



Driver Modeling in Vehicle Handling Analysis

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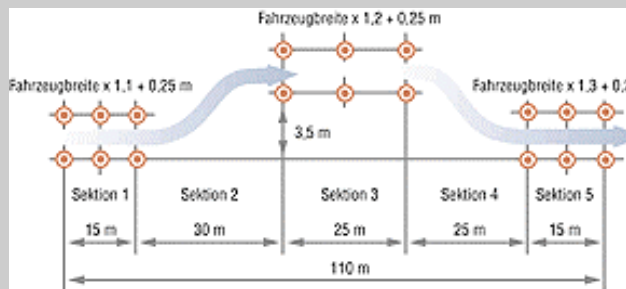
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Thank you

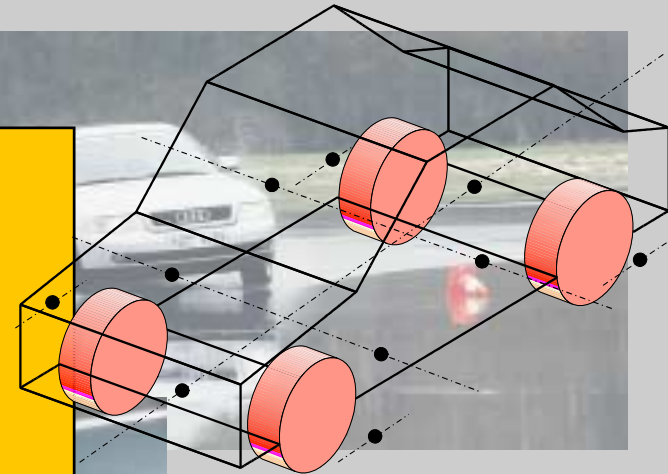
What is it all about? Handling Dynamics



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Goals

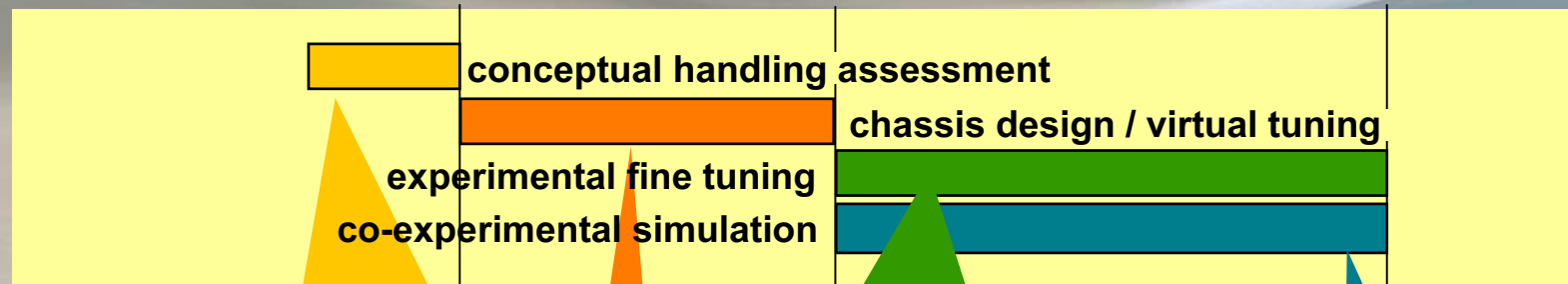
- Customer →
 - driving pleasure
 - driving safety
- Company →
 - development time
 - development costs
 - development risks



