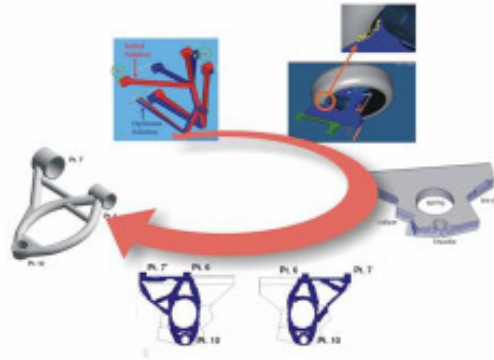


Multi-Attribute Optimization of Suspension Systems

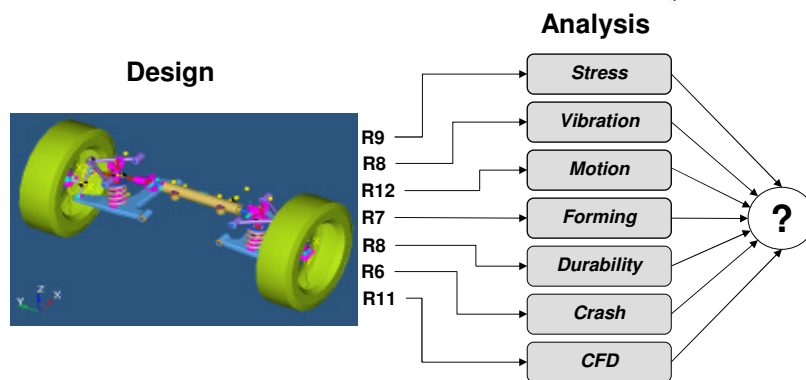
Dr. Michael Hoffmann
Vice President
European Operations



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Challenges in Vehicle Development



- Models re-created multiple times in different environments
- Analysis results based on different design revisions
- Cross attribute optimization not possible

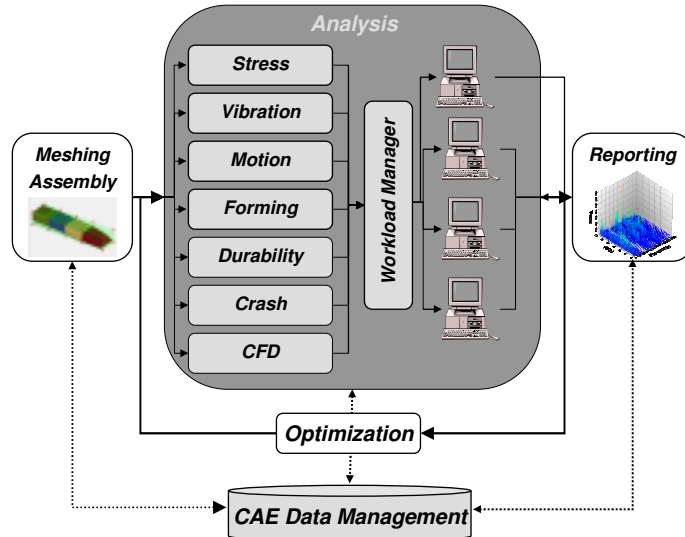
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Vision: Cross Attribute Optimization



