1994 International ADAMS User Conference
Dr. Andreas Riedel, IPG

ADAMS and IPG-DRIVER

A powerful combination for advanced vehicle dynamics analysis

Based on a cooperation agreement between IPG and TEDAS Mechanical Systems the vehicle dynamics and real-time simulation tools of IPG actually get interfaces to the world of ADAMS. Integration work is done commonly by IPG and TEDAS, and it is supported by MDI.

The presentation shows, using the example of IPG-DRIVER, which new possibilities ADAMS users get for vehicle dynamics simulation.

IPG-DRIVER is a simulation model of a real driver, which allows simulation of driver's control actions when driving a car. IPG-DRIVER acts on the vehicle by steering, braking, accelerating, gear shifting and operating the clutch. Necessary inputs to the driver model are mainly the course of the road and the actual motions of the vehicle such as position and orientation as well as the vectors of velocities and accelerations of the car body. The user can define different kinds of drivers and driving tasks by setting easy-to-understand parameters. Essential for the robustness of the model in daily work is it's ability to adapt itself at the dynamics of the specific vehicle, and to learn and remember vehicle's properties.

Customers like Ford, Mercedes-Benz, Porsche or Toyota are using IPG-DRIVER to simulate the driving behavior of passenger cars, trucks and race cars in a wide variety of situations. Some examples give an impression of the new applications which become possible now to ADAMS users.

With IPG-DRIVER, ADAMS users in automotive industry can benefit in multiple ways. But whatever a user is investigating in detail in realistic closed loop simulations, he will always produce better and more impressive results than with open loop simulations. And by focussing tests and experiments accordingly, car manufacturers and suppliers can produce better products in shorter time and at less costs.

IPG

ADAMS and IPG-DRIVER

A powerful combination
for
advanced vehicle dynamics analysis

Breakdown

- Introduction
- Basics of IPG-DRIVER
- Examples
- ADAMS and IPG-DRIVER
- Summary

About IPG

- **„IPG“ = Ingenieurgemeinschaft Prof. Gnadler**
- **Software company in Karlsruhe, South-West of Germany**
- **Founded in 1984**
- **Software development and engineering for automotive industry**
- **Specialized in**
  - Vehicle dynamics analysis (e.g. IPG-DRIVER, IPG-TIRE, IPG-TEST)
  - Real-time simulation / hardware in the loop (e.g. MESA VERDE, IPG-CONTROL)
- **Customers**
  - Mainly german and european car manufacturers and suppliers
  - Many of them using ADAMS

Cooperation IPG – TEDAS Mechanical Systems

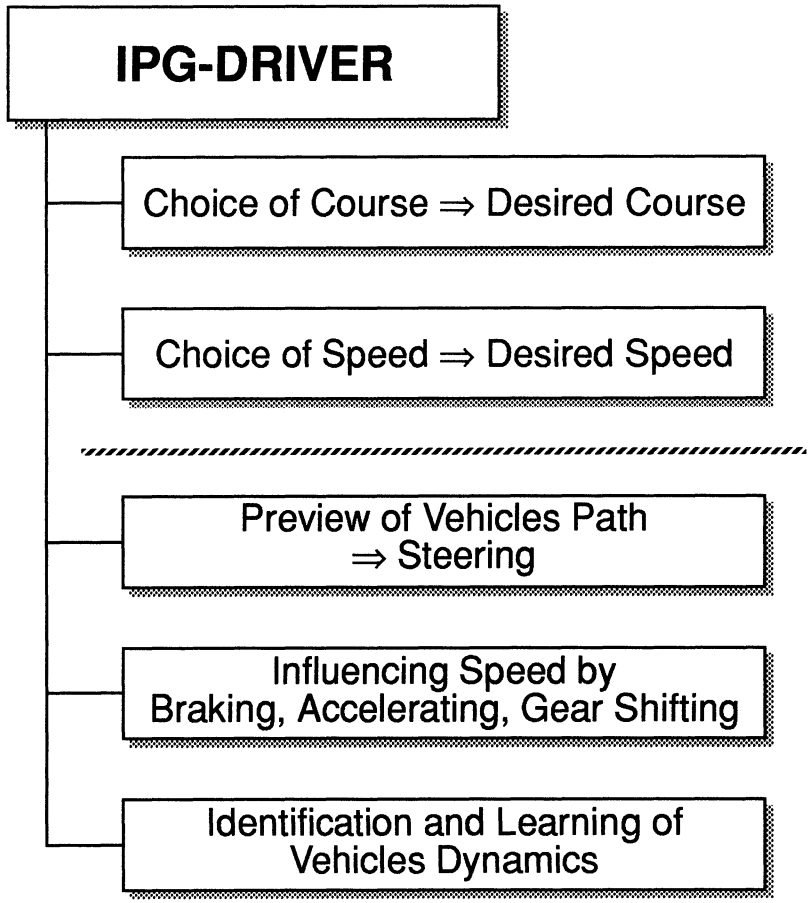
- **Cooperation agreement signed recently (April 1994), supported by MDI**
- **Goals of the cooperation**
  - Optimized integration of IPG's vehicle dynamics tools into ADAMS simulation models
  - Realization of an ADAMS – MESA VERDE interface for real time simulation
- **Schedule**
  - First half year 94: interfaces ADAMS – IPG-DRIVER and ADAMS – IPG-TIRE
  - Second half year 94: interfaces ADAMS – MESA VERDE and ADAMS – IPG-TEST

⇒ **First step: ADAMS – IPG-DRIVER**

Rough structure

Input

- **User input**
  - Course of the road
  - Driver definition
  - Task definition
- **Prior knowledge**
- **Input from vehicle model**
  - Actual vehicles motions
  - Engine speed



Output

- **Vehicle model**
  - Steering wheel angle / steering wheel torque (users choice, dependent on vehicle model)
  - Accelerator position
  - Force on brake pedal
  - Position of clutch pedal
  - Gear number
- **New knowledge**
- **Protocols**

Practical use

- FORTRAN77 package
- Only one FORTRAN interface subroutine needed
- Linking into any vehicle model possible
- No modifications of differential equations necessary
- Short computation time
- No determination and optimization of driver parameters „by hand“

  Learning and adaptation is done fully automatically

⇒ IPG-DRIVER is a tool for engineers daily work !

Customers and applications

- **Active customers**
  - AUDI (D)
  - BOSCH (D)
  - FORD (D)
  - INRETS (F)
  - MERCEDES-BENZ (D)
  - OPEL (D)
  - PORSCHE (D)
  - SIEMENS (D)
  - TOYOTA (J)

- **Applications**
  - Vehicles:
    passenger cars of all sizes, trucks with trailers and semitrailers, race cars
  - Standard handling tests:
    steady state turn, braking in a turn, ISO lane change, cross wind, braking on split-μ, ...
  - Optimization of vehicles with feedforward and feedback control systems:
    anti lock systems, 4WS, driver assistance systems, integrated vehicle dynamics control, ...
  - Setup of race cars to a given track:
    gear ratio, aerodynamics, ...

