Education and Research - ADAMS-CAE Tool at the Aachen University of Technology

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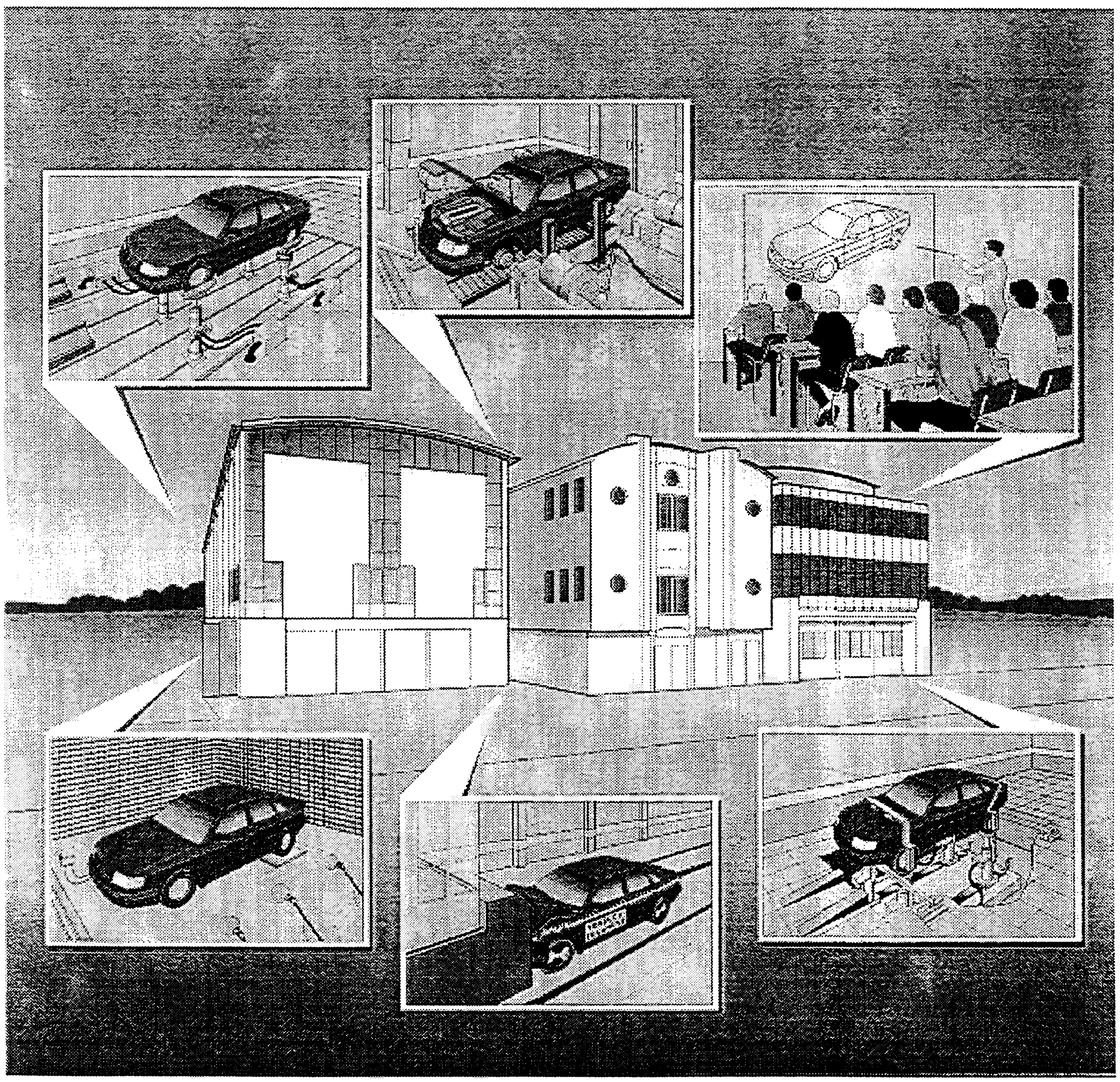

1 Introduction

ADAMS has been used at the Institute of Automotive Engineering of the Aachen University of Technology for several years. Various research-projects have increased the experiences with this simulation programme. From the beginning of the next term on we will also enable students to become familiar with ADAMS more intensively and we will start educating the students in working with this programme.

That's why the opportunity is taken within today's presentation to introduce the institute and its development- and education-programme. In the second part, some development-examples taken from the research programme will be shown by presenting a project which was realized in cooperation with Continental AG.

2 Education and Research at the ika

This summer the Institute of Automotive Engineering moved into new buildings in Aachen-Melaten. Thus, the employees of the institute find ideal work conditions concerning education and research.