Fahrzeugbreite x 1



Development cycle „handling dynamics“ at AUDI



basic functional assessment of vehicle concept

experimental fine tuning
manufacturer's philosophy
optimization of driving safety

chassis design functional standardized maneuvers

need for suitable driver models

- driver as a controller
- subjective assessment

of experiments
analyses,
studies
understanding

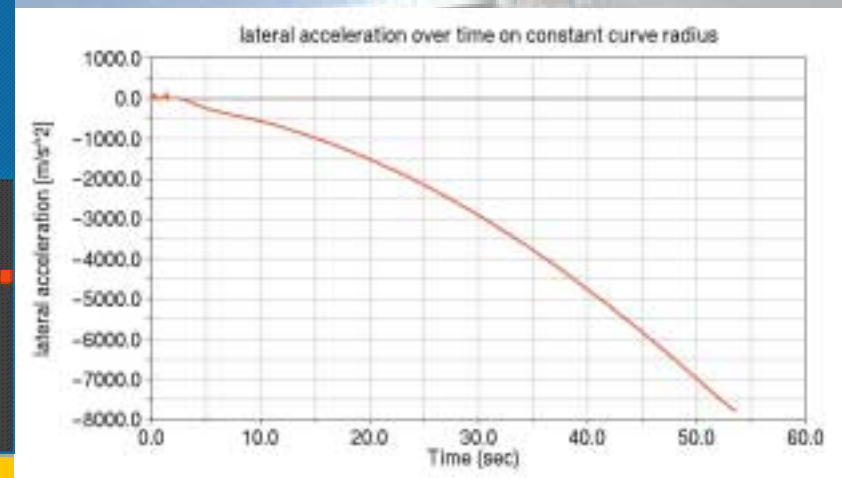
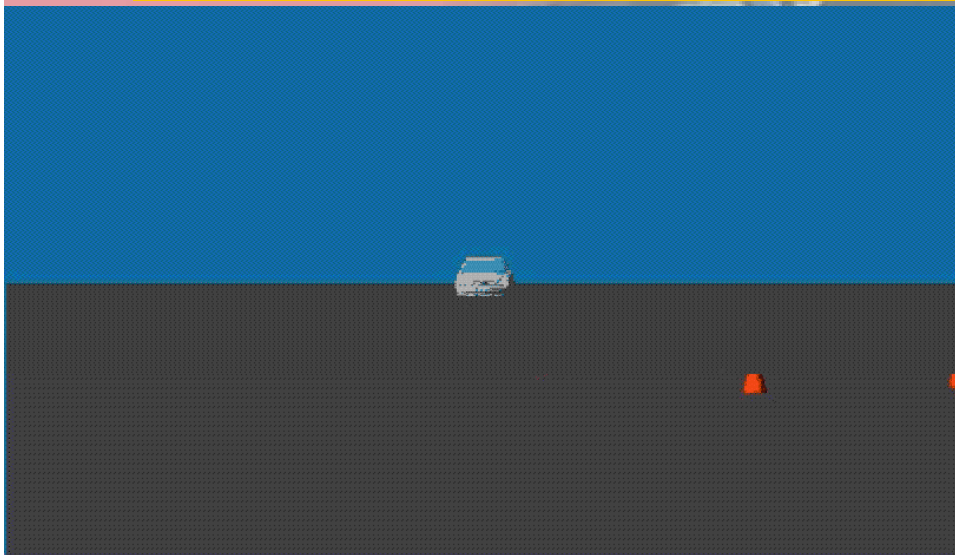


Which driver model for what purpose?

Which driver model for what purpose?

standard maneuvers (quasi open-loop)

- accelerating/braking at defined acceleration/deceleration
- steady state cornering at defined curve radius
- track following under disturbances



pure speed/tracking control:

- simple definition of standard maneuvers

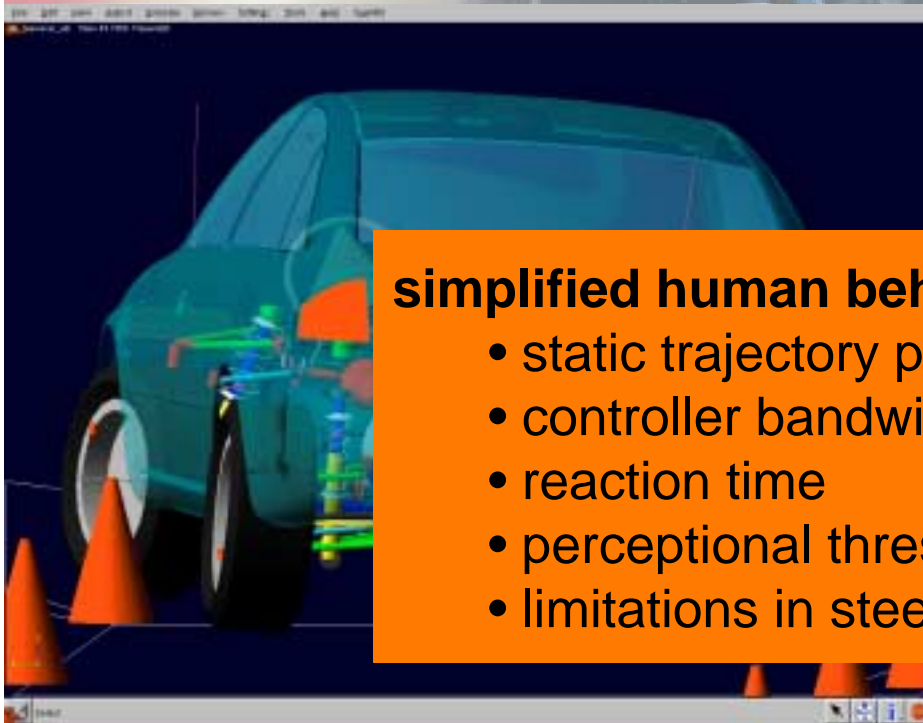
Which driver model for what purpose?

maneuvers with human compensatory control (closed-loop)

- power-off reaction, braking in turn with driver reaction
- ISO, VDA double lane change
- ISO slalom
- cross-wind behavior

simplified human behavior:

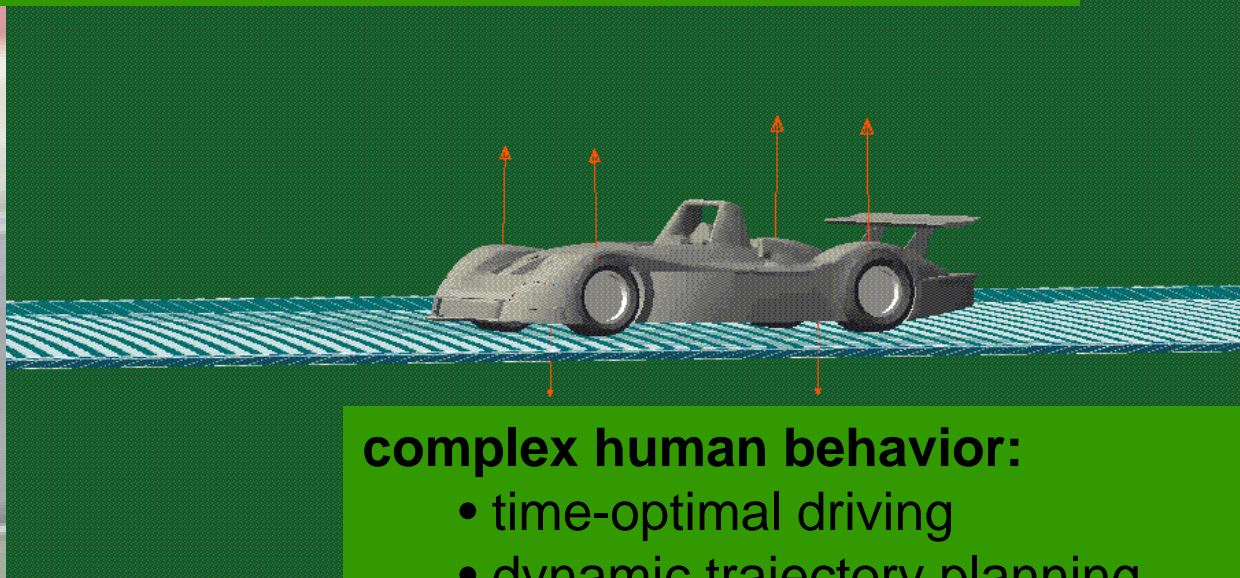
- static trajectory planning
- controller bandwidth, stability margins similar to human
- reaction time
- perceptual thresholds, accuracy
- limitations in steering velocity, steering torque



Which driver model for what purpose?