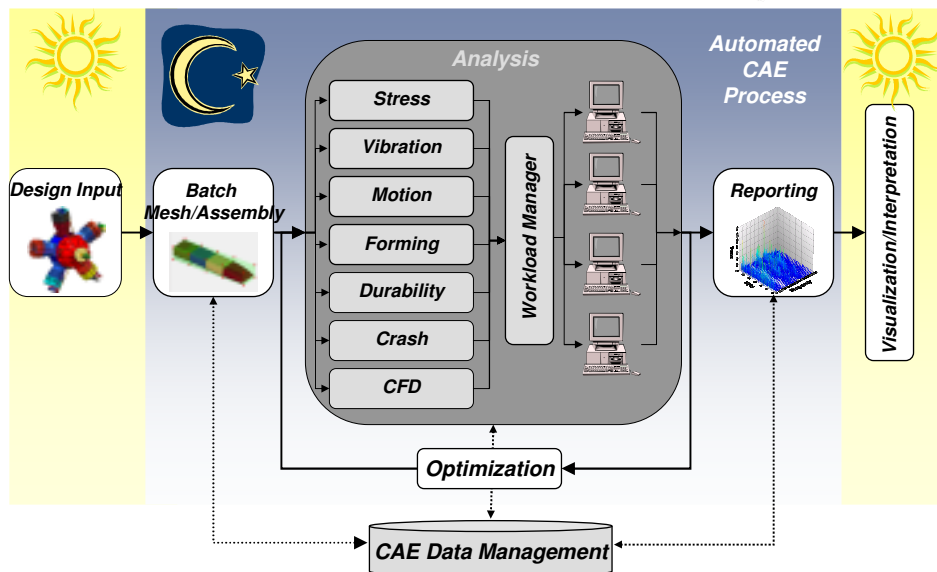
Consistent Data Model Driving Cross Attribute Optimization



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Vision: Batch-CAE



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Requirements



- Knowledge capture & re-use
 - Model, analysis, and reporting templates
 - Encapsulation
- Adaptable component/system models
 - Development stage
 - Concept, Detailed Design
 - Attribute
 - NVH, Durability, Crash, Vehicle Dynamics
- Multi-solver support
 - Select solver which is most efficient for a specific task
- Minimal effort in model creation and maintenance
 - Handling of variants

Realization

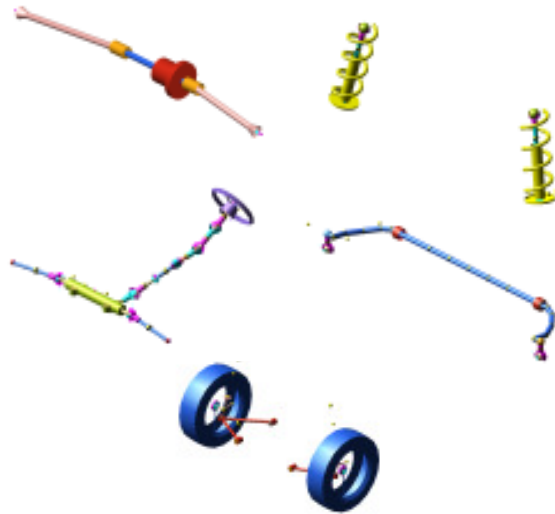


- Suspension model in MotionView
 - Parametric templates with unlimited hierarchy
 - ▶ Knowledge capture & re-use
 - Component models with varying fidelity
 - ▶ Adaptable component/system models
 - Solver neutral data model
 - ▶ Multi-solver support
 - Transparent data model with build in symmetry and conditional logic
 - ▶ Minimal effort in model creation and maintenance

Knowledge Capture Through Templates



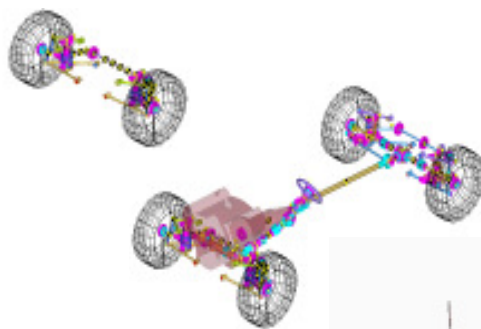
Body
Driveline - Front
Driveline - Rear
Driveline - Transfer
Front Bumpers – External Jounce
Front Bumpers – Internal Jounce
Front Strut
Front Shock
Front Spring - Coil
Front Stabilizer Bar
Front Suspension - Multilink
Front Suspension - SLA
Front Suspension - Macpherson
Front Subframe
Powertrain – Longitudinal
Steering Linkage – Rackpin