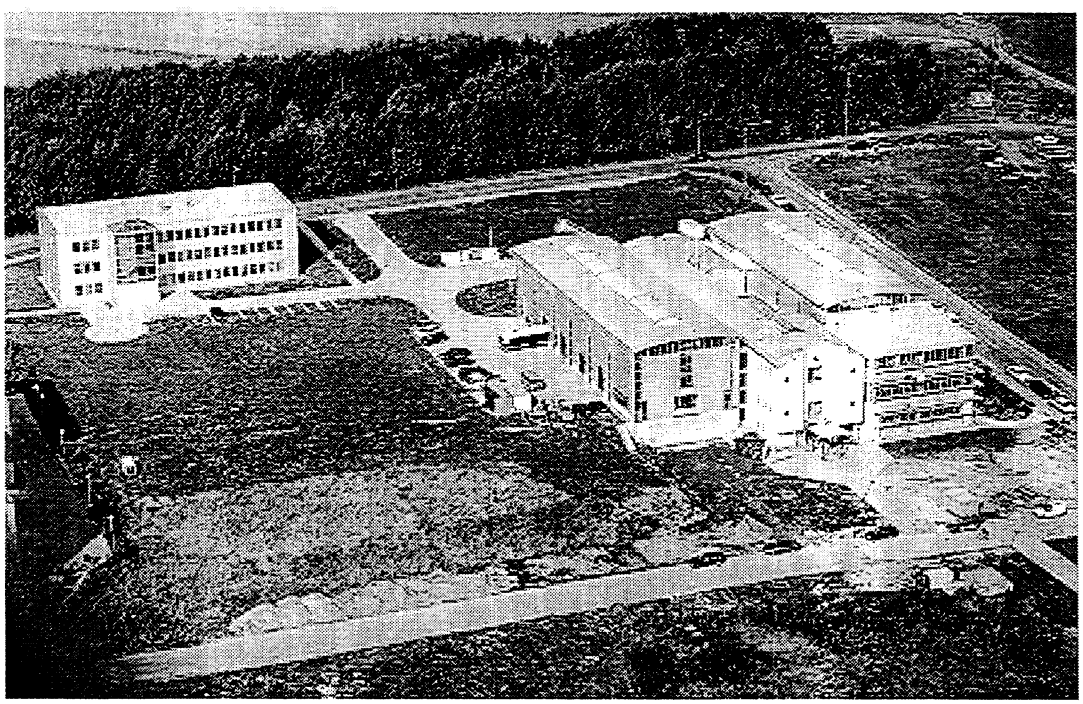

Fig. 1: Institute of Automotive Engineering - New buildings

The possibilities in research and development are of great variety at the institute and they cover the following fields:

- Chassis
- Body
- Drive-train
- Electronics

and • Acoustics.

Besides simulation-accounts at the computer, numerous experiments can be carried out. Moreover, the institute holds its own test track which can be used for driving tests in different conditions.

