



# Efficient Use of Integrated Simulation Software in Automotive Engineering

Johann Hudi / Hans-Ulrik von Bülow / Ernst-Joachim Bocher

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Page 1 / 11

AUDI AG, EK-9

## Authors

### **Johann Hudi**

AUDI AG	Tel. 0841/89-3378
Abt. I/EK-92	Fax. 0841/89-5018
85045 Ingolstadt	E-Mail: johann.hudi@audi.de

### **Hans-Ulrik von Bülow**

AUDI AG	Tel. 0841/89-5441
Abt. I/EK-92	Fax. 0841/89-5018
85045 Ingolstadt	E-Mail: hans-ulrik.buelow@audi.de

### **Ernst-Joachim Bocher**

AUDI AG	Tel. 07132/31-1319
Abt. N/EK-9	Fax. 07132/31-1693
Postfach 1144	E-Mail: ernst-joachim.bocher@audi.de
74148 Neckarsulm	



## Contents

- Introduction
  - Fields of Application for ADAMS/Car
  - Motivation for Integration
- Data Management Concept at Audi
  - TEIM / TeimOrbit
  - Concept Implementation
  - The Data Editor
- TeimOrbit - ADAMS/Car Integration
  - Required Communication
  - Database Communication
  - The Practical Implementation
- Conclusion

## **Abstract**

The specialized vehicle simulation software ADAMS/Car has become a standard strategic CAE-tool in the product development process at Audi. As a member of the ADAMS/Car consortium Audi has supported the development of this automotive specific software.

This paper describes the customized integration of ADAMS/Car into the CAE-environment at Audi including the link to the Audi engineering database system TEIM.

The essential steps leading to the more efficient use of the simulation software and to a higher quality in simulation, through integration of the CAE-tools, are pointed out.

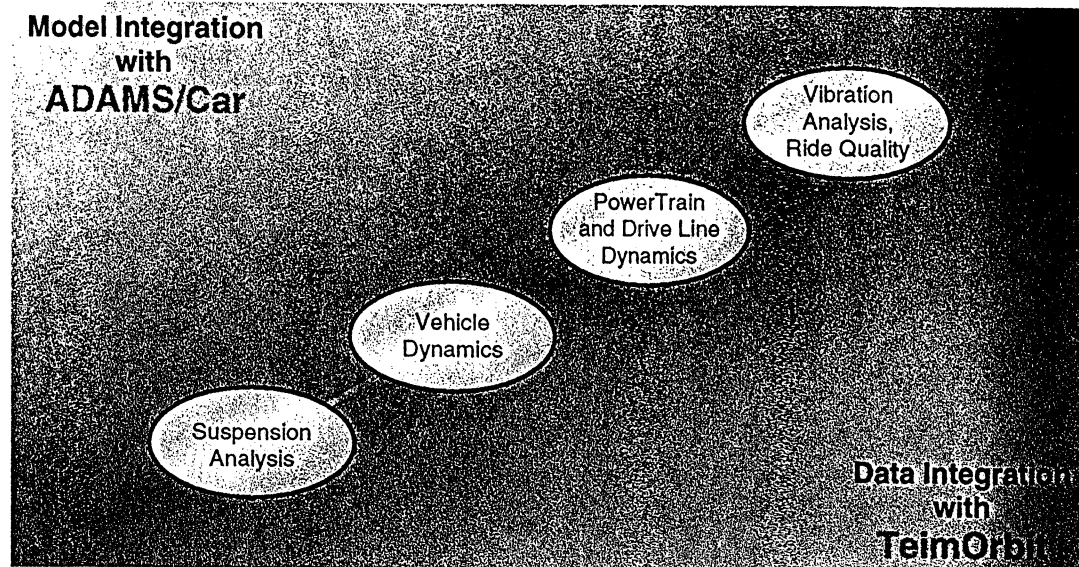
The wide range of ADAMS/Car applications requires a high transparency on the modeling level as well as on the data management level.

The functionality of the ADAMS/Car system with the fully parametric and modular model representation provides the required integration on the modelling level.

The main topic of the paper is the data management system TeimOrbit used to cover the integration on the data level with emphasis on the interaction with ADAMS/Car. The basic concept of the Audi engineering database system TEIM, the graphical user interface TeimOrbit and the structured data preparation for complete ADAMS/Car subsystems will also be presented.

