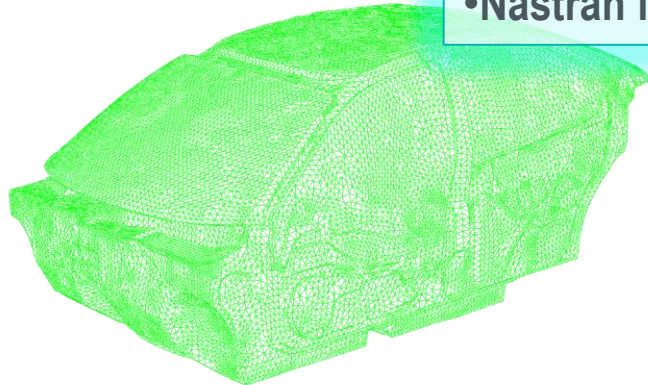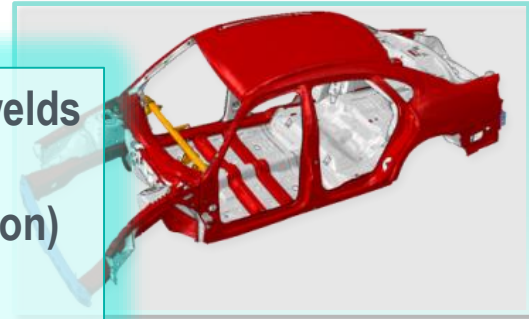
Key Automotive Workflows

- Mesh independent connections
- Material, connection damage/failure
- Composites crushing
- Robust general contact
- Dummy, impactor, barrier models
- Restraint systems (seatbelts, folded airbag deployment)
- Performance/parallelization

Crashworthiness / Occupant Safety
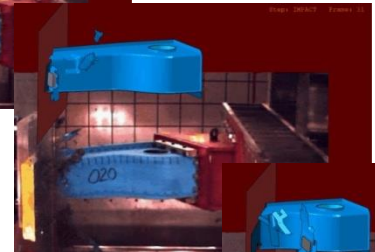
Passive Safety

BMW

Zero prototype design process objective

- Significant cost savings and greater efficiency
- *"Predictiveness"* for design simulation of central importance

Wide range of passive safety applications

- Structural crashworthiness
- Occupant safety
- Pedestrian safety
- …
- Simultaneously accounting for both global response and detailed local behavior (damage/failure)

