

ADAMS/Car in the Vehicle Development Process Using Suspension and Full Vehicle Features

by

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Abstract:

At AUDI the multibody analysis software package ADAMS has been successfully used over the past 10 years. In addition to the kinematic and elastokinematic optimisation of suspension systems, full vehicle simulation is being used to analyse the dynamic behavior of vehicles. The participation of AUDI in the development process of ADAMS/Car and the extensive use of ADAMS/Car in the development of suspension systems proved to boost the efficiency of the design process.

The first part of the presentation explains why KINELA, an in-house developed software for axle kinematics and elastokinematics, has been integrated into ADAMS/Car. The different types of suspension models and analyzing features will be presented.

Standardised analyses with ADAMS/Car to evaluate vehicle dynamics are described in the second part. A comparison of analysis results against measured test data for one typical open-loop maneuver is presented to show the validity of ADAMS/Car results. A short video on full vehicle simulation including a sophisticated driver model shows other possible applications.

The combination of suspension and full vehicle features in one commercial software product, the standardization of the full vehicle simulation process and the powerful interface to in-house postprocessing tools make it possible to analyse new suspension concepts in the advanced development process.

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Audi

**ADAMS/Car in the Vehicle Development Process
Using Suspension and Full Vehicle Features**

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Introduction

ADAMS Applications:

- Suspension Elastokinematics
- Vehicle Dynamics
- Ride Comfort
- Powertrain/Driveline Dynamics

Before ADAMS/Car:

- In-House Software Toolkit KINELA:

- Pre-/Postprocessor for Suspension **Kinematics** and **Elastokinematics**
- Full Vehicle Models based on ADAMS/View or ADAMS-Dataset without Separation of Model Topology and Data.
- Different Models for each Application

With ADAMS/Car:

- All Applications use the same Suspension Templates
- Separation of Model Topology and Data
- Comfortable Model Generator (Template Builder)
- Interface to the Audi Technical Development Database (TeimOrbit)

Suspension Analysis Customization of ADAMS/Car



KINELA Suspension Analysis Features:

- Loadcases for Wheel Travel and Steering Positions
- Loadcase for Forces and Moments at Wheel Center or Wheel Contact Patch
- Auto Generation of a Combined Loadcase for Wheel Travel and Forces which is Representative for a Set of Standard Maneuvers. Complete "Suspension-Characteristics-Profile" for this Loadcase
- Evaluation of the Suspension Kinematic Characteristics
- Evaluation of Wheel Space Requirement
- Evaluation of all Forces and Displacements at Connecting Bushings and Joints (Input for FEM-Analysis)
- Additional Audi Specific Evaluations

Integration into ADAMS/Car:

- All Suspension Templates are "KINELA Compatible"
- Suspension Testrig for KINELA Analysis
- Control of KINELA Analysis and Postprocessing