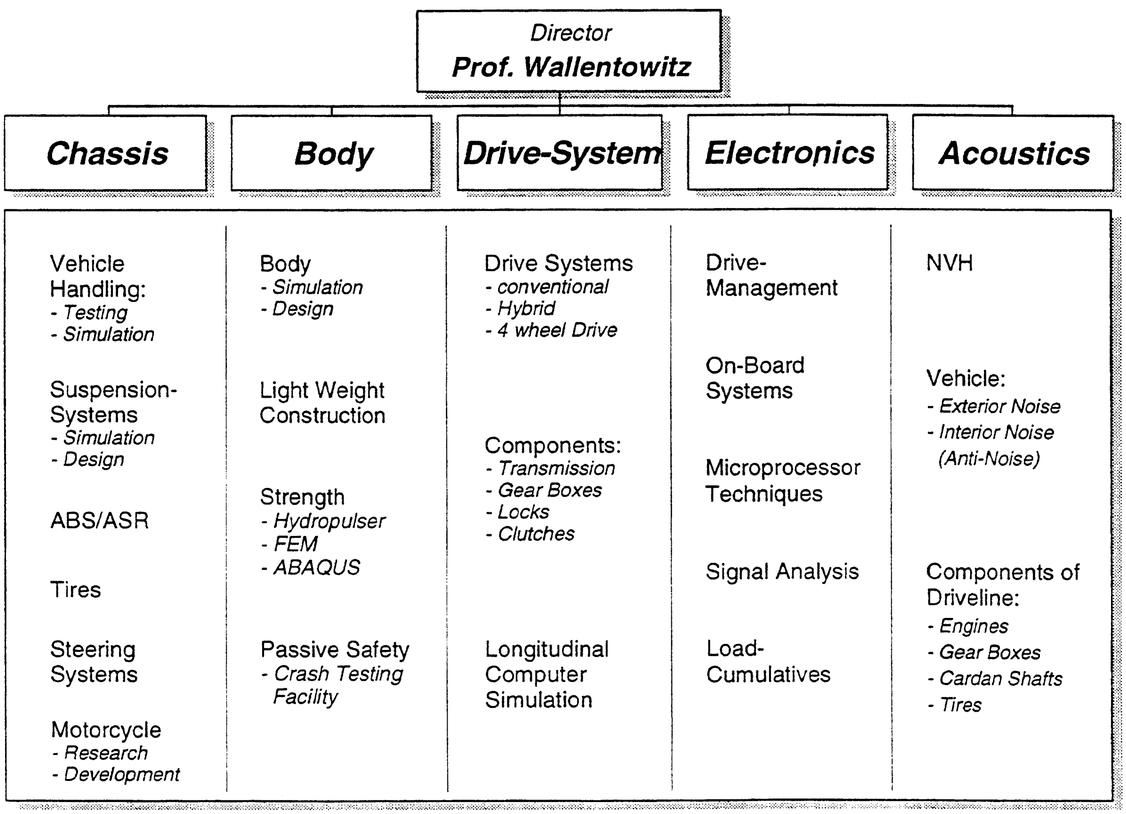

Fig. 2: Institute of automotive Engineering: Elements of Lecture and Research

The design of the new buildings clearly demontrates the special relation towards education which led to the installation of a lecture hall, a PC-laboratory and a laboratory for psycho-acoustics. Offices and drawing rooms for students and employees, a technical library and CAD-facilities complete the installations refering to lecture and practice.

	I. VEHICLE DRIVE SYSTEM		II. CHASSIS		III. BODY	
BASIC KNOWLEDGE	(5. term) Longitudial Dynamics Power Requirements Drive System Power Transmission Transmission, Brakes		(6. term) Vertical & Transverse Dynamics Driving Stability Spring System Suspension		(7. Term) Safety Aerodynamics Passenger Compartment Electronics, Hydraulics	
INCREASED KNOWLEDGE	**Plastics for Vehicles** Wallentowitz, Michaeli	Pf	**Computer Technology in Automotive Engineering** Wallentowitz	Pf	**Noise Emission of Vehicles** Biermann	W Doz
	Fibre Reinforced Plastics (FRP) for Vehicles Wallentowitz, e.g.	W	**Practical Course for Computer Applications** Wallentowitz	W	**Noise Preventation** Biermann	Z Doz
	Material Applications for mechanical engineering Maier, Wallentowitz, e.g.	W	**Unconventional Drive Systems** Wallentowitz	W	**Industrial Development of Trucks** Schittler	W LA
	Aerodynamics Kramer	W Doz	**Motor-Cycles** Wallentowitz	W	**Industrial Development of Passenger Cars** Sorgatz	W LA
	Agrar-Engineering I Gego II Kromer	W LA	**Fluid-Technics for Mobile Applications** Murrenhoff, Wallentowitz	W	**Industrial Development of Drive Syst. Passeng. Cars** Kalkert	W LA

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Pf -Compulsory Lecture **LA** -Invitation to Lecture **Doz** -Lecture **W**- Optional Lecture **Z**- Postgraduate studies

Fig. 3: ika teaching offer with external lectureships

At the Aachen University of Technology the Institute of Automotive Engineering is responsible for the sector „Automotive Engineering", which is one of almost 20 extention subjects students at the faculty of mechanical engineering can choose. After having passed their pre-examination, the students are prepared for their profession as an Automotive Engineer through diverse lectures.

The combination of research and education at the Institute of Automotive Engineering can be found once more with regard to the use of the CAE-Tool ADAMS.

The assistants of the institute have been working with ADAMS for a longer period. Because of frequent requests by the automotive industry and also because of the own demand for engineers with experience in working with ADAMS, the education in using this simulation-programme is included explicitly in the ika teaching offer.

In principle, ADAMS is lectured in two presentations:

- the lecture „Computer Technology in Automotive Engineering"
- the PC-Laboratory „Introduction in the Multibody System Analysis ADAMS"

The lecture „Computer Technology in Automotive Engineering" is one of the compulsory subjects of any student of automotive engineering in 7th term. The essence of this lecture is demonstrated in Fig. 4.