Predictive Crashworthiness Simulation in a Virtual Design Process without Hardware Testing
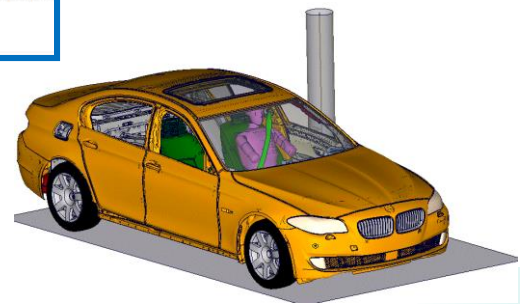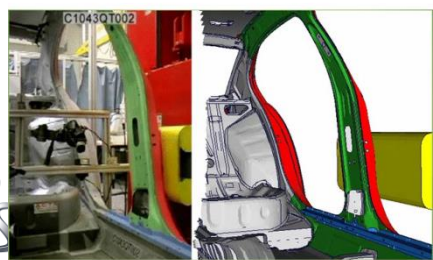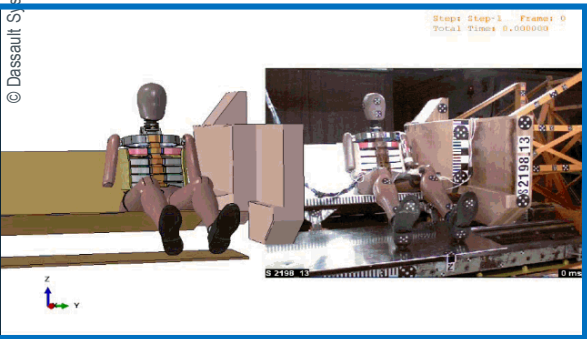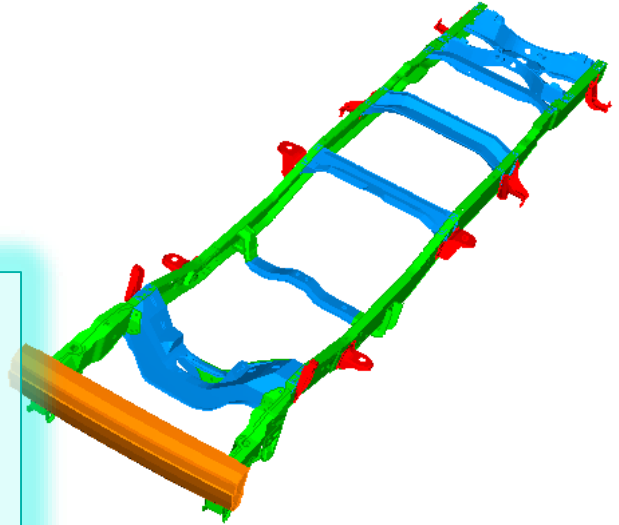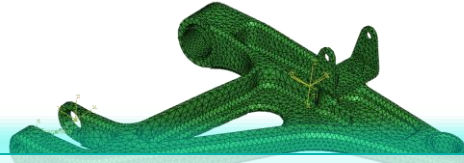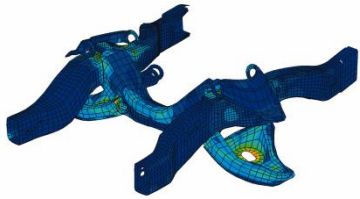
Jürgen Lescheticky, Hariaokto Hooputra, and Doris Ruckdeschel

BMW Group, Munich

In 2006 BMW made a decision to use Abaqus/Explicit for all issues concerning passive safety in the virtual design process. Code quality and reliability of simulation results were identified as the primary reasons to change, and from that decision point forward, all product development teams began migration activities to switch to Abaqus/Explicit.

Meanwhile, the entire vehicle design and development process within BMW began to undergo fundamental changes, from one which previously incorporated key milestones involving physical prototypes, to one which seeks to largely eliminate physical prototypes and associated physical tests. Nowadays, BMW design engineers will get the first feedback from physical tests only after the series production tools have been manufactured. Therefore, design changes at that point will be extremely expensive. Furthermore, no physical test results will be available to calibrate and improve finite element models of virtual crash cars in the earlier phases of the development process. So predictiveness is now the most important criterion for BMW's passive safety