IPG

ISO lane change

Vehicle

Passenger car
Lower middle class

Velocity

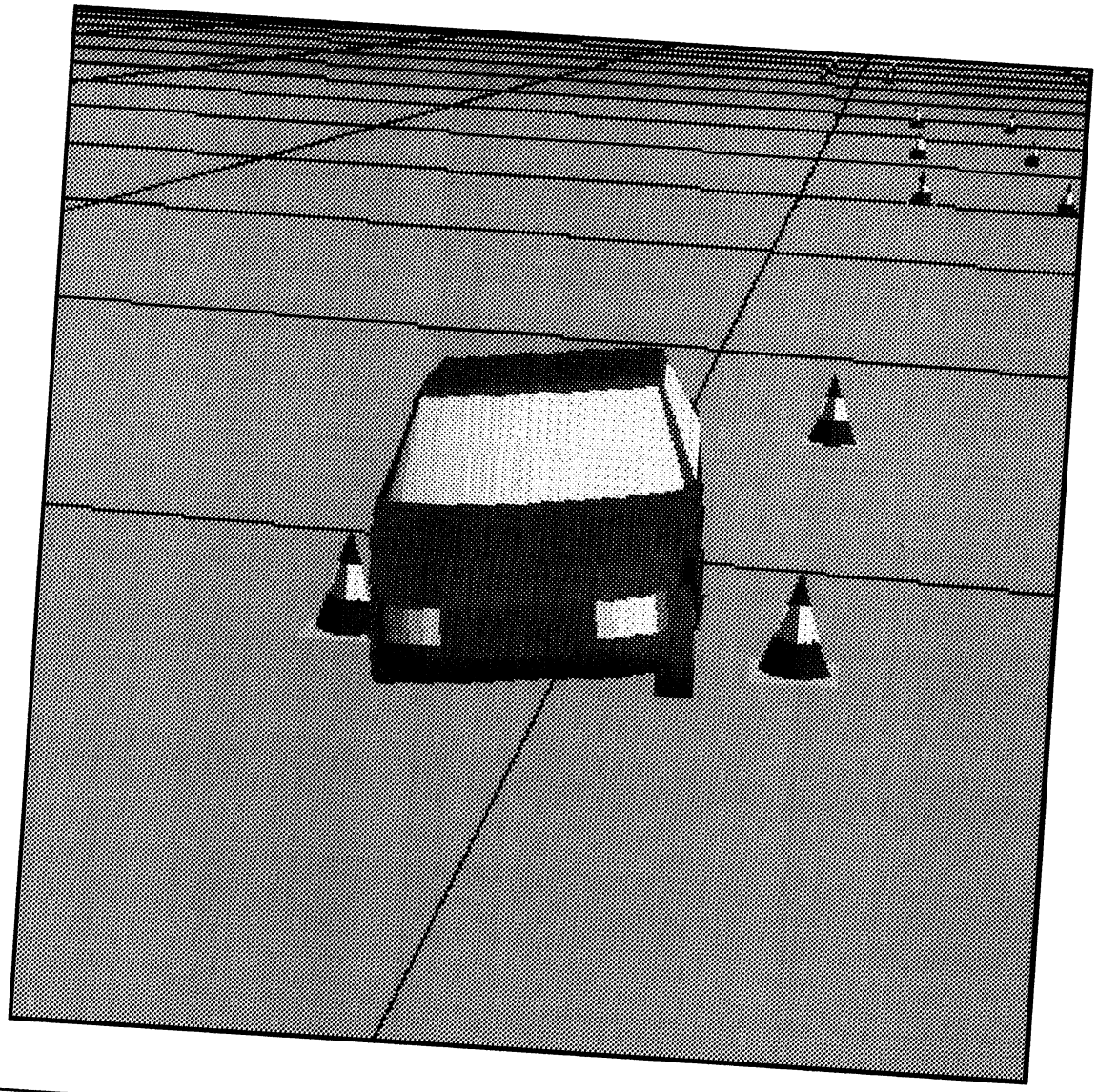
v = 100 km/h = 62 m.p.h.