Computer Technology in Automotive Engineering

1. Introduction

2. Sensors for Automotive Employment

3. Conditioning of Analogue Signals

4. Digital Signal Analysis

5. Creation and transmission of control signals

6. Measurementsystems for vehicle testings

7. Simulation Methods

8. The Multibody System Analysis Software ADAMS

9. The Trafficflow-Programme PELOPS

Fig. 4: Essence of the lecture „Computer Technology in Automotive Engineering“

In the course of a general introduction to simulation techniques, this lecture also covers the multibody system analysis ADAMS in a seperate presentation. The essential components of this presentation are:

- the history of multibody system analysis programmes and the creation of ADAMS
- description of the programme
  - creation of models
  - tire model
  - steering manouevres and power transmission
  - course of calculations
  - possibilities for the presentation of results
- further elements of ADAMS

The important point of this lecture isn't the education in programming ADAMS but the transmission of the actual working method of the programme and the publishment of fundamental elements.

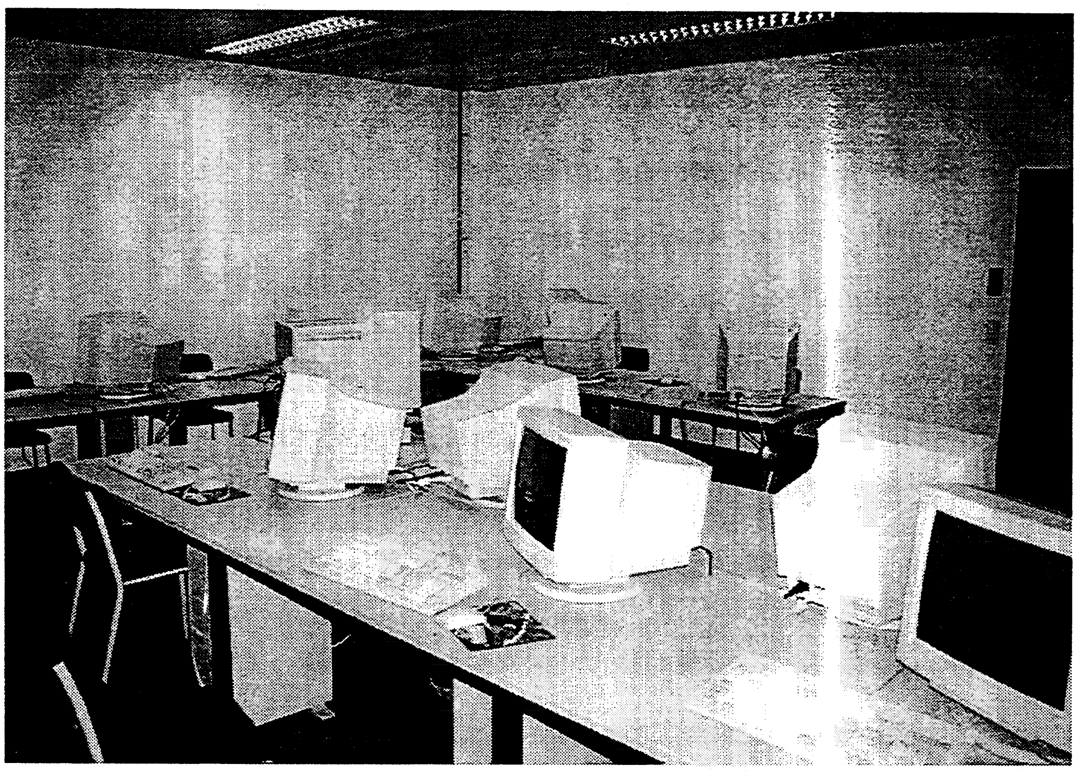

Fig. 5: PC-Laboratory at the Institute of Automotive Engineering

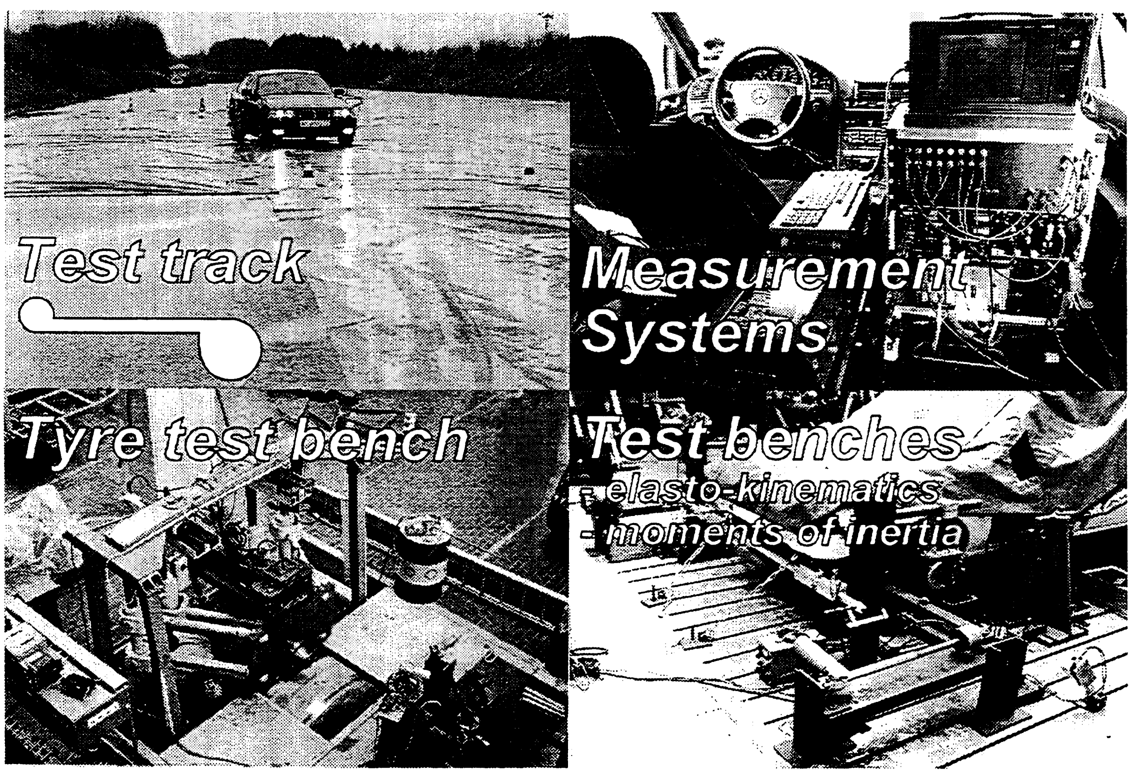

Fig. 6: Testequipment of the ika supporting vehicle-dynamics-simulation

Within the second lecture-presentation, which is the PC-Laboratory „Introduction in the Multibody System Analysis ADAMS", the student is able to become familiar with the programme. He himself carries out exercises at the computer with ADAMS. For this purpose, 12 Penthium-PC with 32 MB-Ram were donated by the companies „Kober" and „Lemförder Metallwaren" and are equipped with ADAMS-PC-versions.

Some students get the possibility to work as a „Student Assistant" beyond this laboratory and to assist directly in industrial projects. Just because of the equipment of the institute with test-benches, equipment for driving tests and computers for ADAMS, a complete examination of this subject matter is possible.