Suspension Analysis Customization of ADAMS/Car

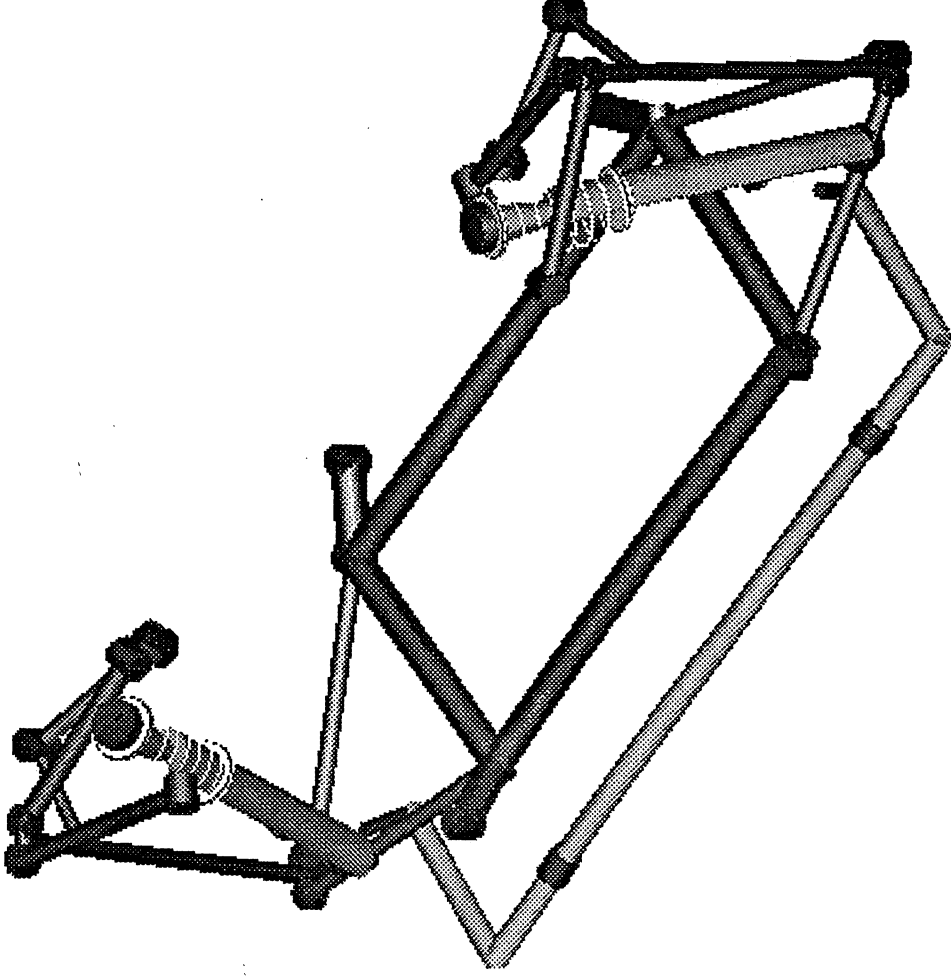


ADAMS/Car Templates:

- Four Link Suspension
- Double Wishbone Suspension
- Mc Pherson Suspension
- Trapezium-Arm Suspension
- Twist Beam Suspension

Four Link Suspension Functionality:

- Possible Switch at Lower and Upper Level from two Single Links to one Arm
- Possible Switch at all Links from Bushing to Joint
- Possible Switch for Subframe Active or Inactive



Full Vehicle Simulation Standard Test Procedure



- Objective Testing:**
- Standard Test Procedure According to DIN/ISO Standards (e.g. Steady State Cornering, Step Steer, etc. ...)
 - Evaluation of the Vehicle Response in a "Vehicle-Profile" (Representative for the Vehicle Characteristics)
 - Evaluation of Additional Maneuvers from Subjective Testing

- ADAMS/Car Features:**
- Standard Maneuvers
 - Standard Requests (Full Vehicle Testrig)

- Audi Customization:**
- Interface to DIAdem (Standard Software for the Evaluation of Measured Test Data), Cross Plotting of Simulation and Testing Results, "Vehicle-Profile" Derived by Analysis

- Audi Customer Wants:**
- Set of Maneuvers in one Loadcase (Automatic Simulation)
 - Toe and Camber Setting in a Different Load Condition as Specified for the Maneuver

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Full Vehicle Simulation Step Steer Maneuver



Example Step Steer:

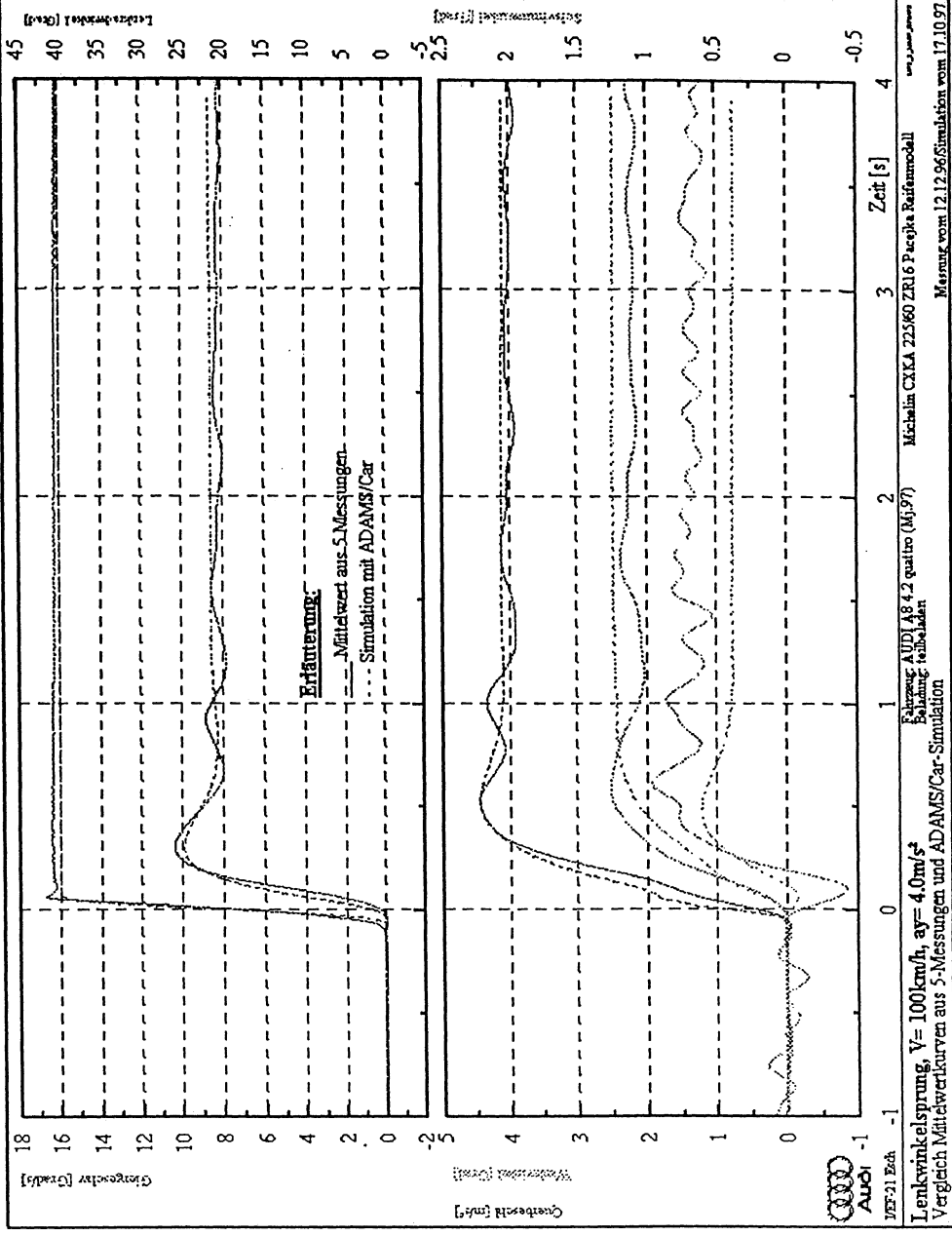
- Lat. Acceleration: 0.4 g
- Vehicle Velocity: 100 km/h

Measured Variables:

- Steering Wheel Angle
- Steering Wheel Torque
- Long./Lat. Acceleration
- Vehicle/Yaw Velocity
- Body Slip Angle
- Roll/Pitch Angle
- Toe/Camber Angle
- Wheel Displacement

Evaluations:

- DIN/ISO Standard
(e.g. Peak Response
Time)