Parameter

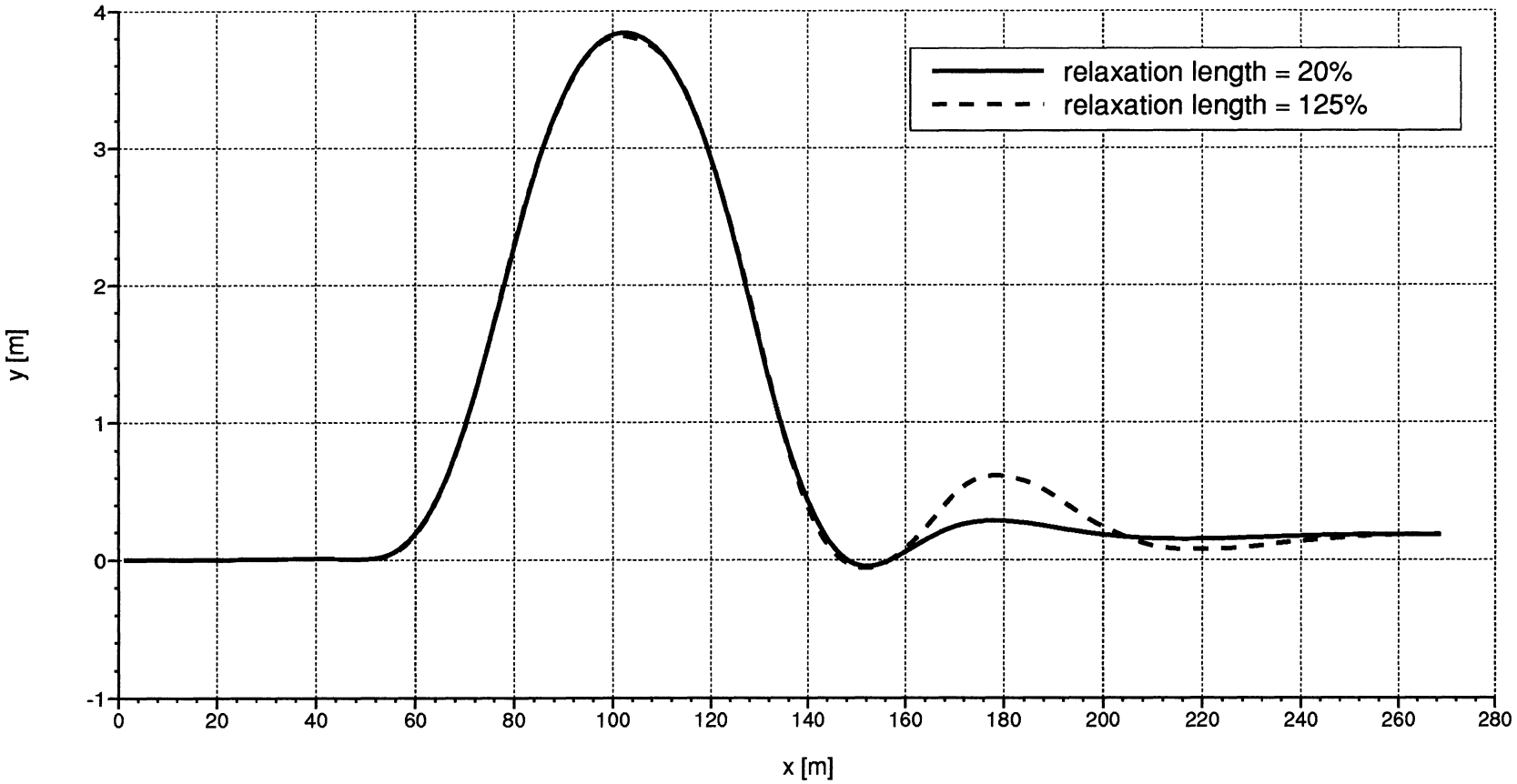
Tire properties

Relaxation length

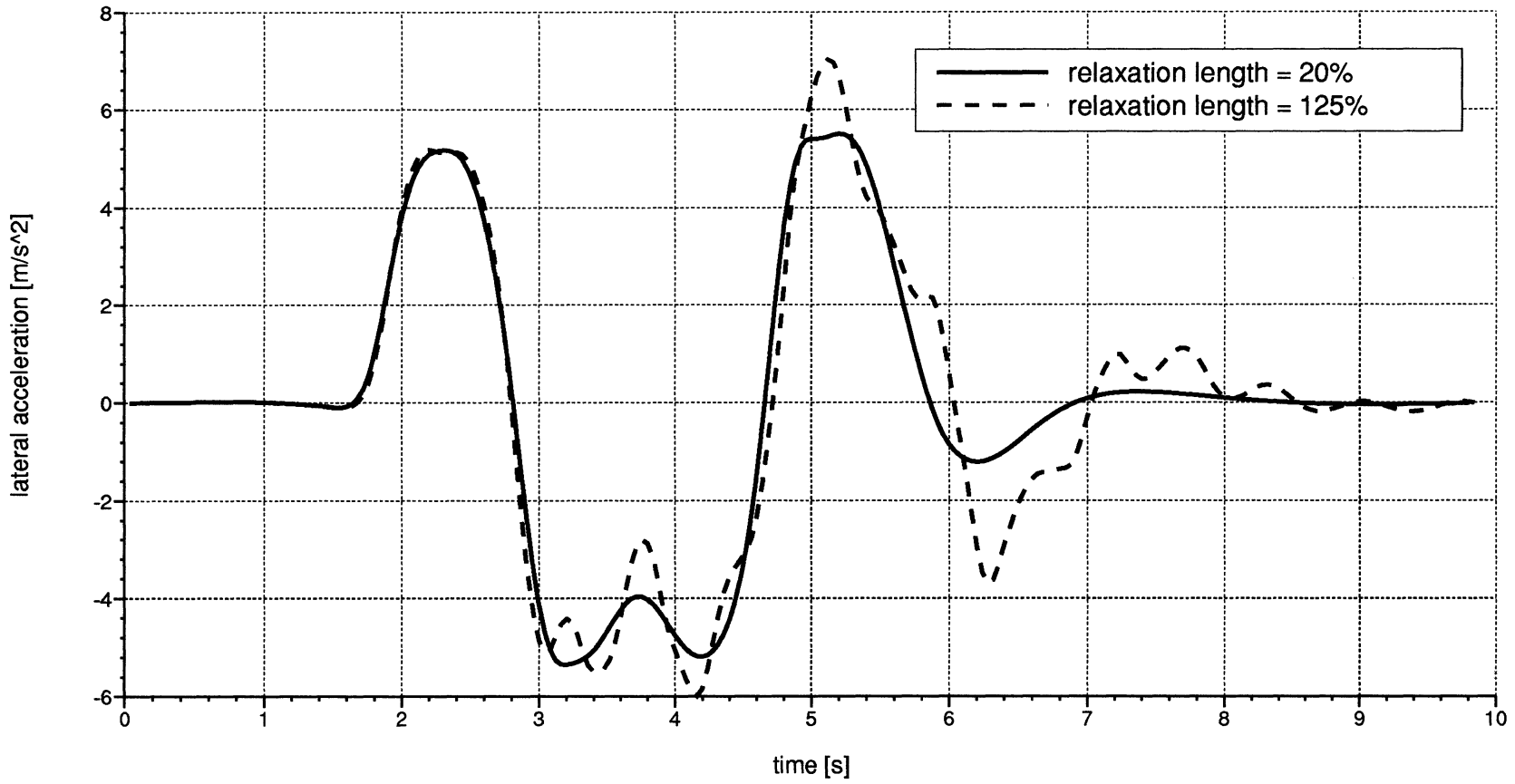
- rl = 20% of circumference
- rl = 125% of circumference