By the help of diverse equipments there is the possibility for the differents fields of vehicle-dynamic-examination.

- Data determination
  - Tyre test bench for measurement of longitudinal and lateral forces as well as rolling resistance and noise
  - Test bench for investigations on axle-kinematics and elasto-kinematics
  - Test bench for definition of centre of gravity and moment of inertia of vehicle-parts and of total vehicles.

- Creation of models on diverse computers (workstation and PC)

- Validation by the help of the results from driving tests at the own test track

An example which is typical of a research-project that was realized at the Institute of Automotive Engineering in close cooperation with the industry is the „Development of a semitrailer truck simulation-model". This project was executed in cooperation with Continental AG and is presented in the following part.

3 Development of a semitrailer truck simulation-model

This part of the paper deals with the cooperation of the institute of automotive engineering with industrial partners. With the Continental AG / Hannover we worked together at a 40 t semitrailer-truck model. Because of earlier experiences with truck models the ika built and validated the model for different load conditions and ride-maneuvers.

The measurements of the truck-geometry was done by Continental. Some special quantities could be taken from earlier models we have built.

The truck runs with a Pacejka tire-model, that was built by Continental. Also the measurements of the tire and the curve-fitting for the Pacejka-parameters were done by Continental. Coupling with the truck-model is made by the TIRE-statement and the tirsub-subroutine, that calls some other user-written-subroutines, e.g. for initialisation.

In order to connect tire-model and vehicle-model with the right signs and to investigate the tire-model, a tire-tester was used. In this model, the tire is coupled with a part, that is lead in translational x-direction. After loading the system, with stationary or quasistationary rotation of the tire about the slip-axle or the camber-axle, the behaviour of the tire can be investigated.