## Introduction

### Fields of Application for ADAMS/Car



## Introduction - Fields of Application for ADAMS/Car

The importance of computer simulation in automotive engineering has increased significantly in recent years. The specialized vehicle simulation software **ADAMS/Car** has become a strategic CAE-tool in the product development process at Audi. ADAMS/Car is used in the fields of suspension analysis, vehicle handling dynamics, powertrain and driveline analysis as well as vehicle ride analysis (planned for the future) in order to accomplish the development process from the virtual product to the real product.

These fields of application cannot be treated independently from each other. Links between the different applications on the modelling level as well as on the data description level are obvious. The same suspension model, used in an elastokinematic analysis, should be incorporated in a full vehicle model for studying handling behavior. This is necessary for transferring the designed behaviour of the suspension assembly correctly into the full vehicle model. The same requirements must be fulfilled by the specific data describing a model. The required data for a suspension assembly is always a sub-part of the data describing the full vehicle model.

Covering this wide range of applications therefore requires a high degree of consistency and transparency both on the modelling level and also on the data level. The functionality of the ADAMS/Car system provides the required integration on the modelling level. The data management system **TeimOrbit** is used at Audi to integrate ADAMS/Car into the CAE-environment on the data level.

## Introduction

### Motivation for Data-Integration



### Simulation in the Product Development Process

- TeimOrbit is the standard data manipulation tool coupled to a relational database
- Data management independent from the CAE-Applications
- Access to test-data
- Data responsibility shared among the development departments

### ADAMS/Car Concept

- Fully parametric and modular model representation
- Separation of generic model structure (Template) from specific model data (Subsystem Files)

## Introduction - Motivation for Data-Integration

From the view of integrating CAE-simulation into the product development process, the main motivation for the data integration of ADAMS/Car was that TeimOrbit was already a standard data manipulation tool at Audi for many CAE-Applications with the added plus of a coupling to an existing relational database.

The ADAMS/Car database, a structured file system containing all model data in ADAMS/Car is very specific to ADAMS/Car itself. In the sense of integrating ADAMS/Car applications in the process of virtual prototyping, this kind of data should be available for other applications as well. In other words, data management and storage should be independent from specific CAE-Applications.

Another reason for introducing TeimOrbit as the data management system for ADAMS/Car was to provide access to test-rig data, such as measured bushing characteristics. This data is not only for use by ADAMS/Car, but also for other CAE-Applications, such as Finite-Element Analysis.

Furthermore, the company-wide responsibility for vehicle data is not only concentrated on single persons performing the simulations, but instead certain development departments are responsible for providing and maintaining correct data in the engineering database.

On the other hand, the concept of ADAMS/Car provides the two fundamental prerequisites for the database coupling: fully parametric and modular model representation and the separation of generic model structure (reflected in the ADAMS/Car template) from specific model data stored in subsystem files.



### **Engineering Database System TEIM**

- Structured collection of vehicle specific elements and assemblies in a data base
- Modular design of vehicle specific data objects
- Functionality based on a relational database (Data Integrity, Data Security, Data Consistency, ...)