Key Automotive Workflows

- Plasticity, contact, other nonlinearities
- Joints, mechanisms (connectors)
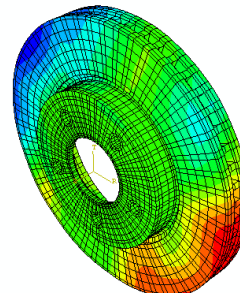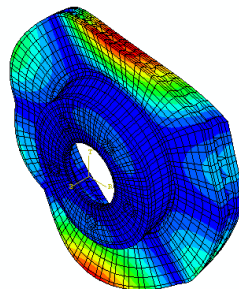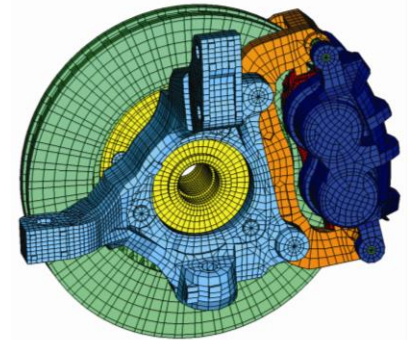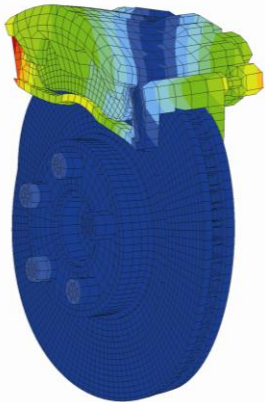- Brake squeal (complex eigensolver)
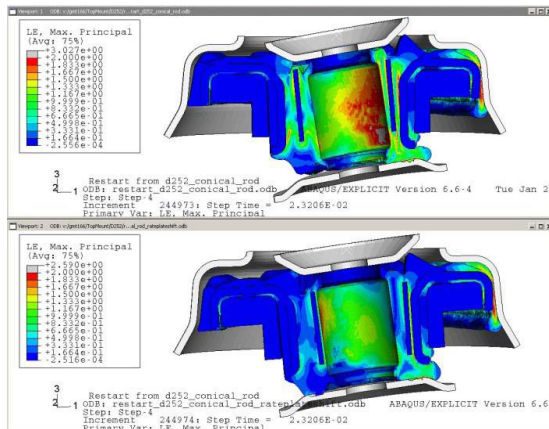- Thermomechanical durability
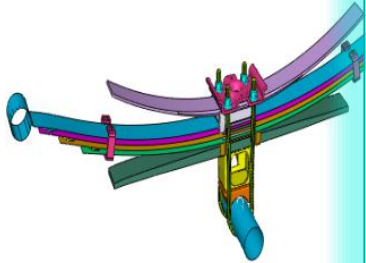
Chassis / Brakes

Chassis Durability

GENERAL MOTORS

- Simulation incorporated into mainstream product design processes
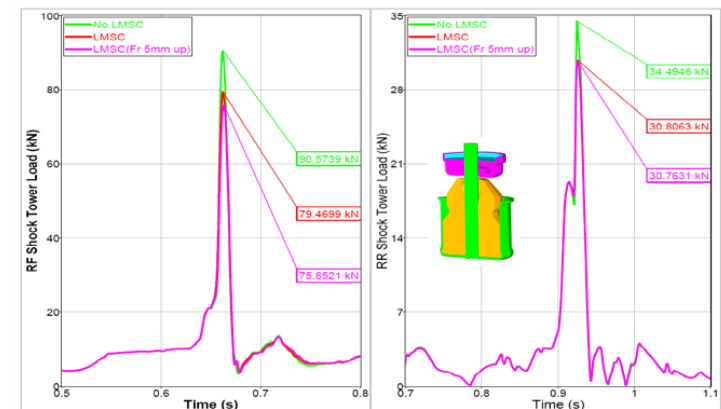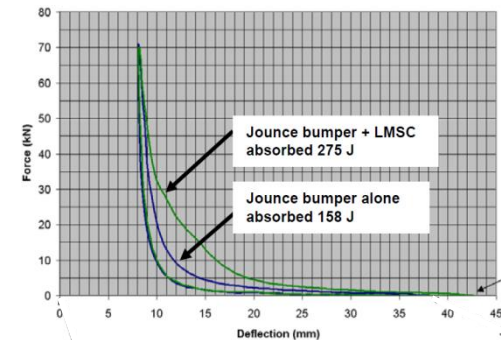 - Strength/durability design simulation for metallic and elastomeric components and assemblies
 - Static, dynamic; nonlinear, linear

Recent Applications of Abaqus/Explicit in GM Chassis CAE

Robert L. Geisler, Ravindra Patil, Dr. Joseph Schudt, Dr. Sung-Ling Twu

General Motors Global Product Development – Chassis CAE

Abstract: GM Chassis CAE has used ABAQUS successfully for many years. In the past most problems examined were more traditional durability and strength analyses of metallic structural components. Recently we have used ABAQUS/Explicit to great advantage to assess and solve for a wider range of component materials and loadings such as elastomers, sealing and impact. This presentation highlights some recent examples of these types of analyses, as well as sharing some general conclusions and lessons learned from these studies.