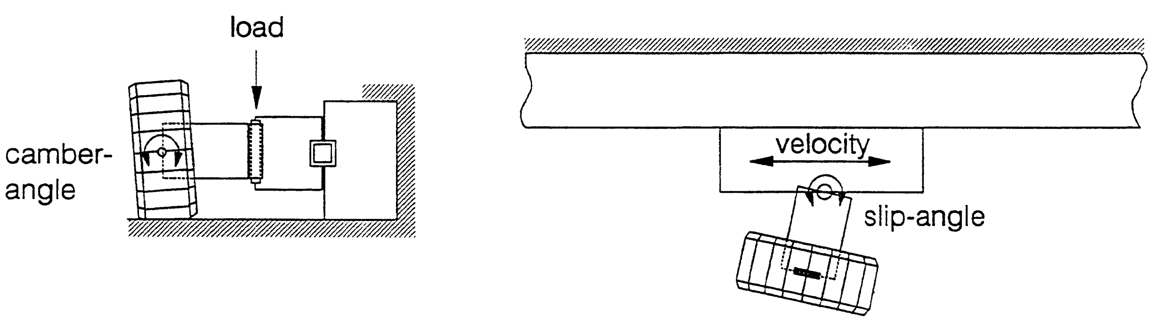

Fig. 7: Tire-tester

The truck-model consists of a tractor that is devided in two body parts and a semi-trailer, that was first build as a one-body-part and then devided in up to five parts to investigate the according influence. The complete model has 110 degrees of freedom for the two-part semitrailer

The tractor is devided into a front-part, that summarizes driver-cabine, drive-unit and front-axle-mountings as well as a rear-part with rear-axle-mountings and couple-unit. Front and rear body of the tractor are connected by a revolute-joint so that a torsional displacement is possible. The torsional stiffness is modelled by a rotational-stiffness parallel to the revolute-joint. The torsional stiffnes of the tractor-frame was measured by the vehicle-manufacturer.

The front-axle leaf-spring was modelled by a translational stiffnes in front and behind the axle at each side. The front part of the leaf-spring, that takes the guide function of the axle, was replaced by a stiff part with the same length and the same connecting-points at frame and axle like the leaf-spring. It is coupled with revolute joints to the frame at both sides and coupled to the axle with a spherical at one side and an inline-primitive at the other side. The anti-roll-bar for the front-axle is modelled by five beam-statements.