Lap Time Simulation

Model Description Audi A6 2.8 quattro



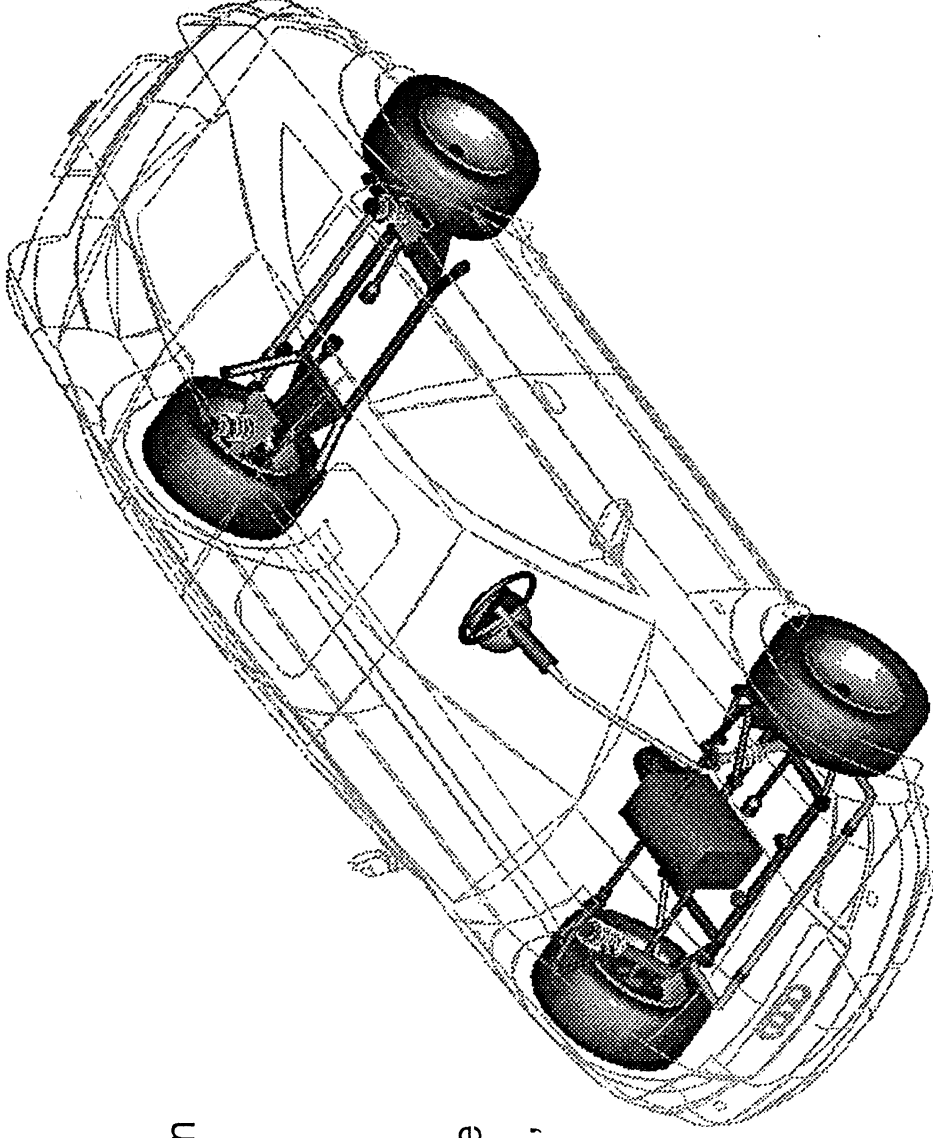
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Standard Audi Templates:

- Four Link Front Suspension
- Double Wishbone Rear Suspension
- Steering, Brake, Chassis, Tire (Magic Formula, Pacejka)

Additional Features:

- Advanced MDI Powertrain/Driveline (Engine Torque Map, Clutch Model, Gear Shifting on Driver Demand, Differential Equations instead of Modelling Rotating Parts)
- Aerodynamic Drag Forces
- ADAMS/Driver