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From Subsystems to Full Vehicle Models



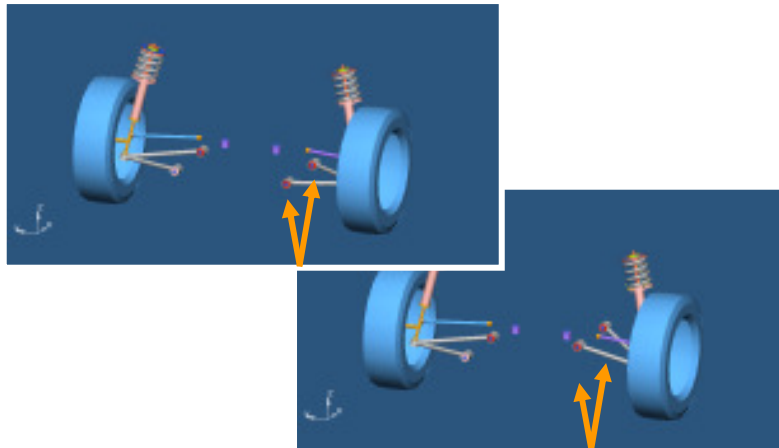
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Parametrics



- Use parametric expressions to build and manipulate points and associated objects



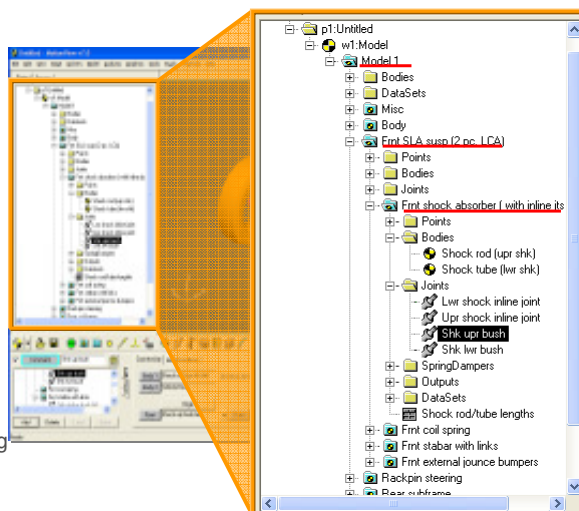
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MotionView Data Model



- Hierarchy Support
 - Model consists of
 - atomic modelling elements
 - points
 - bodies
 - forces
 -
 - systems consisting of
 - systems
 - atomic modelling elements



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Case Study: Component Models with Different Fidelity



▪ Challenge

- Different analysis types require different fidelity of component models
- Historically, users keep multiple models
- Maintenance, synchronization issues

▪ Solution

- Utilize the concept of systems and conditional logic

▪ Results

- One simulation model which holds multiple component models for different analysis types
- Improved efficiency and quality
 - Faster model building
 - No synchronization issues
 - Foundation for cross attribute optimization

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Case Study: Component Models with Different Fidelity



▪ Schematic system definition

```
*DefineSystem(connector, anal_type, body1, body2, ....
  *IF(anal_type=="kinematic")
    *AtPointJoint(.....
  *ElseIf(anal_type=="elasto_kinematic")
    *Bush(.....
  *ElseIf(anal_type=="NVH")
    *ControlSISO(...
    *ActionReactionForce(....
  *EndIF()
*EndDefine()
```

▪ Instantiation

```
*System(LCA_bush,"LCA multi discipline bush", connector, .....
```

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Case Study: Component Models with Different Fidelity