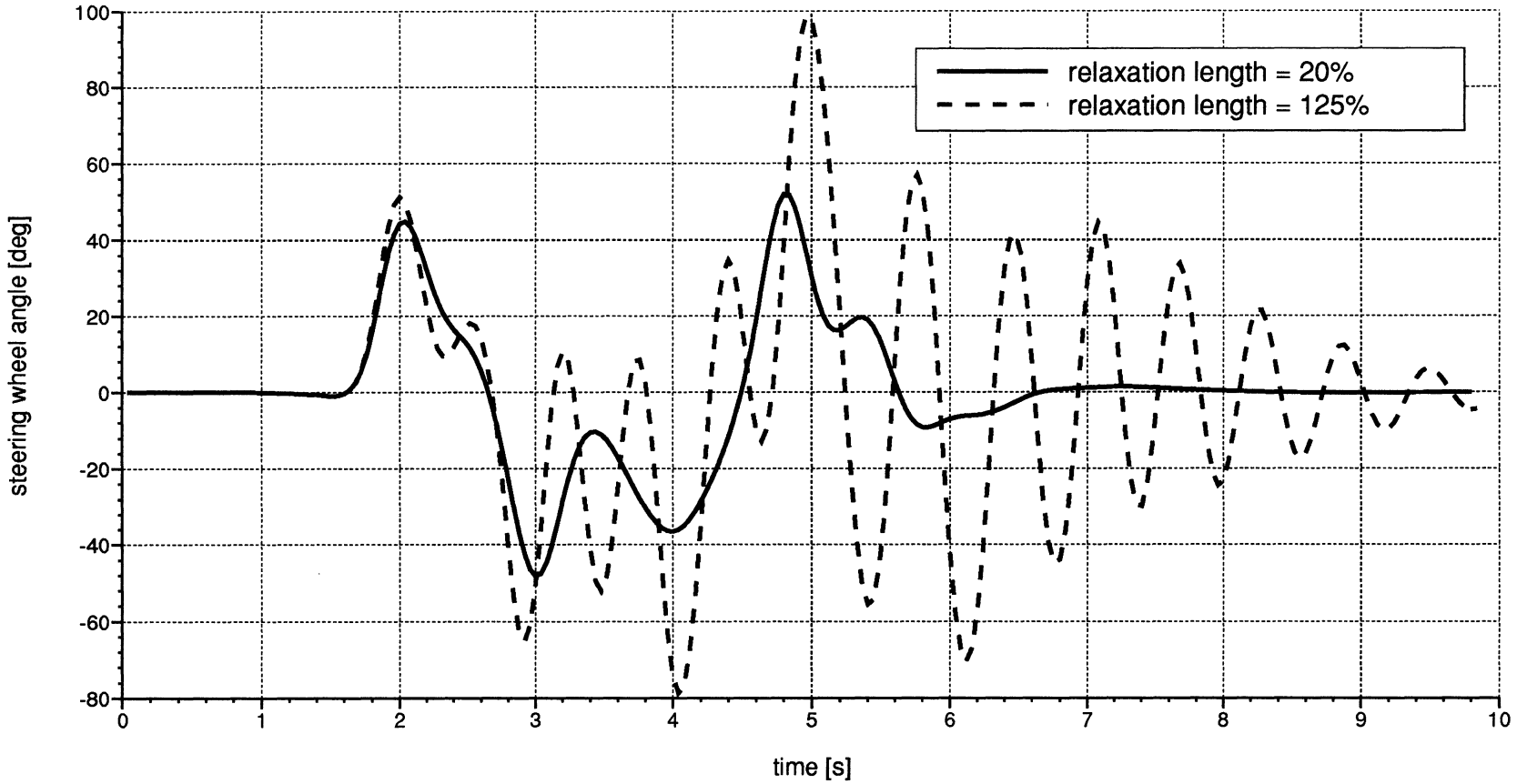
Trajectory of COG



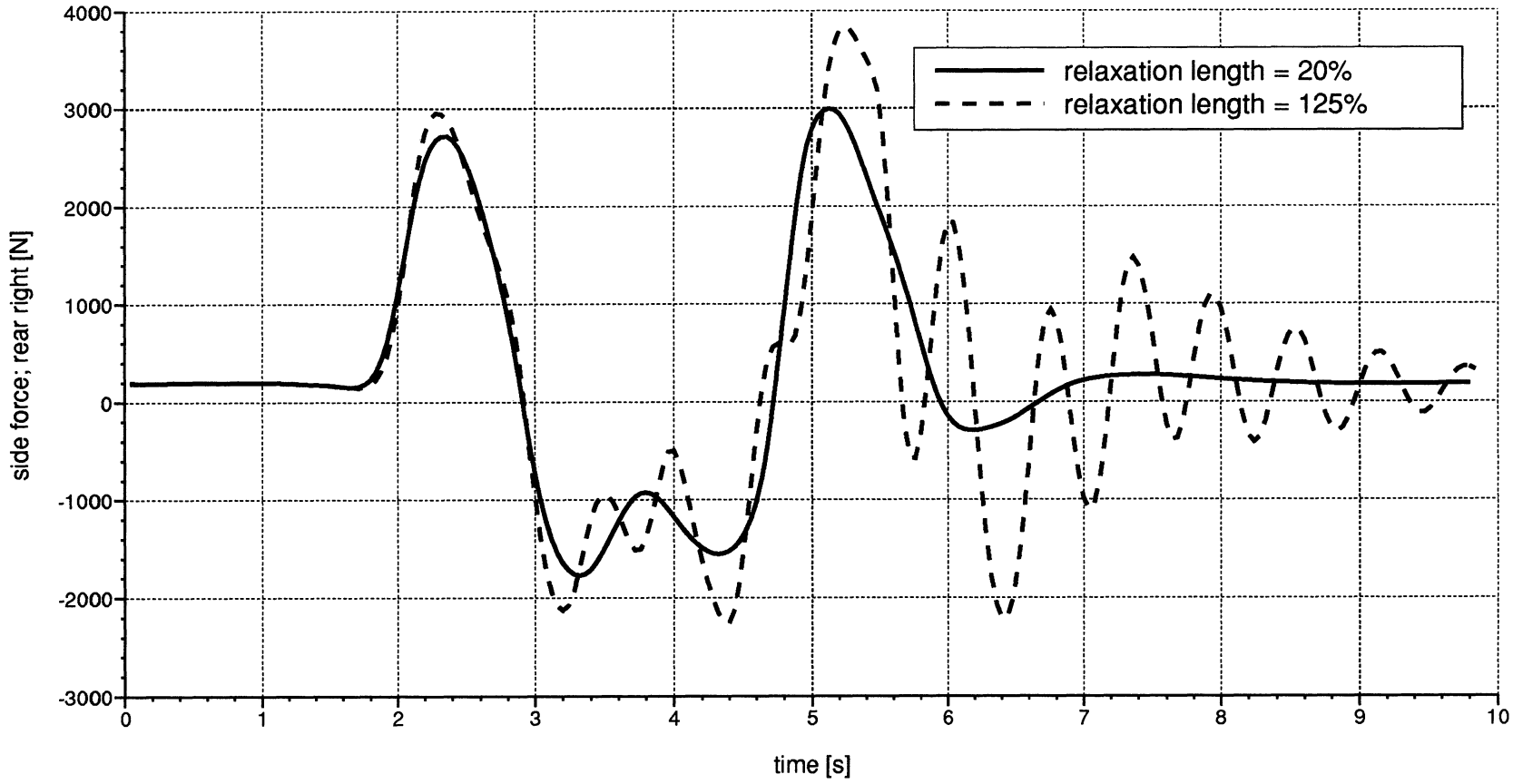
Lateral acceleration



Steering wheel angle



Lateral tire force



IPG

Braking in a turn

Vehicle

Truck with semitrailer
35.000 kg

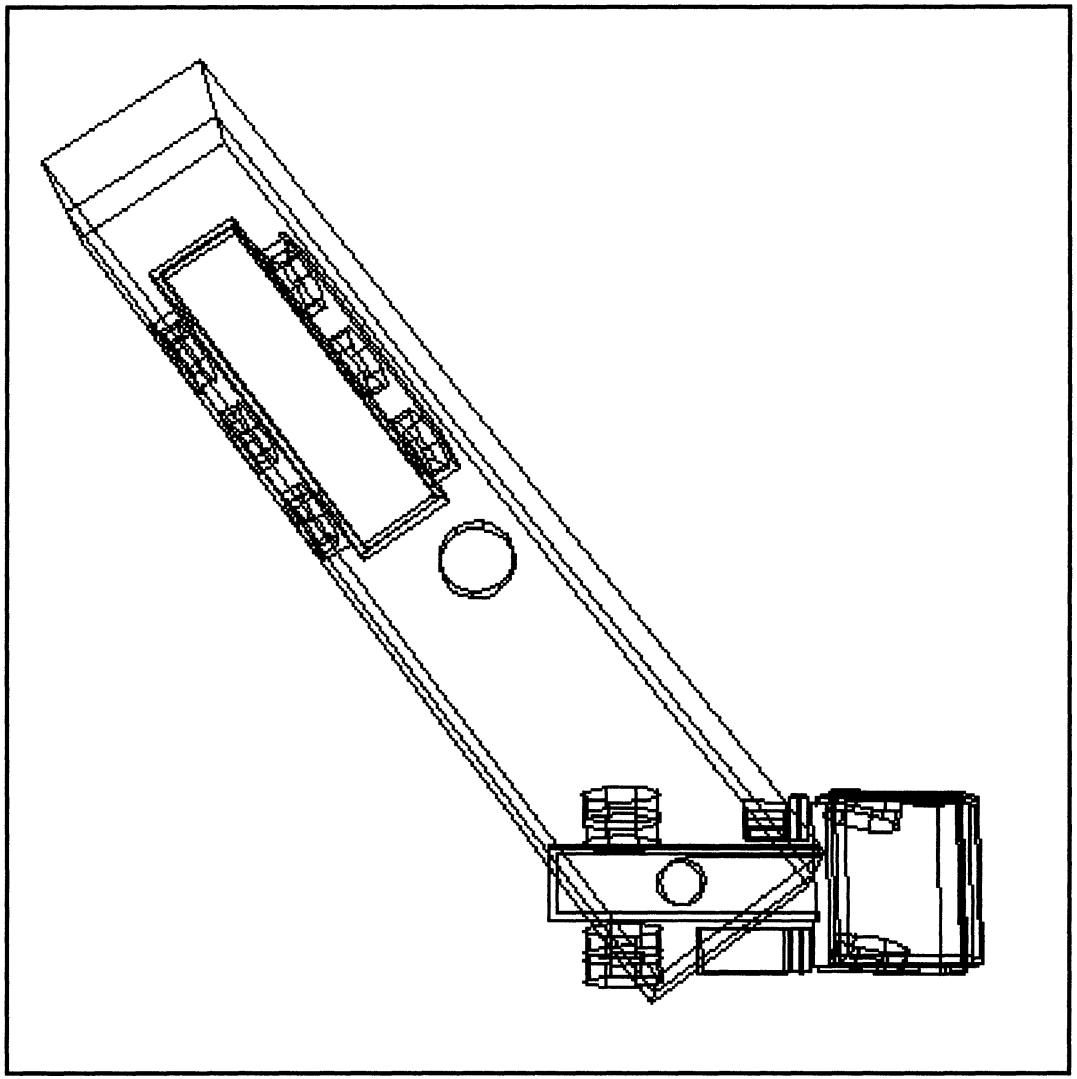
Velocity

v = 65 km/h = 40 m.p.h.