### **Graphical User Interface TeimOrbit**

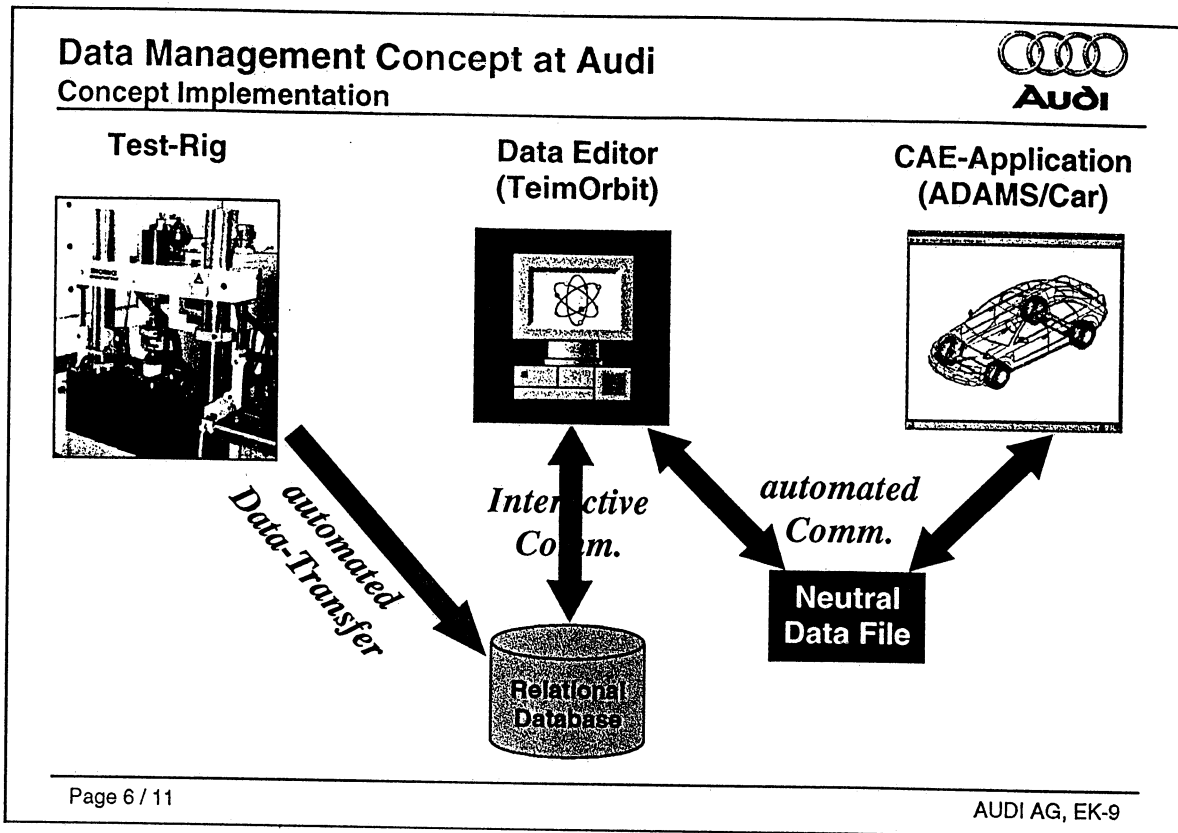
- Powerful Data Editor
- Data Selection Functionality
- Preparation of data files for vehicle specific applications (ADAMS/Car Database)

### **Data Management Concept at Audi - TEIM / TeimOrbit**

**TEIM** is a technically-oriented engineering database system designed at Audi for managing technical product data. The system provides a structured collection of vehicle-specific elements, such as parts, bushings, springs, dampers, etc. and complex assemblies in a relational database. The more complex vehicle-specific data objects are built up in a strictly modular manner. **TEIM** fully supports the functionality of a relational database with data integrity, data security, data consistency, etc.

Data selection and manipulation is supported by the graphical user interface **TeimOrbit**. This data management system provides data files for vehicle-specific applications like ADAMS/Car. In the case of ADAMS/Car the data files are written to the user's private ADAMS/Car database.

TeimOrbit is a commercially available product and has already gained a foothold among german automotive manufacturers.



### Data Management Concept at Audi - Concept Implementation

The data management concept at Audi is based on a relational database (ORACLE), the **TEIM Database**. The data editor in TeimOrbit communicates interactively with the TEIM database bi-directionally, extracting as well as writing data into the database. For selecting data, the user can specify his own selection criteria and set up filters.

The automated link to CAE-Applications such as ADAMS/Car is established via "**Neutral Data Files**". For ADAMS/Car the Neutral Data Files are **subsystem** and **property files** stored in the user's private ADAMS/Car database. The file format used for all ADAMS/Car data files matches the Neutral Data File definition of TeimOrbit. This enables ADAMS/Car and TeimOrbit to share and exchange data files directly in the ADAMS/Car database.

As mentioned before, the data management concept at Audi also supports automated transfer of measured data from test rigs to the TEIM database, for example bushing characteristics. On a test-rig for elastomeric bushings the characteristic force-displacement curves are recorded as are dynamic stiffness and loss angle.

For use in ADAMS/Car the recorded test-rig data has to be manipulated by applying regression or smoothing techniques to reduce the initial number of data points in a curve. Extrapolation techniques are used to extend the characteristic curves beyond the measured range in order to perform misuse loadcase analysis in ADAMS/Car.