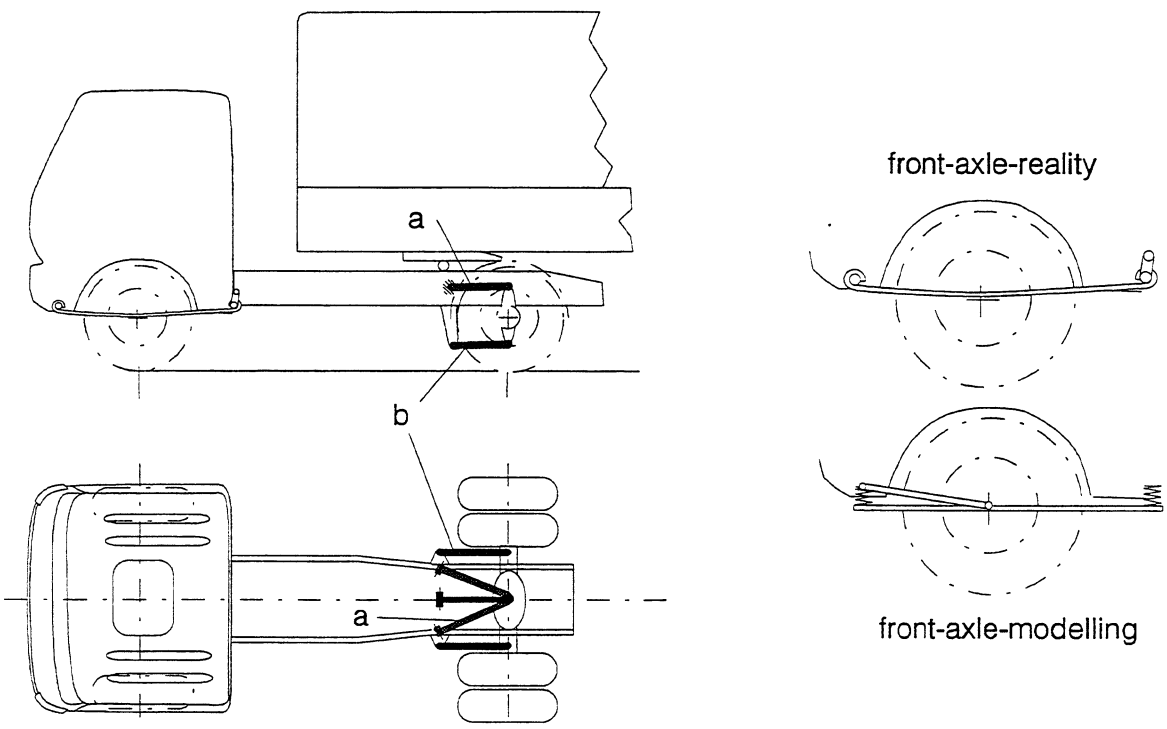

Fig 8: Tractor-model

The rear-axle is supported by two air-springs for each side. This air-springs were modelled as stiffnesses in the working point and they are different for the unloaded and the loaded truck-model. The guiding of the rear-axle is done by two trailing-arms that are mounted deeper than the tire-center and have bushings for the frame-connection and sphericals for the axle-connection. A 'V-formed' arm takes the lateral control for the axle in reality. In the model a kinematic equal ability can be reached by a trailing-arm, that is connected to the frame with a revolute-joint. At the rear-axle there is also an anti-roll-bar, that consists of five beams.

Coupling of tractor and semi-trailer is realized by a universal-joint, that allows the relative motions 'yaw' and 'pitch' between the two vehicles.

The three-axle semitrailer consists of a body, that has torsional stiffnesses realized like those of the tractor. Different bodies were investigated such as total stiff bodies up to bodies with four torsional degrees of freedom. The semitrailer with four degrees of freedom has revolute joints between the king-pin and a middle-part, the middle part and the first axle and between first-second and second-third axle.

The semitrailer air-springs are guided by trailing-arms, that are formed of spring-steel and act as anti-roll-bars for the semitrailer. In the model, this drivers are build by beam-statements with revolute-joint-connection to the frame and fixed-joint-connection to the axle.

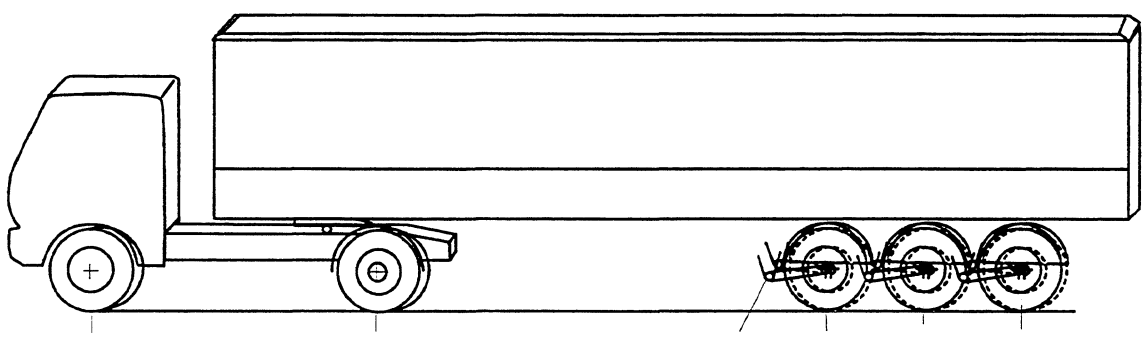

Fig 9: Roll-movement of the semitrailor-axles

To use the model in a modular way, that means in this case to change the wheel-base simply, the rear axle of the tractor and the axles of the semitrailer aren't connected direct to the frame but connected to a subframe. Springs, shock-absorbers and joints work between axle and subframe. Subframe and mainframe are connected by fixed joints. All part-coordinate-systems of parts belonging to one axle have their origin in the x-z-coordinates of the tire-center. The Marker-coordinates of the parts belonging to this axle are always related to the tire-center. To change the wheelbase, only the part-coordinate-systems have to be changed to another x-coordinate. By this way, the changing of about 10 coordinates can move the whole axle.