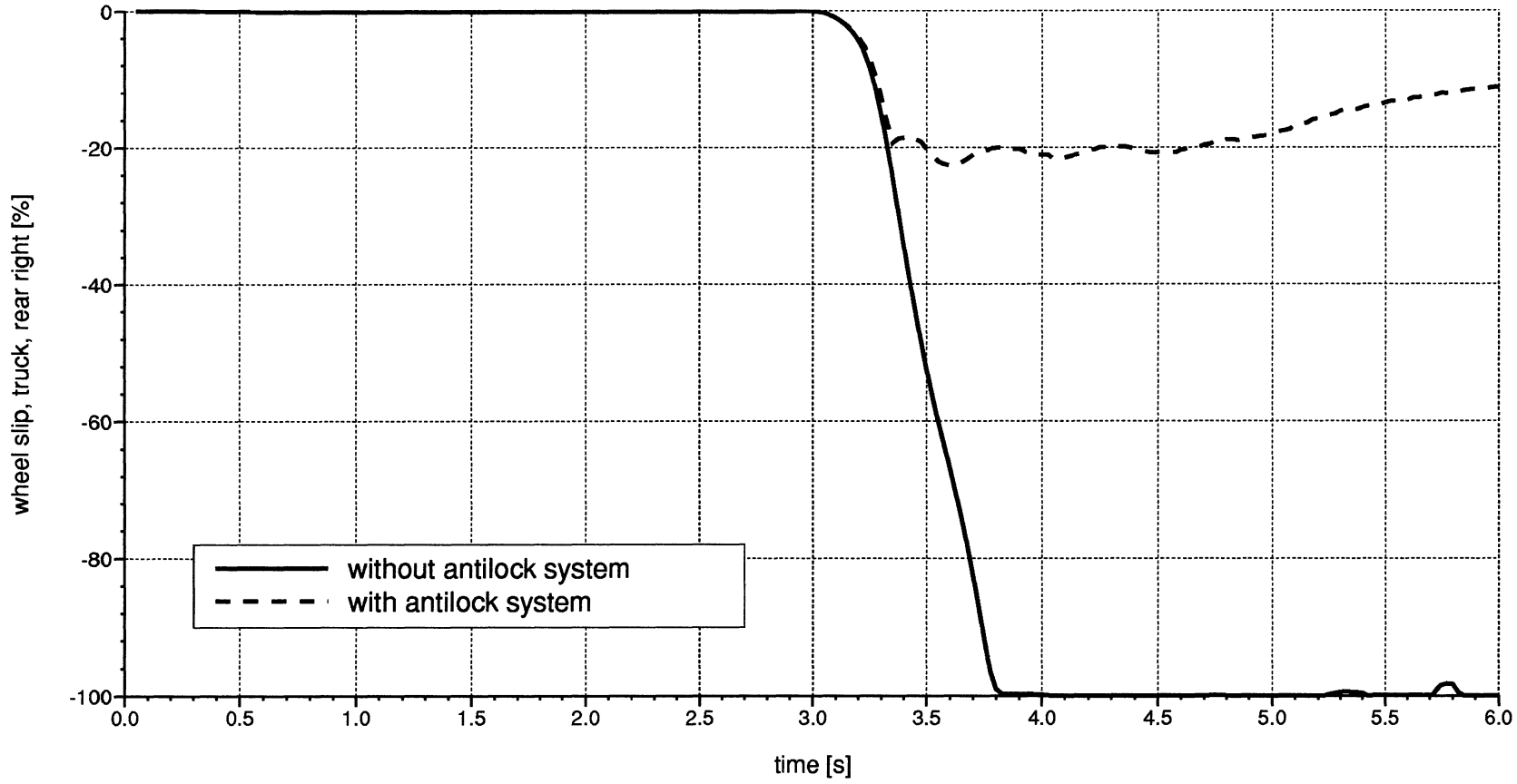
Parameter

Brake system

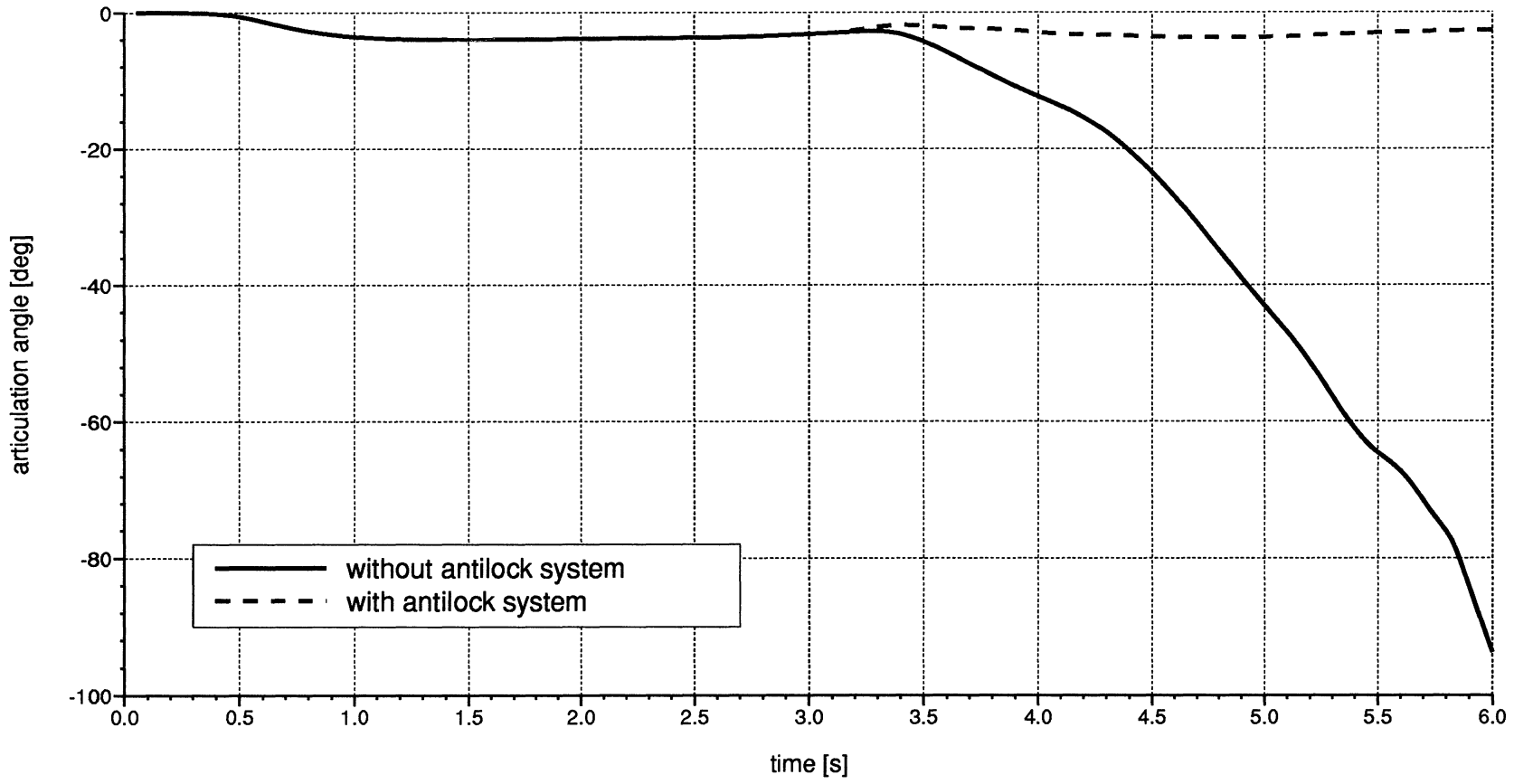
- without antilock system
- with antilock system