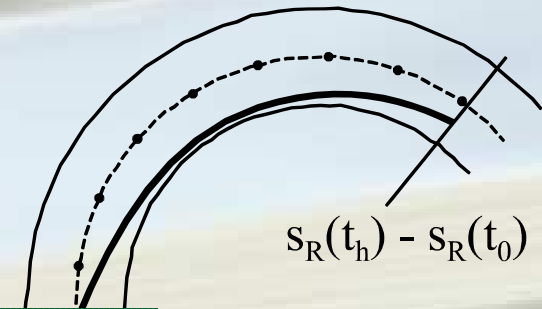
complex maneuvers

- lap time simulations
- closed-loop testing under driving skill variation
- interaction with active chassis control systems
- dynamic obstacles, surrounding traffic



complex human behavior:

- time-optimal driving
- dynamic trajectory planning
- variations in driving skill
- variations in driver characteristics, preferences



Which driver model for what purpose?

standard maneuvers (quasi open-loop)

pure speed/tracking control

maneuvers with human compensatory control (closed-loop)

simplified human behavior

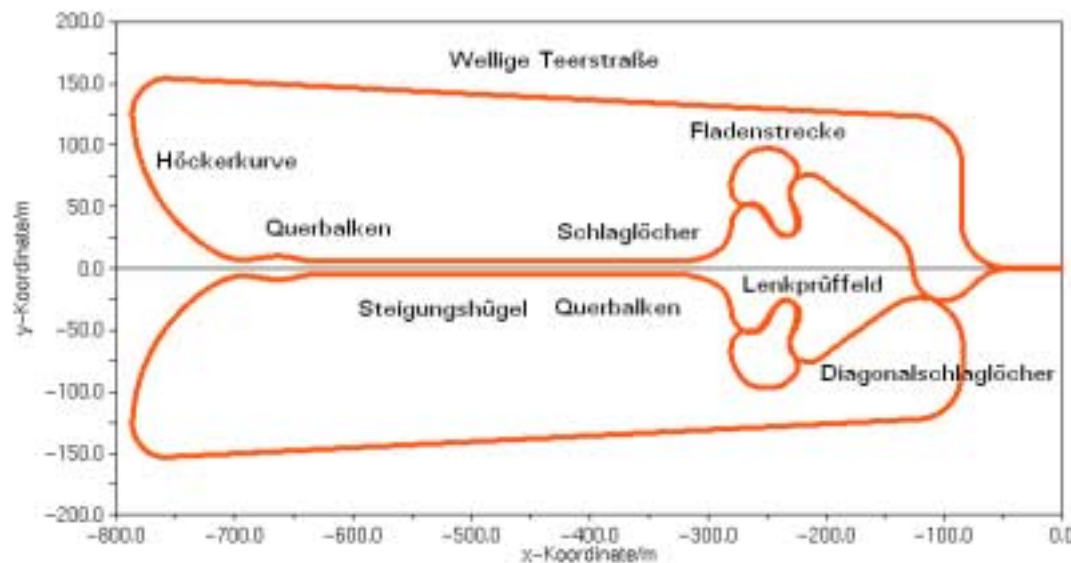
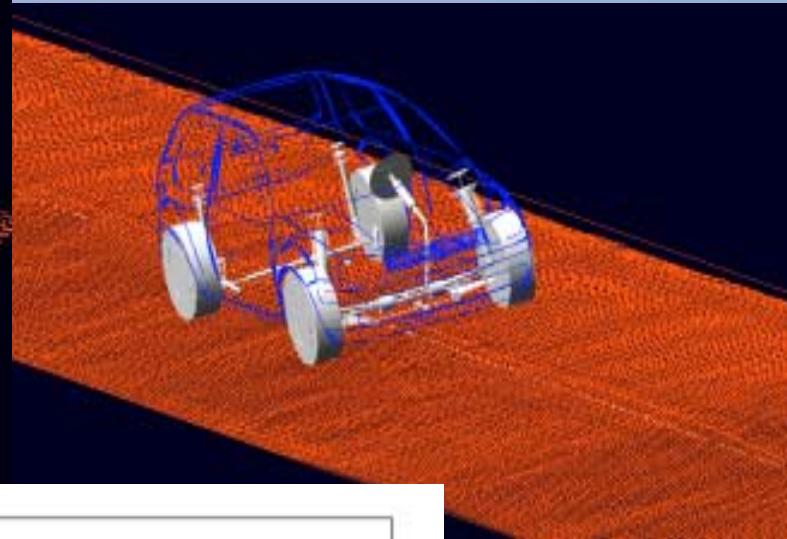
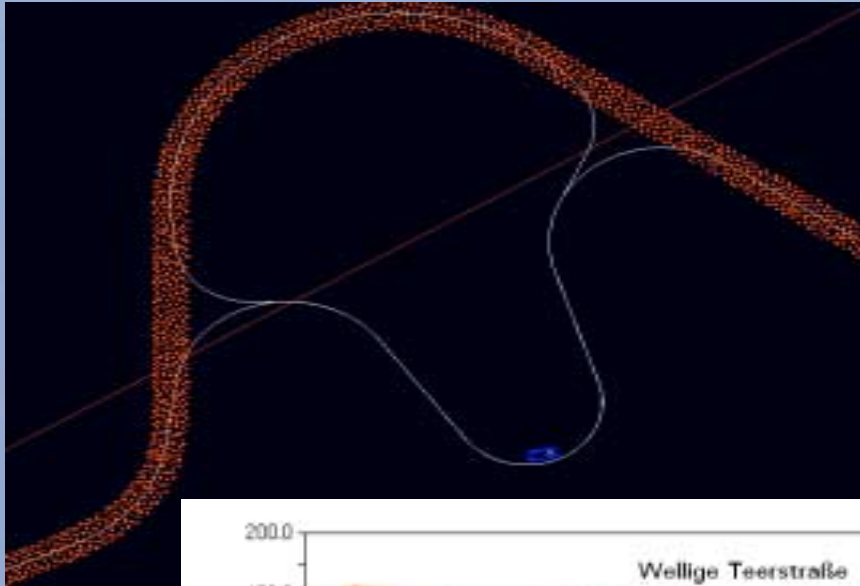
complex maneuvers