Key Automotive Workflows

Durability
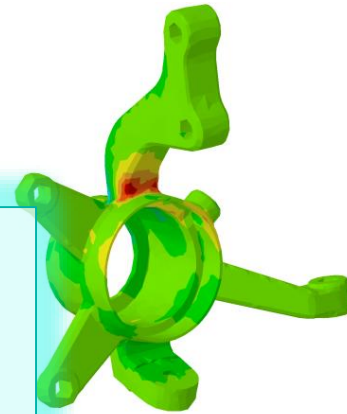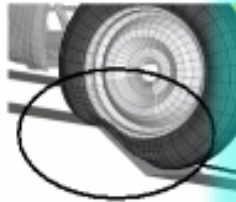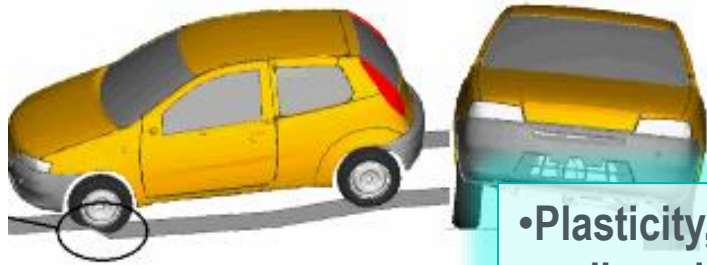
- Plasticity, contact & other nonlinearities
- Tires, substructures, connectors,…
- Implicit-Explicit co-simulation
- Full vehicle simulation (abusive event, rough road)
- Links to fatigue codes

3S SIMULIA
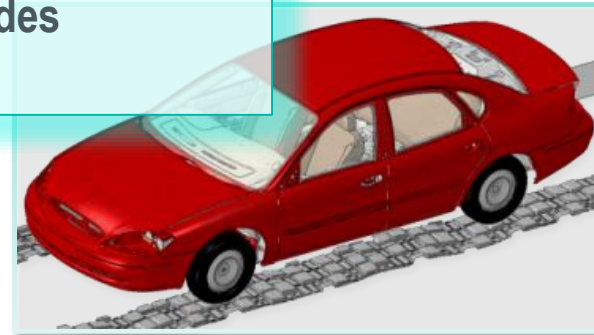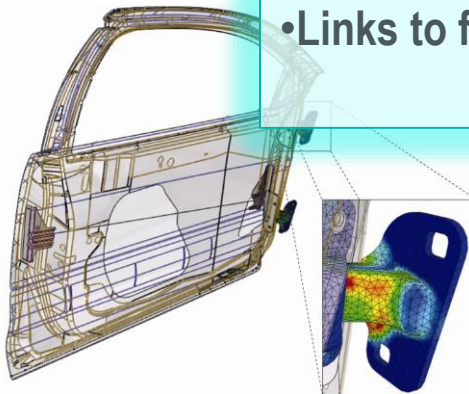
Full Vehicle Durability

FIAT

E. Duni, G. Toniato

FIAT Group Automobiles

R. Saponaro, P. Smeriglio

FIAT Research Centre

*Abstract: This work describes a numerical methodology based on the Finite Element approach able to simulate the dynamic maneuver of the full vehicle running on fatigue reference roads. The basic idea of present work stays in combining a moderately complex and general tire model with traditional full-vehicle methods, including both implicit and explicit finite element techniques, in order to predict – within the early design phases when no prototypes are available - the loads transmitted to the vehicle running on the real fatigue reference roads. Some issues related to*

- Enhanced simulation realism for vehicle durability
  - Abusive events (pothole,…)
  - Fatigue reference roads