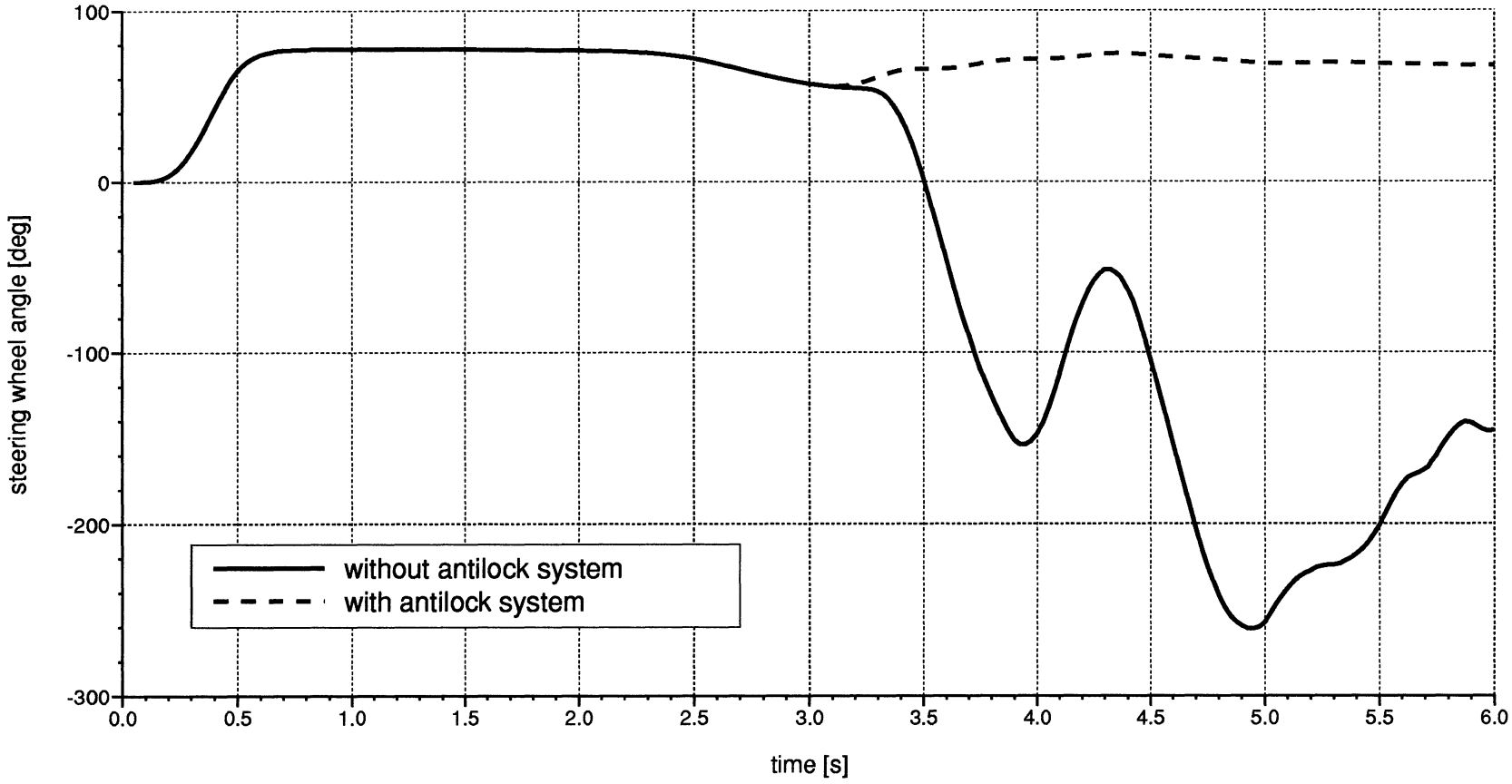
Wheel slip


0
-20
-40
-60
-80
-100
wheel slip, truck, rear right [%]
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
time [s]
without antilock system
with antilock system

Articulation angle
(Angle between truck and semitrailer)