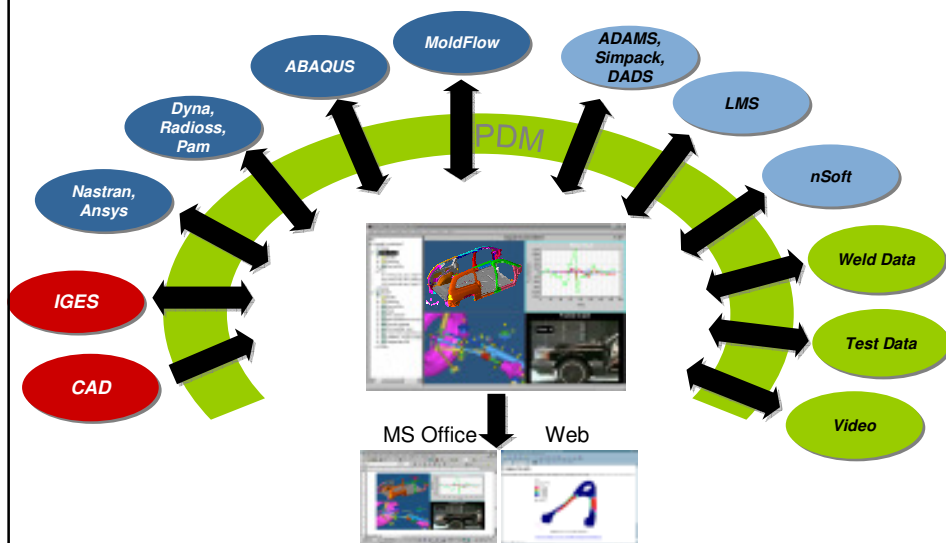
Application

- Assume you want to run a cross attribute optimization where the attributes are obtained from
 - Kinematic analysis
 - Elasto-kinematic analysis, and
 - NVH analysis
- One model (constructed as described before) now holds the different component models
 - Activated by simply setting the variable `anal_type` to
 - Kinematic
 - Elasto-kinematic
 - NVH

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Open Interfaces to CAD/CAE Software



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Symmetry



- Symmetry part of the data model
 - No need to do special programming

Part	Ln	Ly	Lz	Ref	Rx	Ry	Rz
First morphoset: long (1 pc. LCA)							
Wheel LCA	1808.000	-758.000	1808.000	1808.000	758.000	1808.000	
Wheel member	1808.000	-758.000	1808.000	1808.000	758.000	1808.000	
Spindle align	1808.000	-858.000	1808.000	1808.000	858.000	1808.000	
Knuckle LCA	1808.000	-658.000	1808.000	1808.000	658.000	1808.000	
LR1	9971.000	-808.000	918.000	9971.000	808.000	918.000	
OTR1	1128.000	-875.000	1808.000	1128.000	875.000	1808.000	
OTR2	1128.000	-875.000	1808.000	1128.000	875.000	1808.000	
LCA heel bushing	847.000	-318.000	1808.000	847.000	318.000	827.000	
LCA rear bushing	1247.000	-318.000	1808.000	1247.000	318.000	827.000	
Strut tube bar	1818.000	-823.000	1128.000	1818.000	823.000	1128.000	
Spring upr	1807.000	-542.000	1808.000	1807.000	542.000	1808.000	
Spring lwr	1808.000	-606.000	1358.000	1808.000	606.000	1358.000	

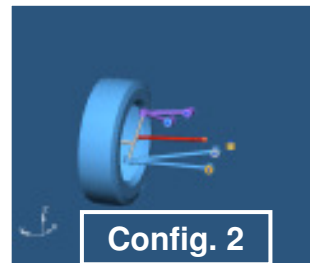
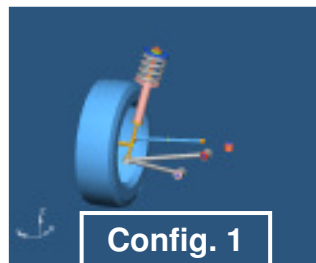
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Model Variants



- Conditional logic
 - Conditionally changing the joint type or suspension configuration
 - Both variants in memory