- Leveraging several Abaqus features simultaneously
  - Standard-Explicit co-simulation
  - Nonlinearities: contact, material,…
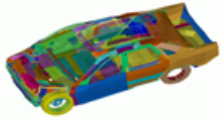 - Substructures, connectors
  - Tire modeling
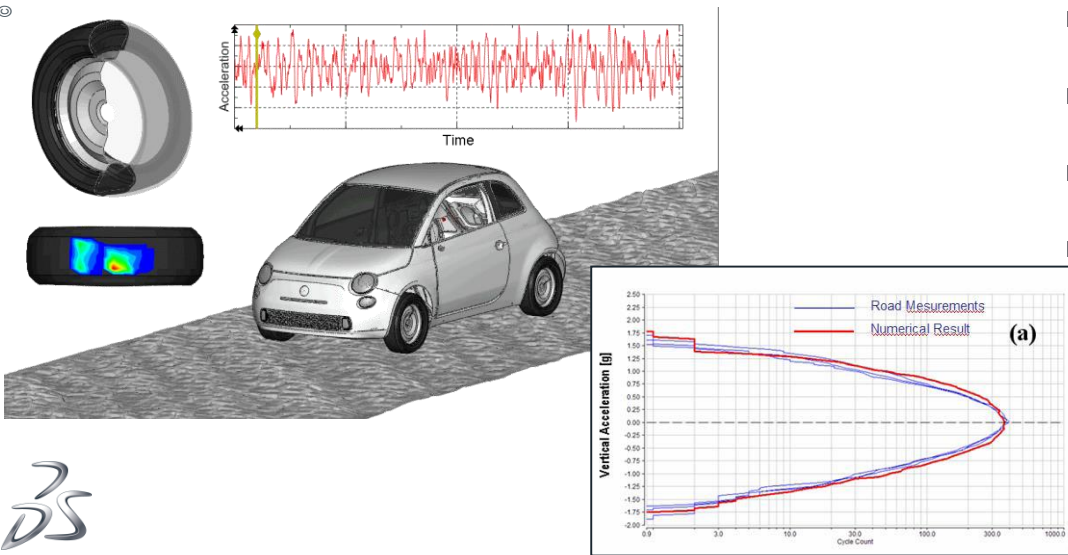
Isight

Automotive application examples

Frontal impact model

Reference	Baseline	Optimum	Improvement (%)
Weight (Kg)	63.6	530	15.4
Chest G (g)			4.7
HIC			11.8
Intrusion (in)			2.6
Internal Energy (Jkl)	3340	3990	19

Weight ↓ 10.6 kg

Roof crush model

Performance	Baseline	Optimum	Improvement (%)
Weight (Kg)	416.8	403.3	3.2
Peak force (lb)	7069	7234	2.2

Weight ↓ 13.3 kg
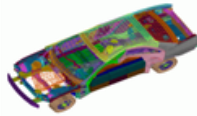
Side impact model

Performance	Baseline		Optimum	
	Design	Rating Score	Design	Rating Score
Weight (kg)	29.15	–	23.59	–
Abdomen Force (kN)	0.46	4	0.45	4
Chest Deflection (mm) V*C (m/s)	34.0 0.11	1.6	31.3 0.20	2.15
Pubic Symphysis Force (kN)	4.05	2.55	3.72	3.04
HIC		4		4
Total Score	–	11.2	–	13.2