Steering wheel angle



Magny Cours

Vehicle

Passenger car

Driving task

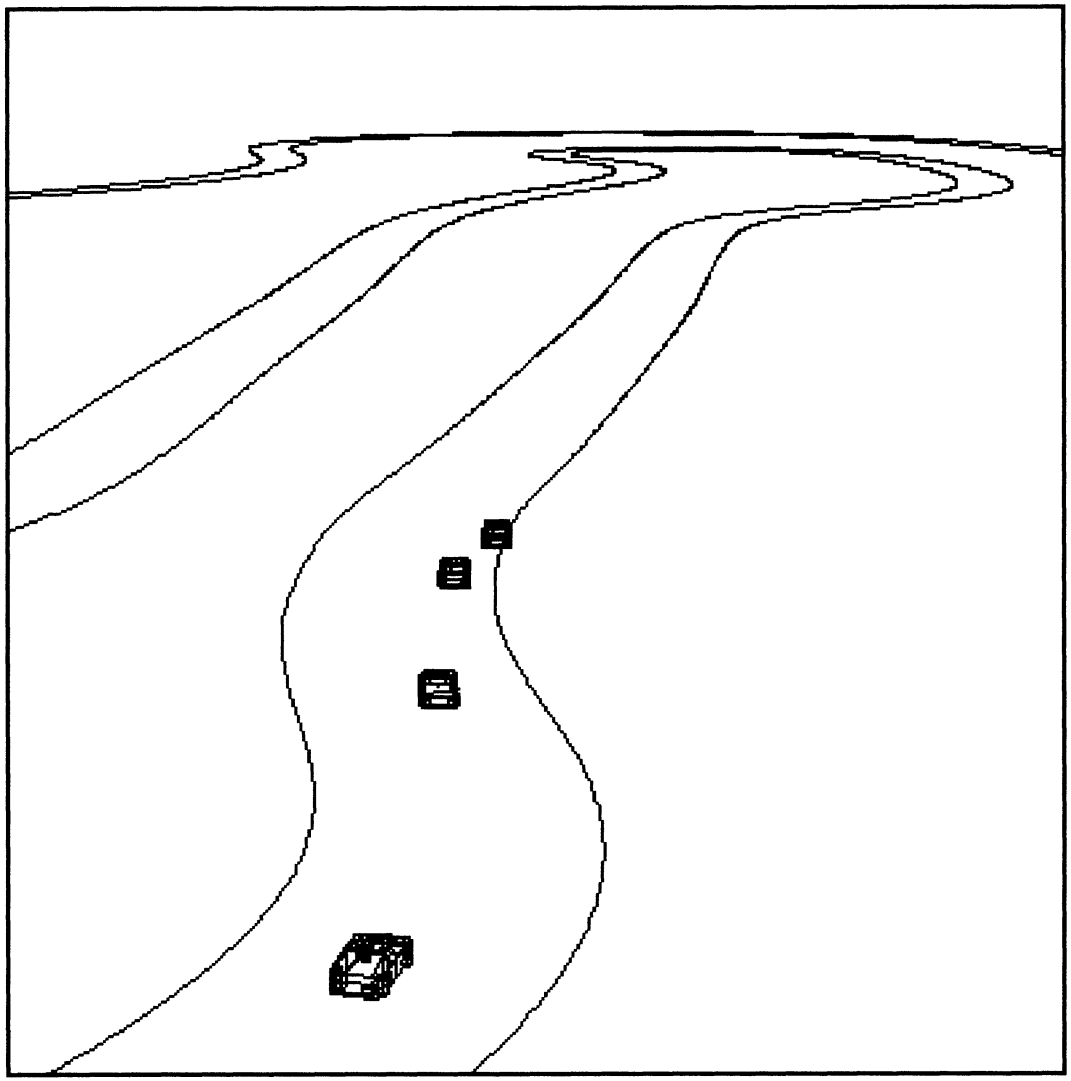
Max. accelerations

- lateral: 7.5 m/s^2
- longitudinal: +3 / -4 m/s^2

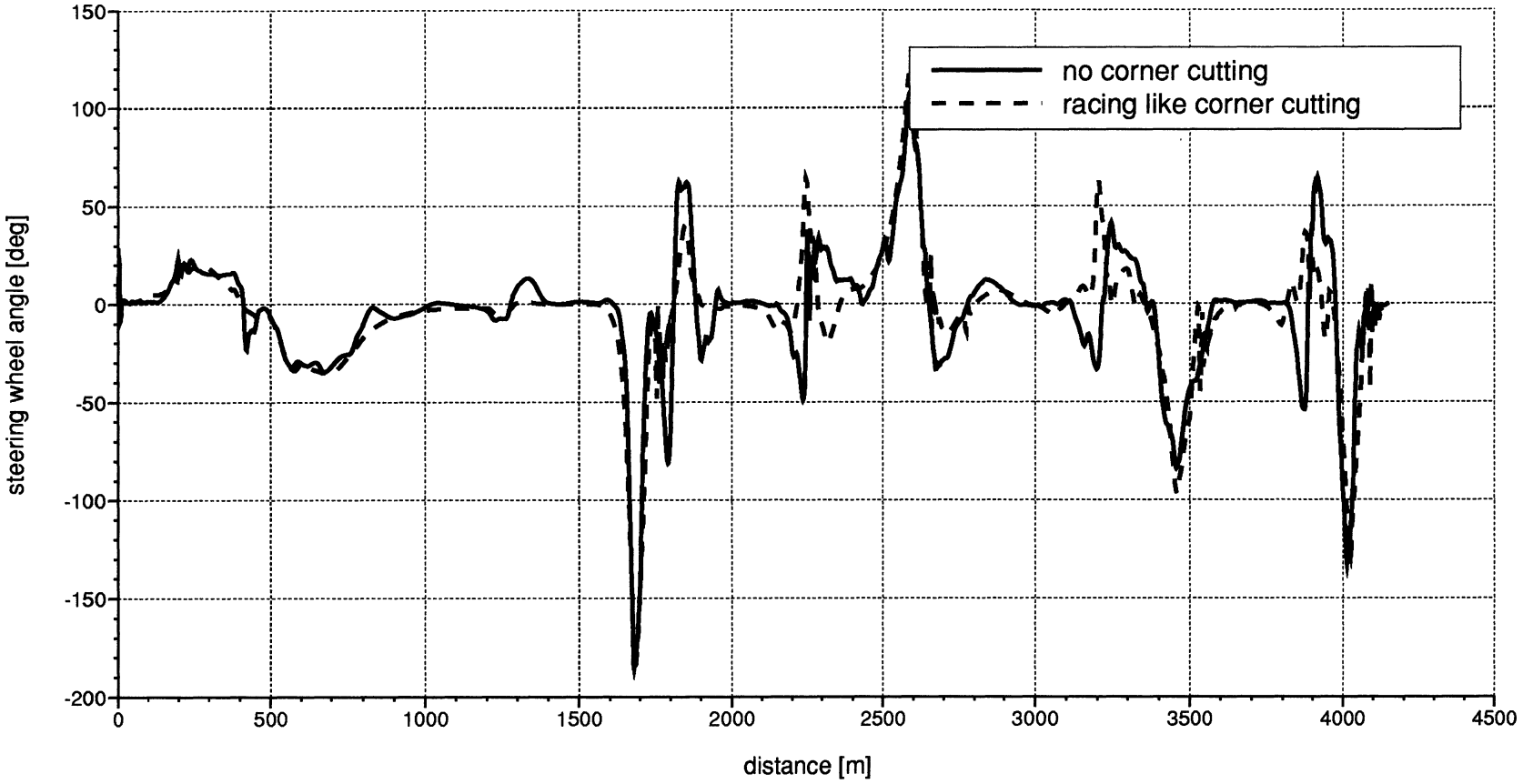
Parameter

Corner cutting strategy of the driver

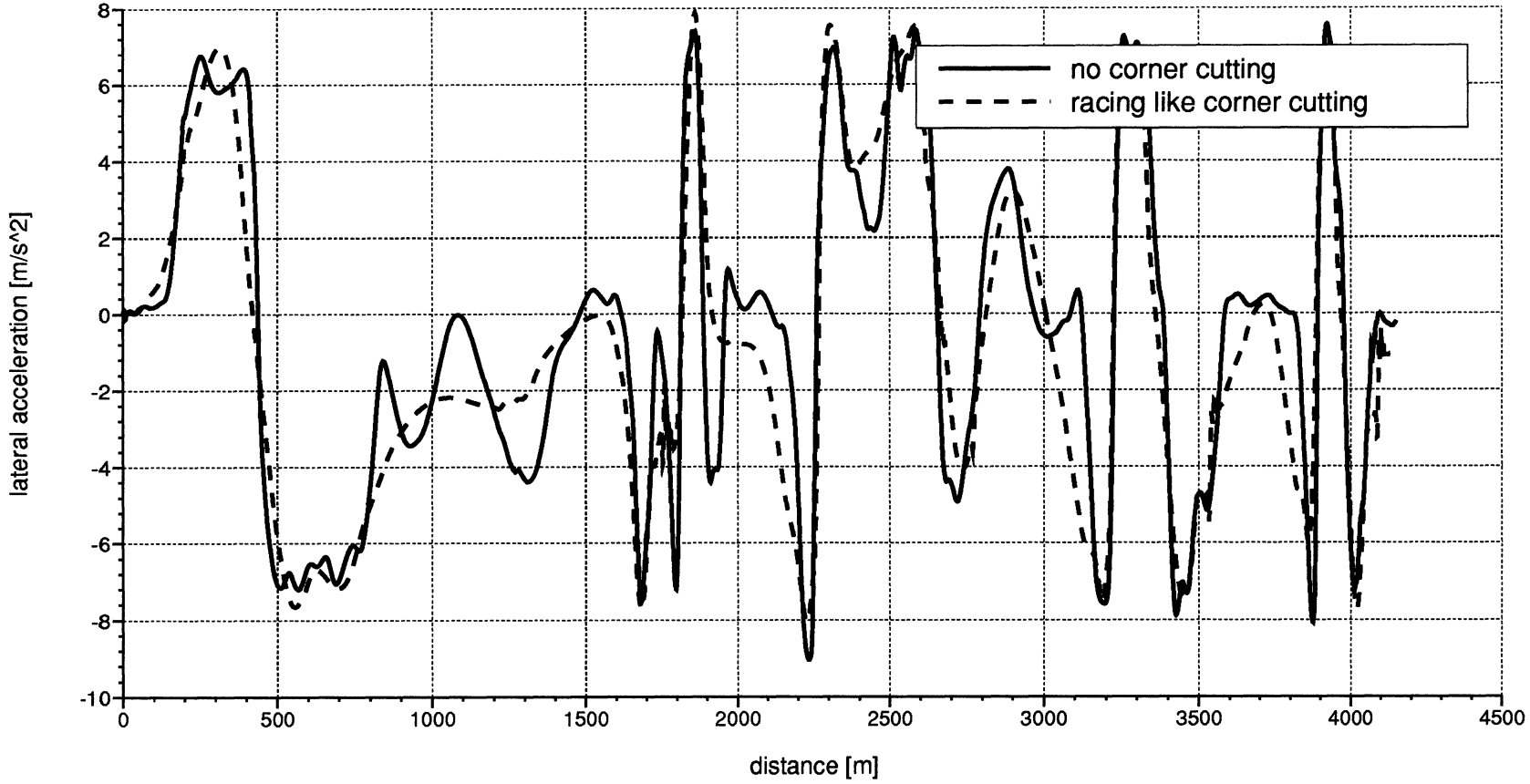
- no corner cutting
- racing like corner cutting