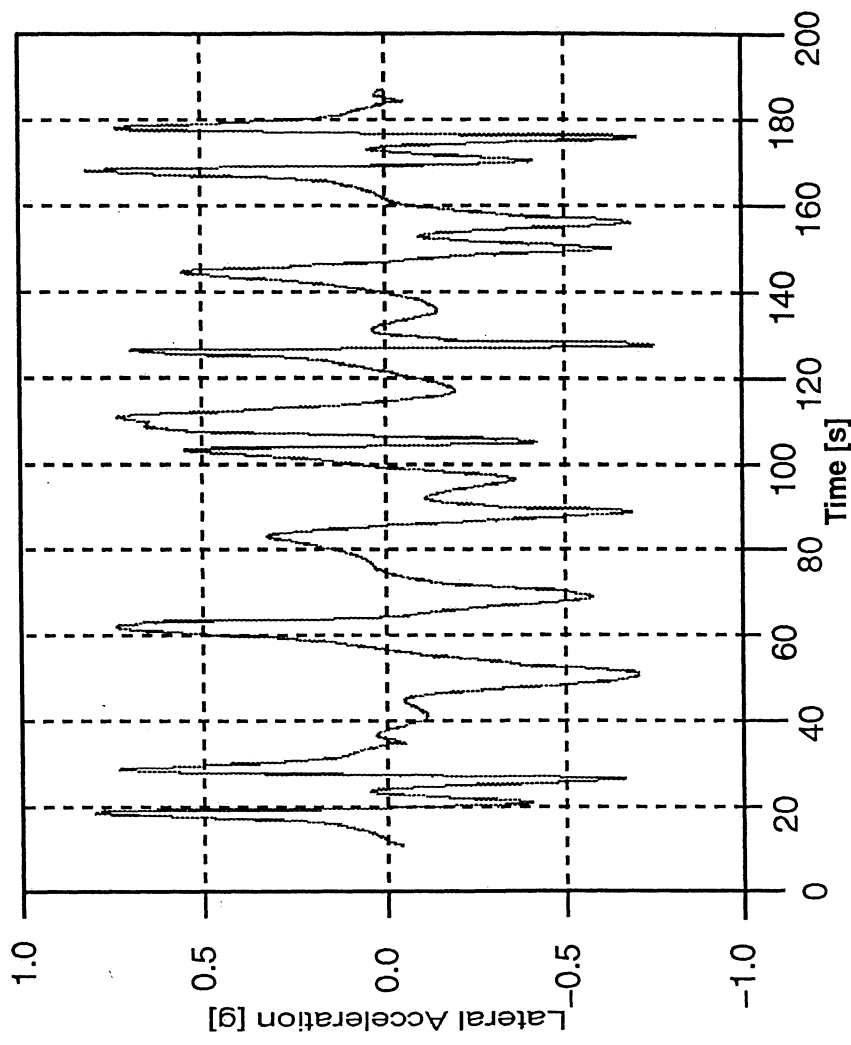




Lap Time Simulation Results

Audi A6 2.8 quattro ADAMS/Car + Driver @ Imola

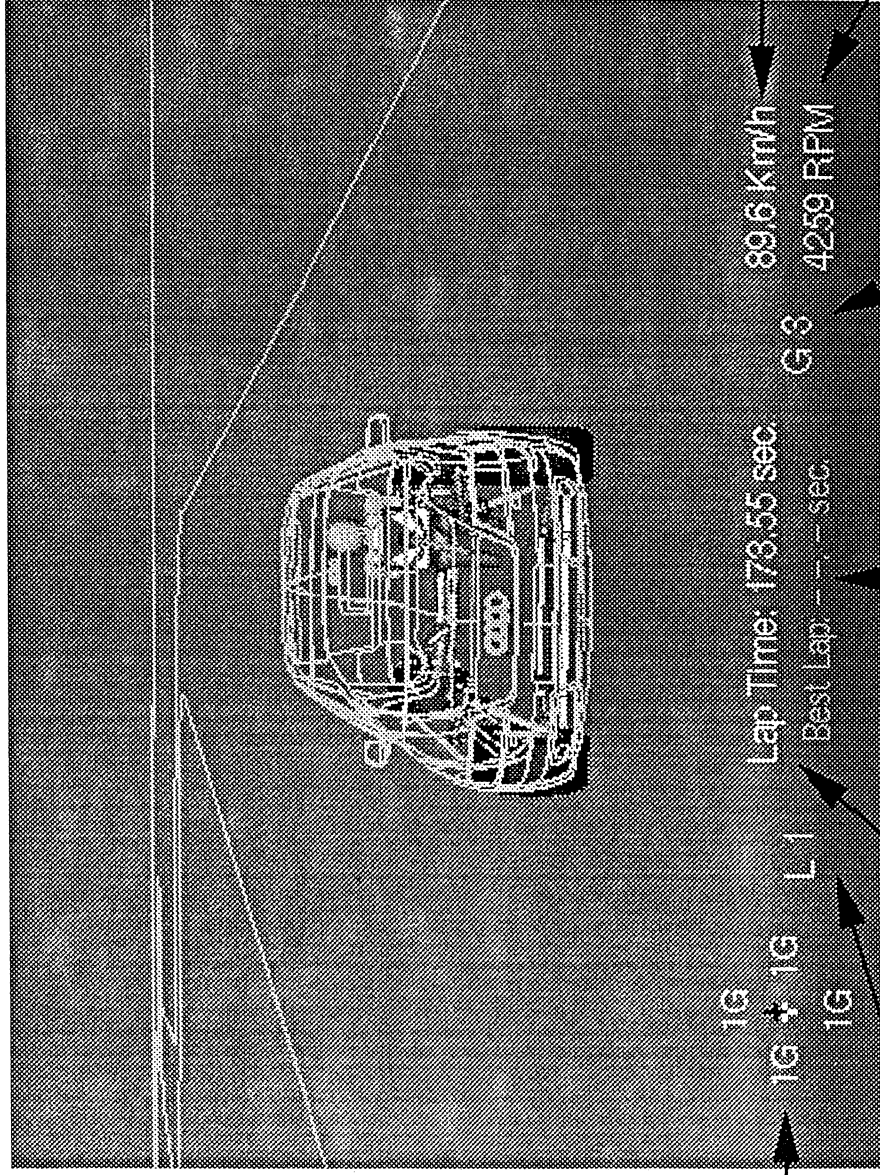
Lateral Acceleration [g] vs Time [s]



- Target:**
- ADAMS/Driver Ability to Control the Vehicle at the Limit and the Ability to Learn Vehicle's Limits and Improve the Driving Performance from this Acquired Knowledge
- Results:**
- Easy Integration of ADAMS/Driver
 - Realistic Dynamic Behavior for a Saloon Car of this Performance Level (e.g. Lateral Acceleration vs Time)
 - Fastest Lap 164.42 sec. with an Average Speed of 107.94 km/h



Lap Time Simulation Animation Effects



G-G Diagram → 1G 1G + 1G 1G → Lap Counter → L1 → Lap Time: 173.55 sec. Best Lap: --- sec. → Gear Position → G 3 → Vehicle Speed → 89.6 Km/h → Engine Speed → 4259 RPM

Lap Counter

Current Lap Time Best Lap Time Gear Position

Engine Speed

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Summary

Main Advantages of Using ADAMS/Car:

- Commercial Software Product with Support, Maintenance and Development by Mechanical Dynamics (Outsourcing)
- Same Software Standard for Manufacturers and Suppliers
- Customization Capabilities (KINELA)
- Modular and Parametric Models
- Separation of Model Topology and Data
- Various Applications use the same Templates for Suspension, etc.
- Reduced Modelling Time in Combination with the Sophisticated Audi Database (TeimOrbit)