Weight ↓ 5.6 kg
Safety rating score ↑ 1 point
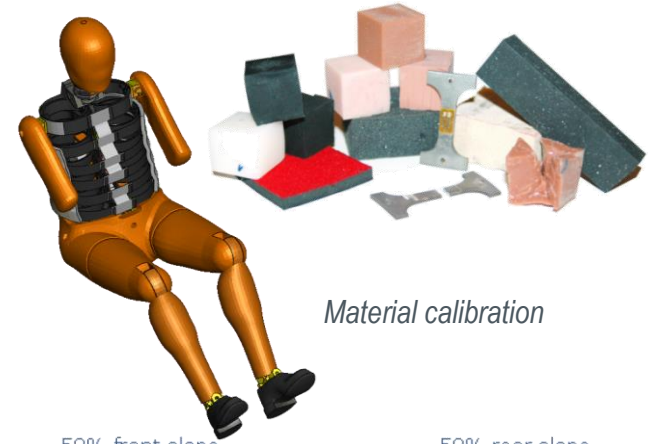
Weight reduction & Robust design

Valve profile optimization

Material calibration
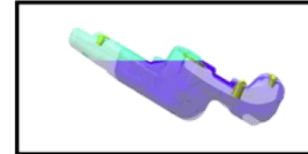
50% front slope   50% rear slope
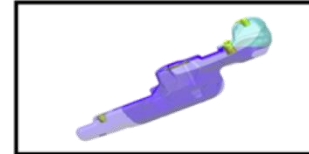
50% right slope   50% left slope

Optimization of position and number of valves in fuel tank venting process
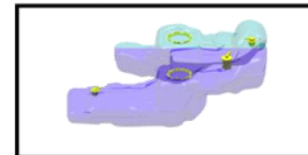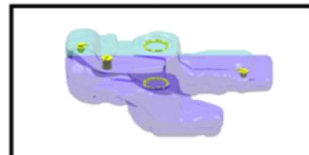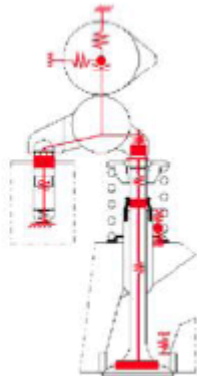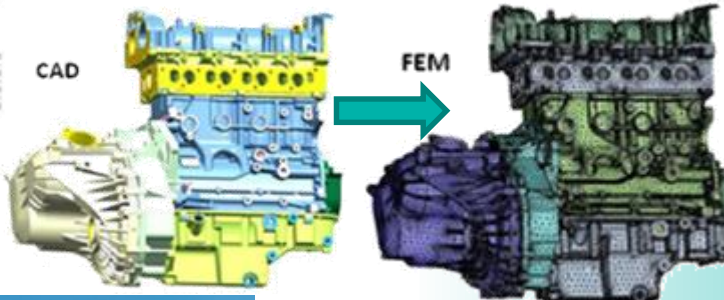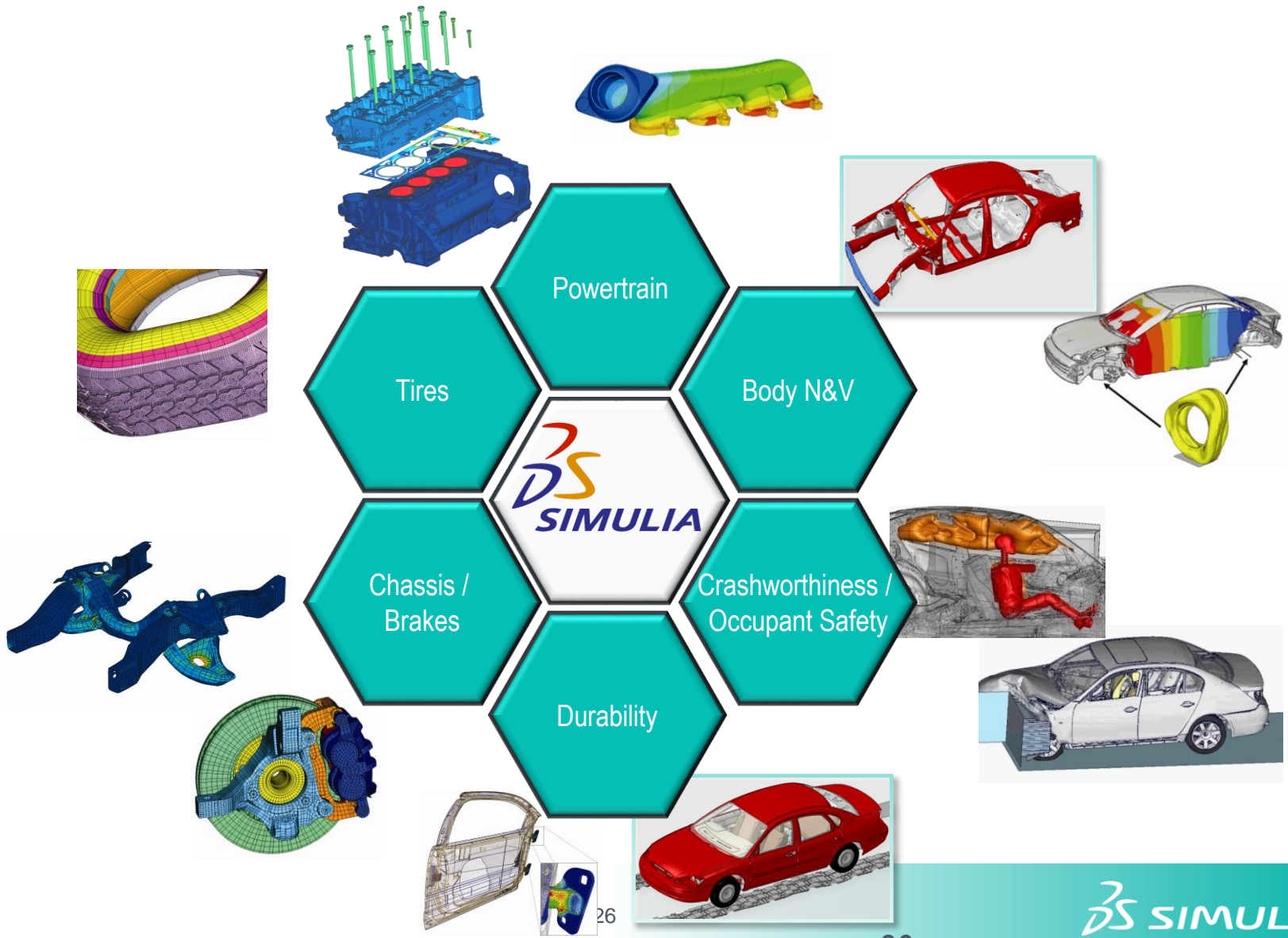
Cost savings from 5 days to 3 hours