**Data Management Concept at Audi**  
The Data Editor



The screenshot shows the TeimOrbit Data Editor interface. On the left is the **TeimOrbit Object Navigator** showing a tree structure of components. The main window displays a **Graphics Facilities** view of a bushing component with a table of **Editable Data**.

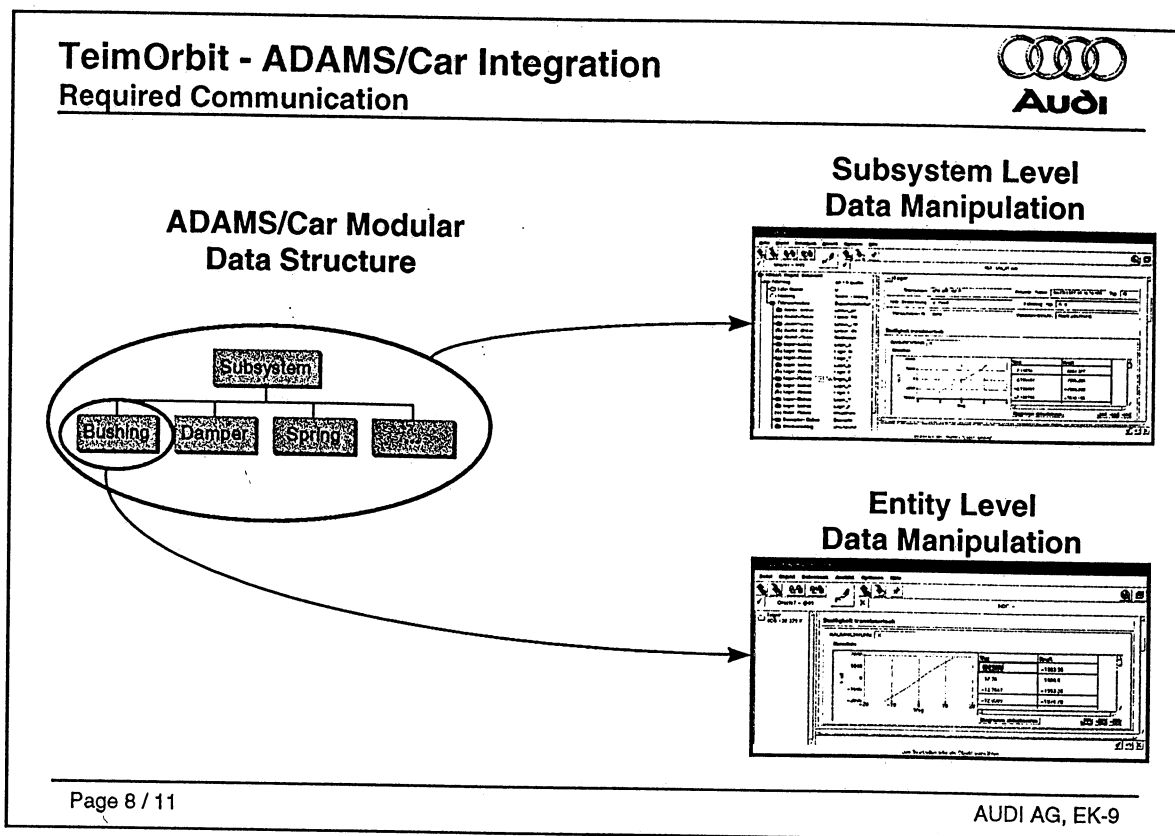
Koordinate	Wert	Einheit
-1.9574	-8061.327	
-2.195587	-7995.224	
-2.193451	-8027.295	
-2.180798	-7918.156	

**Data Management Concept at Audi - The Data Editor**

This screen shot shows a scenario for modifying an ADAMS/Car subsystem in TeimOrbit using spreadsheet facilities.

On the left-hand side of the TeimOrbit window, the **TeimOrbit Object Navigator** displays the structure tree of the subsystem with all entities. The user selects certain elements from the navigator by choosing them manually. The **TeimOrbit Object Browser**, invoked by the edit button displays all data for the selected element, for example a bushing, shown above.

Special icons are provided for the database communication and for read/write access to the neutral file level for communication with the CAE-Application (ADAMS/Car). TeimOrbit also offers some graphics facilities for viewing and manipulating bushing or spring characteristics.