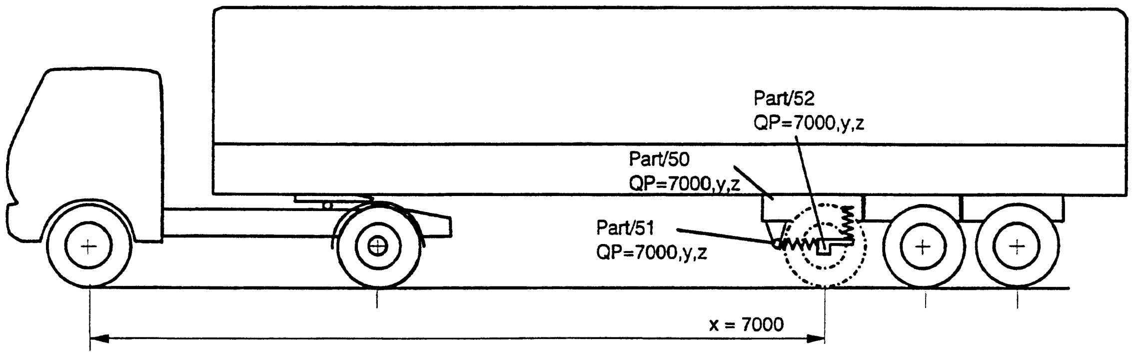

Fig 10: Modular construction of the model

For static investigations of its behaviour, the model can be build up on a test-rig. The tires are replaced by simple springs with the according radial stiffness. Depending on the investigation, the body-frame can be mounted to the ground und e.g. the tire-patches can move in z-direction, specially for toe-curves of passenger-cars. With this test-rig the steering-kinematic between right an left front wheel was investigated.

For controlling the different driving-maneuvers, the adm-file contains the steering-gear-motions for each maneuver. With the according acf-file, all motions become deactivated except that one which is needed for the desired maneuver. So with one model-file all maneuvers can be executed.

For holding the desired course, the steer-angle can be given as a time function (e.g. sinusoidal steer) or be computed by a controler (e.g. stationary state cornering) so that the course-radius keeps constant. The controler for stationary state cornering used in the model is a serial connection of a PD- and a PT_1- controler based on the comparison between expected and real yaw rate for the current velocity.

$$u = \dot{\Psi}_{expected} - \dot{\Psi}_{real} = \frac{v_{veh.}}{radius} - \dot{\Psi}_{veh.} \qquad \text{(controler-input)}$$

$$x = K_1 \cdot u + K_1 \cdot T_v \cdot \dot{u} = K_1 \cdot (u + T_v \cdot \dot{u}) \qquad \text{(PD-element)}$$

$$y = K_2 \cdot x - T \cdot \dot{y} \qquad \text{(PT}_1\text{-delay-element)}$$

After substitution, the equation of a PDT_1 -element can be received:

$$T \cdot \dot{y} + y = K \cdot (u + T_v \cdot \dot{u}) \qquad \text{(PDT}_1\text{ - element)}$$

The input-variables $v_{veh.}$ and $\Psi_{veh.}$ are known in the simulation. So the variable u can be computed. The controler-output-variable y is transferred as input for the steering motion.

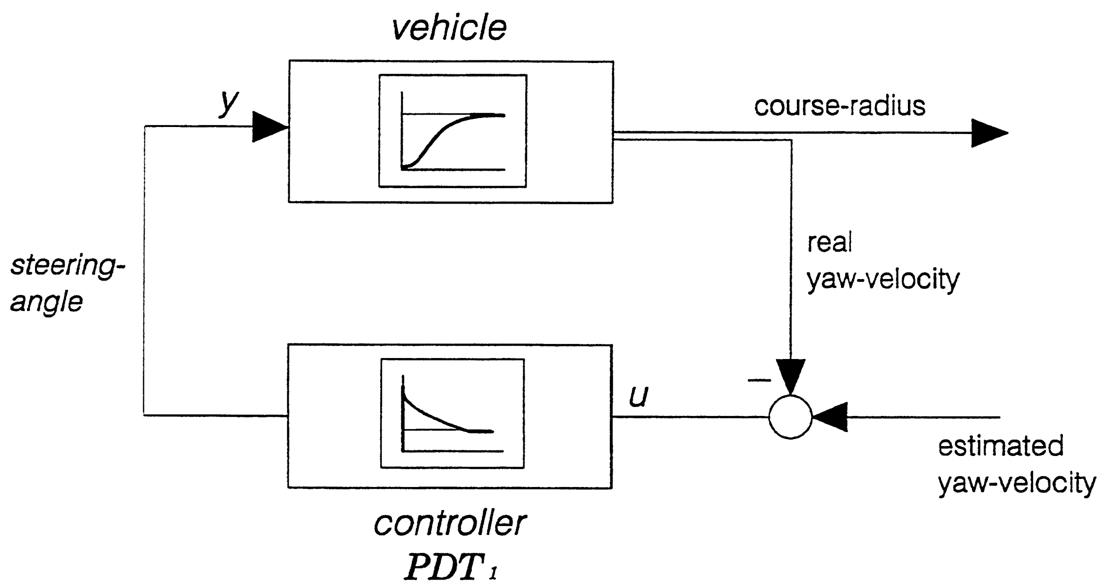

Fig 11: Feedback control system for stationary state cornering

The driving moments are also selected in the acf-file. Depending on the driving maneuvers, the different possible driving moments for a rising (stationary state cornering) or a constant velocity course (e.g. sinusoidal steer) are selected by deactivating the unwanted moments. The desired moment is determined by comparison of expected and real velocity.