CAD   FEM

Process automation: FE mesh generation

Key Automotive Simulation Solutions

Powertrain

Tires

Body N&V

Chassis / Brakes

Crashworthiness / Occupant Safety

Durability

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Key SIMULIA Solution Strengths

Technology

- Broadest structural offering for the Automotive market
  - Powerful features for all automotive structural applications
- Competitive and leading technologies across broad automotive categories
  - Powertrain
  - Tires
  - Noise & Vibration
  - Durability
  - Crashworthiness / Occupant Safety

Industry-leading customer support

- Local personnel
- Deep knowledge of automotive processes

Leveraging Realistic Simulation as an Integral Business Practice

- Proven Technology Available
  - Robust Realistic Simulation solutions
  - Process Automation and Design Optimization
  - Design-integrated Realistic Simulation
  - Simulation Lifecycle Management

- Simulation experts needed to champion and guide transformation
  - Deep understanding of simulation technology and methods
- Visionary managers needed to drive process improvements and culture change
  - Document, capture, and deploy best practices

Realistic Simulation Delivers Real Business Value

- Deeper Understanding of Product Behavior
- Better products
  - …reduced physical testing
  - …faster to market
  - …lower costs
- Improved competitiveness and profitability

Your Partner to Make…

Realistic Simulation
an
integral
business practice…

Thank You!