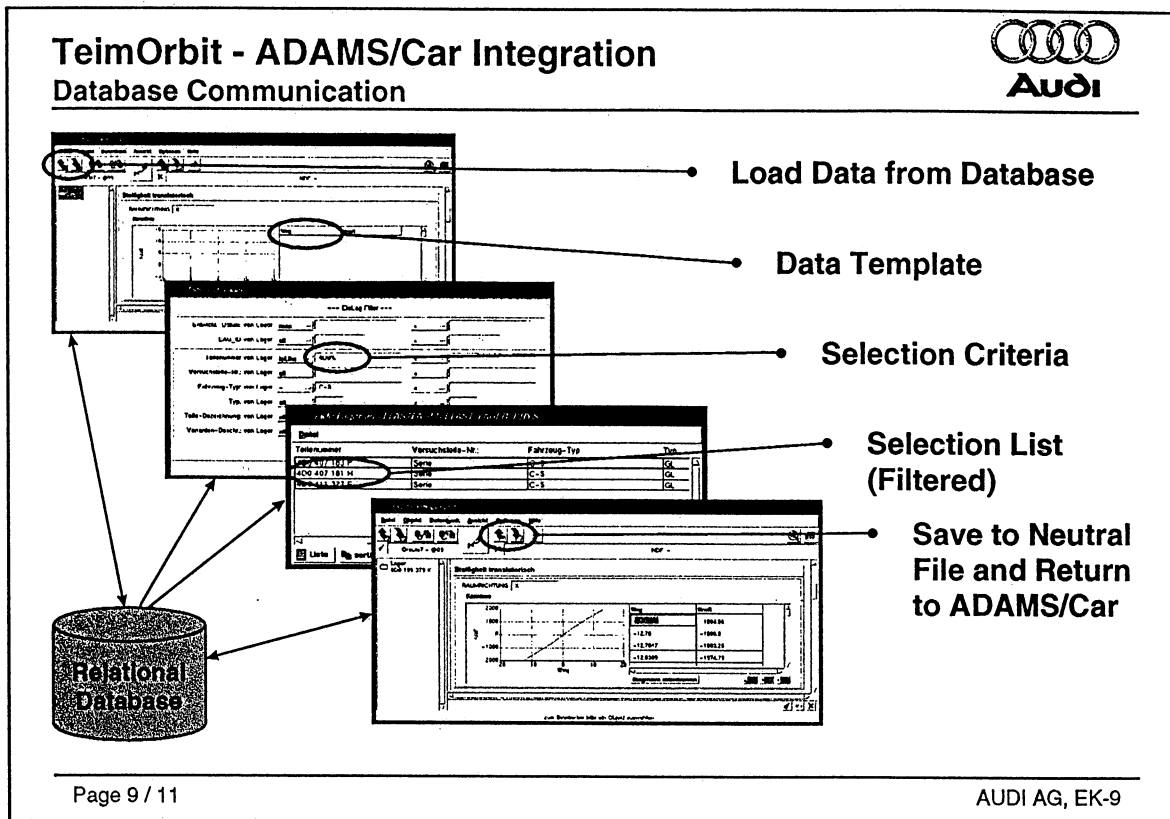


### TeimOrbit - ADAMS/Car Integration - Required Communication

The integration of TeimOrbit and ADAMS/Car has been implemented on **two** different **levels**: on the basic entity level and on the subsystem level.

ADAMS/Car follows a strictly modular modelling structure. An ADAMS/Car subsystem consists of certain basic model entities such as bushings, dampers, springs, etc. The TeimOrbit data editor can be used to manage model data for these basic objects as well as for editing complex subsystems.





### TeimOrbit - ADAMS/Car Integration - Database Communication

Through the implemented integration of ADAMS/Car and TeimOrbit, the ADAMS/Car user has full access to the extensive database communication functionality of TeimOrbit.

The major steps included in the communication with the relational database are illustrated above in the case of a bushing object.