complex human behavior



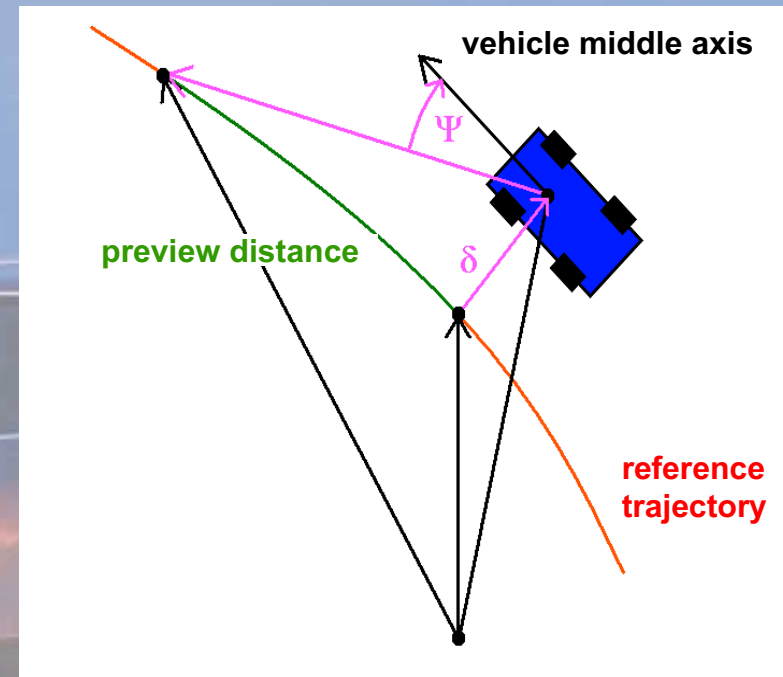
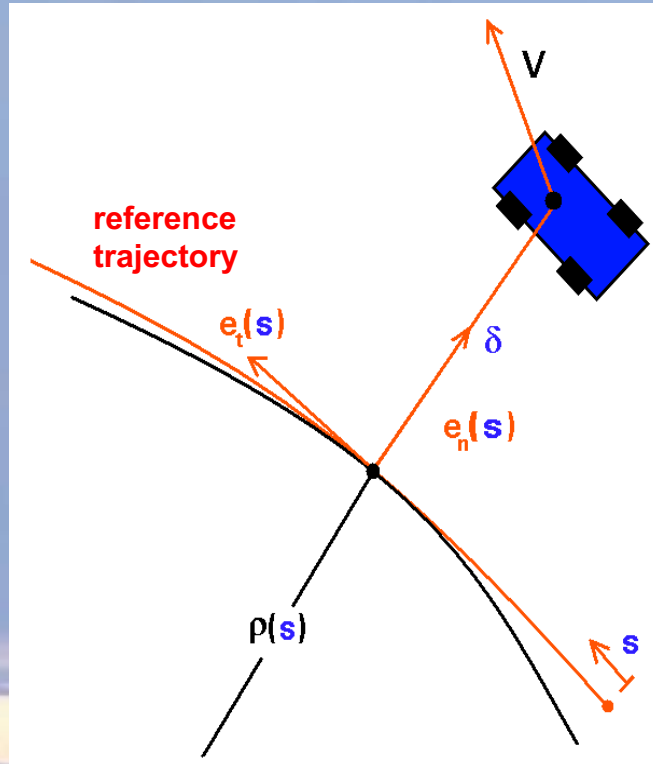
Application examples

Quasi open-loop: Simulation of dynamic loads on the EVP test track



Source: Volkswagen AG

Quasi open-loop: Simulation of dynamic loads on the EVP test track



distance on reference trajectory

lateral path deviation

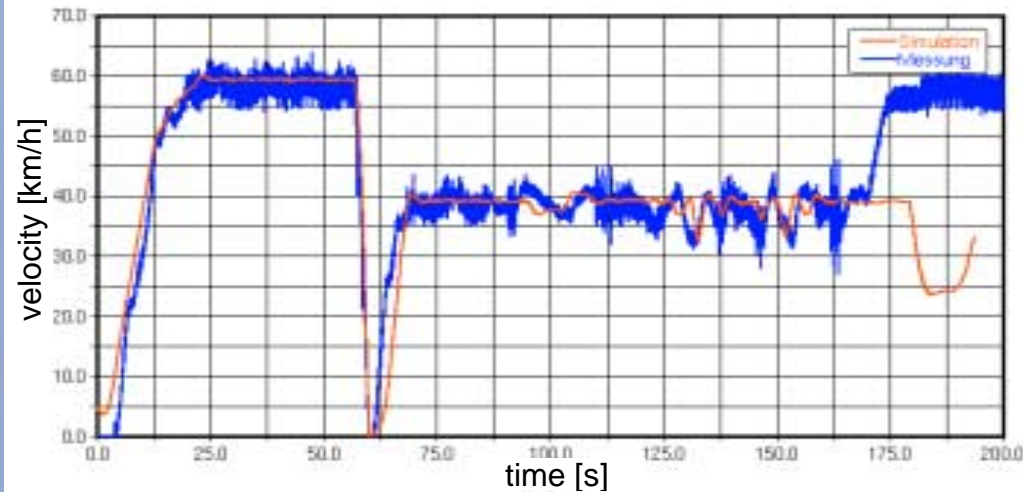
$$\frac{ds}{dt} = \frac{\rho}{\rho + \delta} \mathbf{V} \cdot \mathbf{e}_t$$

$$\frac{d\delta}{dt} = \mathbf{V} \cdot \mathbf{e}_n$$

steering angle

$$\frac{d\varphi}{dt} = \frac{1}{\tau} (\alpha_\psi \psi + \alpha_\delta \delta - \varphi)$$