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Application Example



Challenge

- Develop a new suspension for a high class sports car

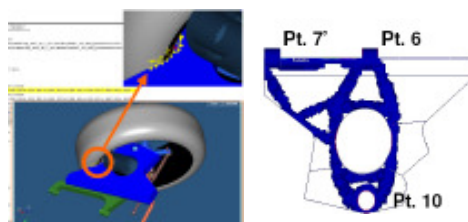


Solution

- Employ HyperWorks for an integrated multibody – structural optimization

Results

- New suspension satisfies packaging constraints, superior handling performance and structural reliability



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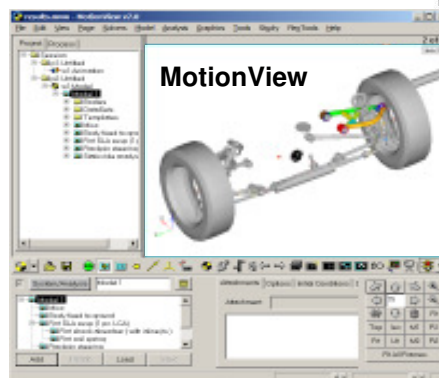
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Consistent data model supporting multiple solvers



Bodies

- Rigid
- Flexible
 - Modal (CMS)
 - Full FEA



Vehicle Dynamics
with
Adams

Packaging
with
MotionSolve

Crash
with
RADIOSS

NVH
with
Nastran

Mis-Use Tests
with
ABAQUS

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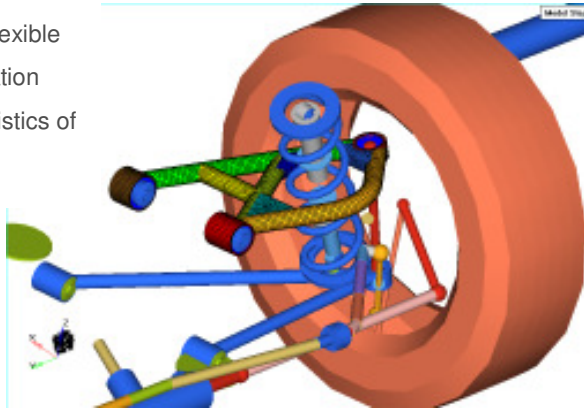
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System Level Structural Model



■ ABAQUS realization

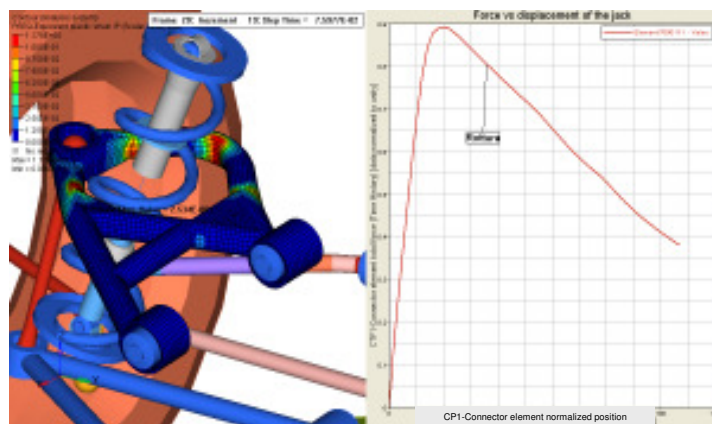
- Upper control arm flexible
- Full FEA representation
- Nonlinear characteristics of
 - Spring
 - Bushings
 - Etc.



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Mis-Use Simulation with ABAQUS



- Impact of the suspension system against a guard rail at the upper end of the rim

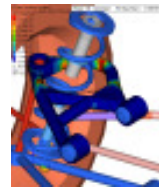
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Conclusions



- Altair's MotionView provides a consistent simulation model
 - Supporting vehicle dynamics as well as vibrations and mis-use tests
 - Minimizing modeling errors and model synchronization issues
 - Facilitating cross attribute optimization
- Successfully applied within the 8C Competizione project



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Italian Abaqus Users' Conference 2006

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