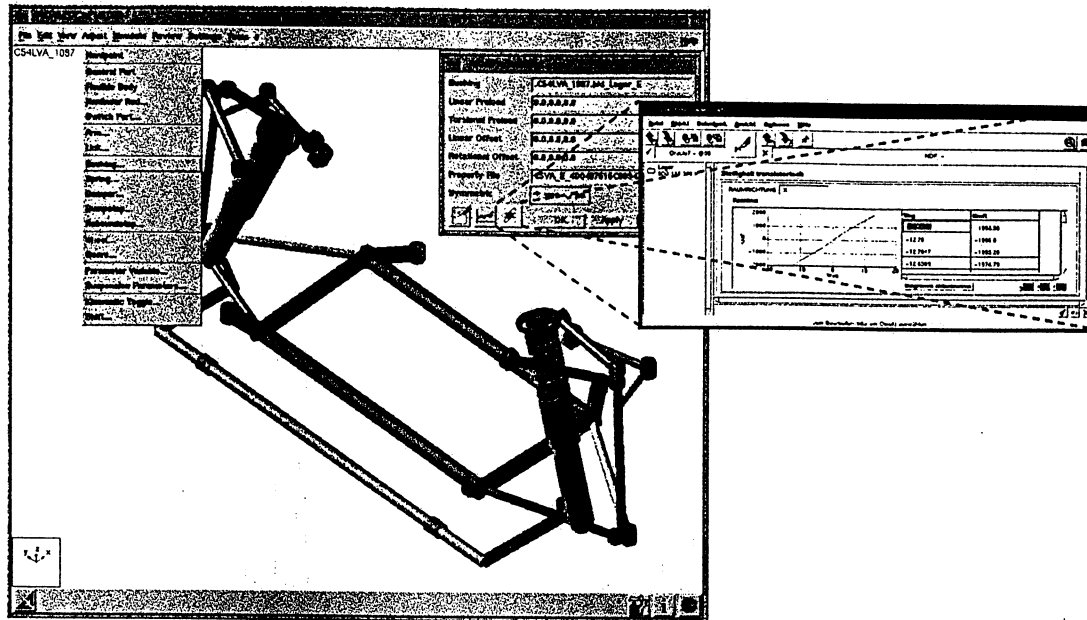
The database communication is initiated through the TeimOrbit data editor.

The user is able to define the data set using user-definable selection criteria. For example, it is possible to select bushings based on a certain vehicle assembly, a part number, a manufacturer or release status, etc. These selection criteria may also be abbreviated, or contain wild-cards for a broader selection.

Subsequently TeimOrbit presents the user a filtered list of bushings which match the selection criteria. From this list the user is able to select the required bushing, and load its' data from the database.

After selection of a bushing, the user may alter the data before saving to a neutral data file and returning to ADAMS/Car.

## TeimOrbit - ADAMS/Car Integration The Practical Implementation



Page 10 / 11

AUDI AG, EK-9

### TeimOrbit - ADAMS/Car Integration - The Practical Implementation

For Preparing and modifying model data, ADAMS/Car provides an easy-to-use graphical user interface together with special facilities such as the curve manager. Basic entities, e.g. a bushing, as shown above can be manipulated through the guided use of menus and dialog boxes.

Selecting a specific bushing to be modified through the “**Adjust**” menu, the appropriate dialog box pops up. Through the additional TeimOrbit button, introduced by the customized version of ADAMS/Car for Audi, the communication with **TeimOrbit** and thereby with the relational database **TEIM**, is initiated.

The **TeimOrbit** window for editing bushings is opened with the data for the currently selected bushing. The user can access the TEIM database and select bushing elements from the database using predefined selection filters. Saving the selected bushing data to a property file in the private ADAMS/Car database exits the TeimOrbit dialog and returns back to the ADAMS/Car environment.

The communication for the data management of complex subsystems in TeimOrbit is implemented in a very similar way.

Through the communication of ADAMS/Car and TeimOrbit the power of TeimOrbit for data management has been integrated in ADAMS/Car.



## Conclusion

### Efficiency increase through integration using:

- **Modular, Parametric and Consistent** modelling
- **Structured, Transparent, Redundancy-free and Consistent** data management
- **Automated analysis** for complex applications
- **TeimOrbit** as the data manager
- **ADAMS/Car** and **TeimOrbit** to provide a higher quality of simulation in **“Virtual Prototyping”**

**“Advancement through Technology” ... in CAE-Simulation**

## Conclusion

The general benefit from the integrated use of **ADAMS/Car** and the data management system **TeimOrbit** in the development process at Audi is a significant increase in efficiency of their use. The essential steps leading to more efficiency are listed above.

Overall a higher quality of simulation has been achieved in **“Virtual Prototyping”**, according to Audi's motto **“Advancement through Technology”** ... also in CAE-Simulation.