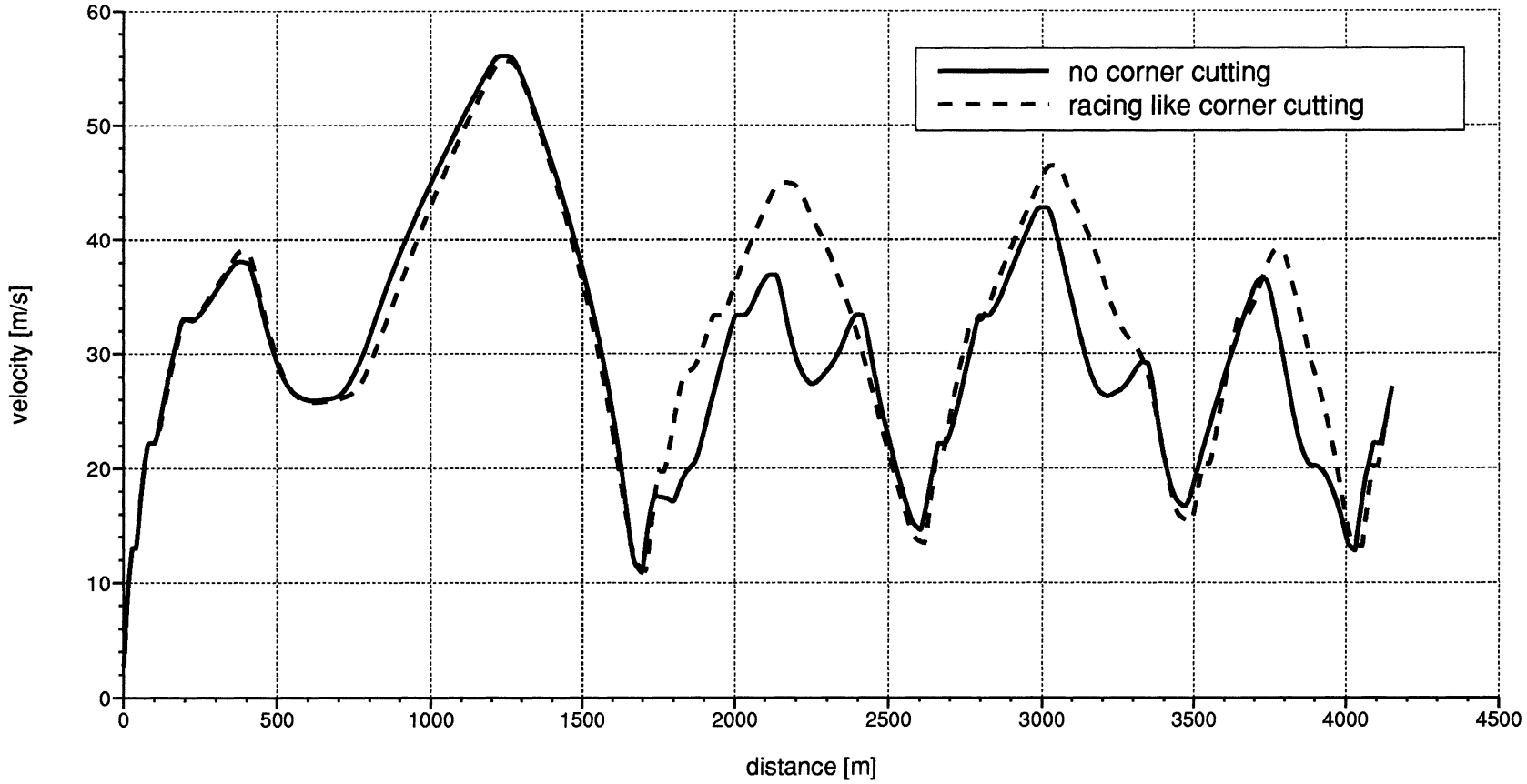
Steering wheel angle



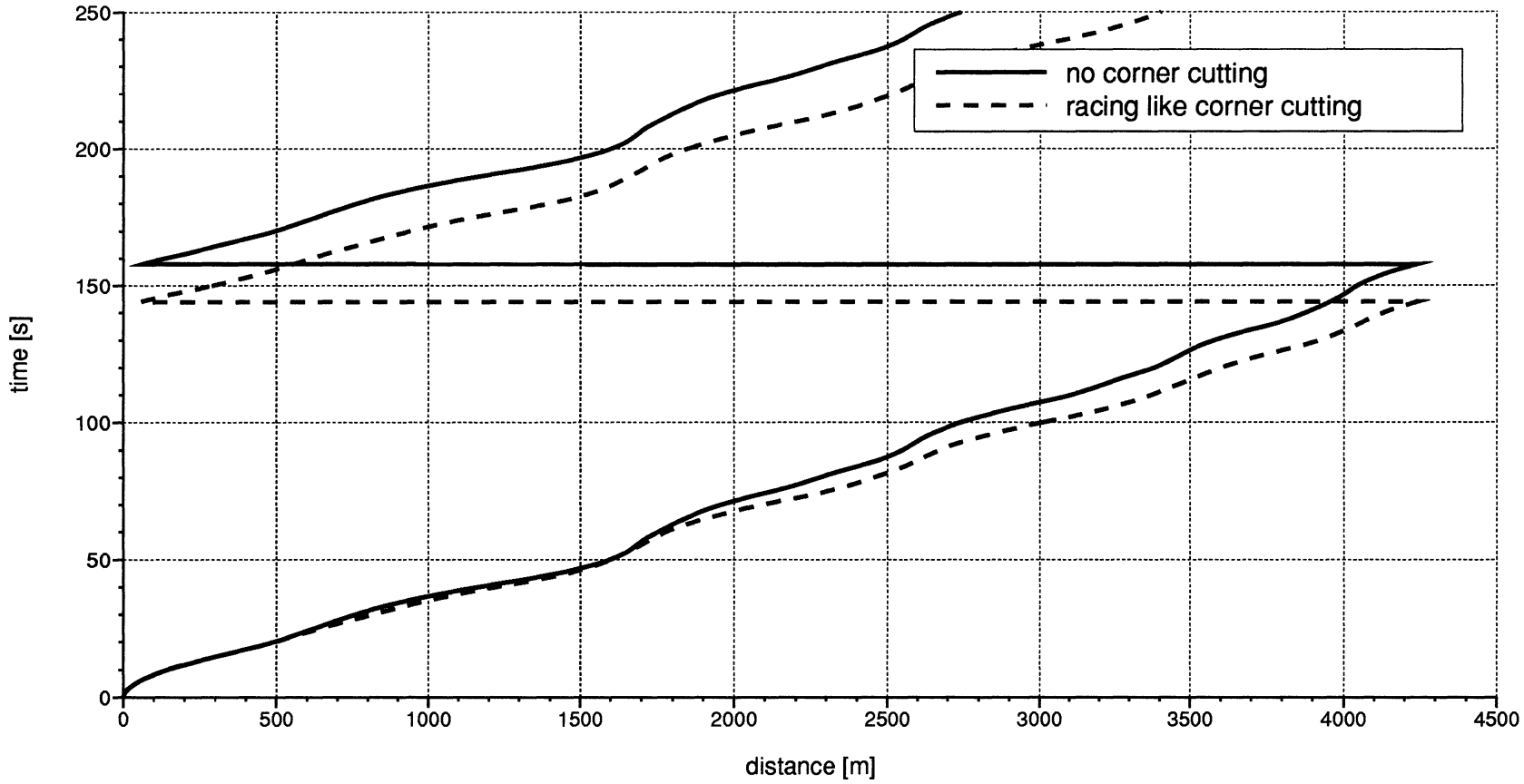
Lateral acceleration



Speed profile



Time versus distance



IPG

Design of the interface

Attention:
Topic is subject of actual work together with TEDAS!
Original slide will follow!

IPG

ADAMS simulation with IPG-DRIVER

Attention:
Topic is subject of actual work together
with TEDAS!
Original slides will follow!

IPG

IPG-DRIVER

- Enables simulation of real driver's actions when driving a car
- Increases number and complexity of possible driving maneuvers in vehicle dynamics simulation
- Gives the engineer a tool for detailed analysis of driver-vehicle interaction in realistic situations

ADAMS and IPG-DRIVER

- Strong enhancement of simulation capabilities!
- Expensive tests with more and more complex prototypes can be reduced
  $\Rightarrow$ less time and less costs, better results!

ADAMS + IPG-DRIVER

=

New Impact on Virtual Prototyping of Cars