Quasi open-loop: Simulation of dynamic loads on the EVP test track



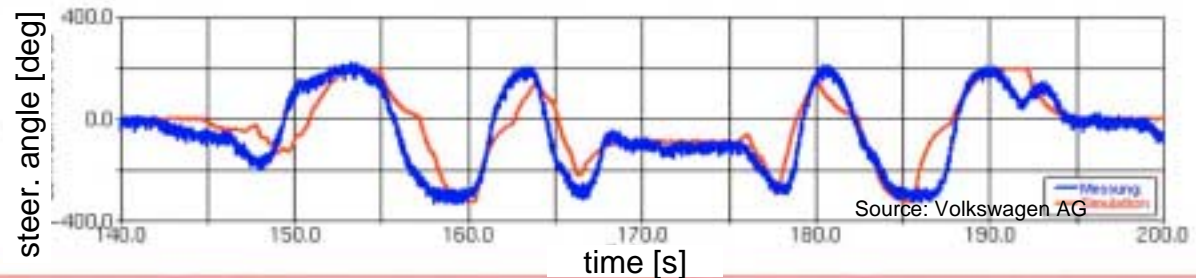
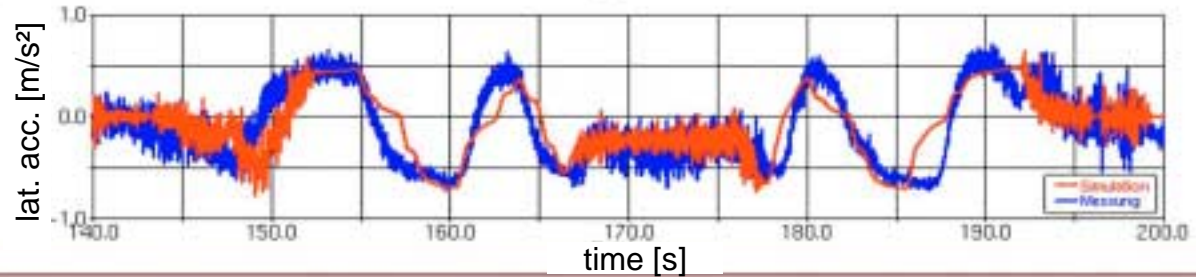
longitudinal controller:
velocity



lateral controller:

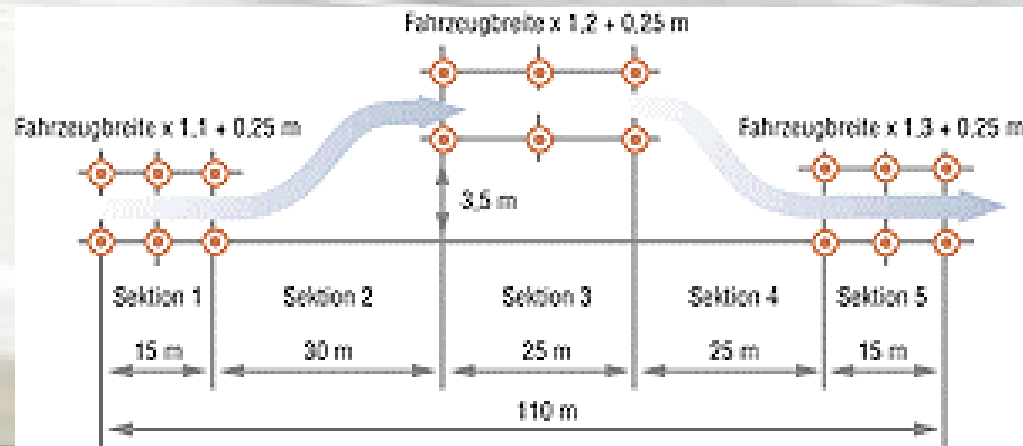
lateral acceleration

steering angle



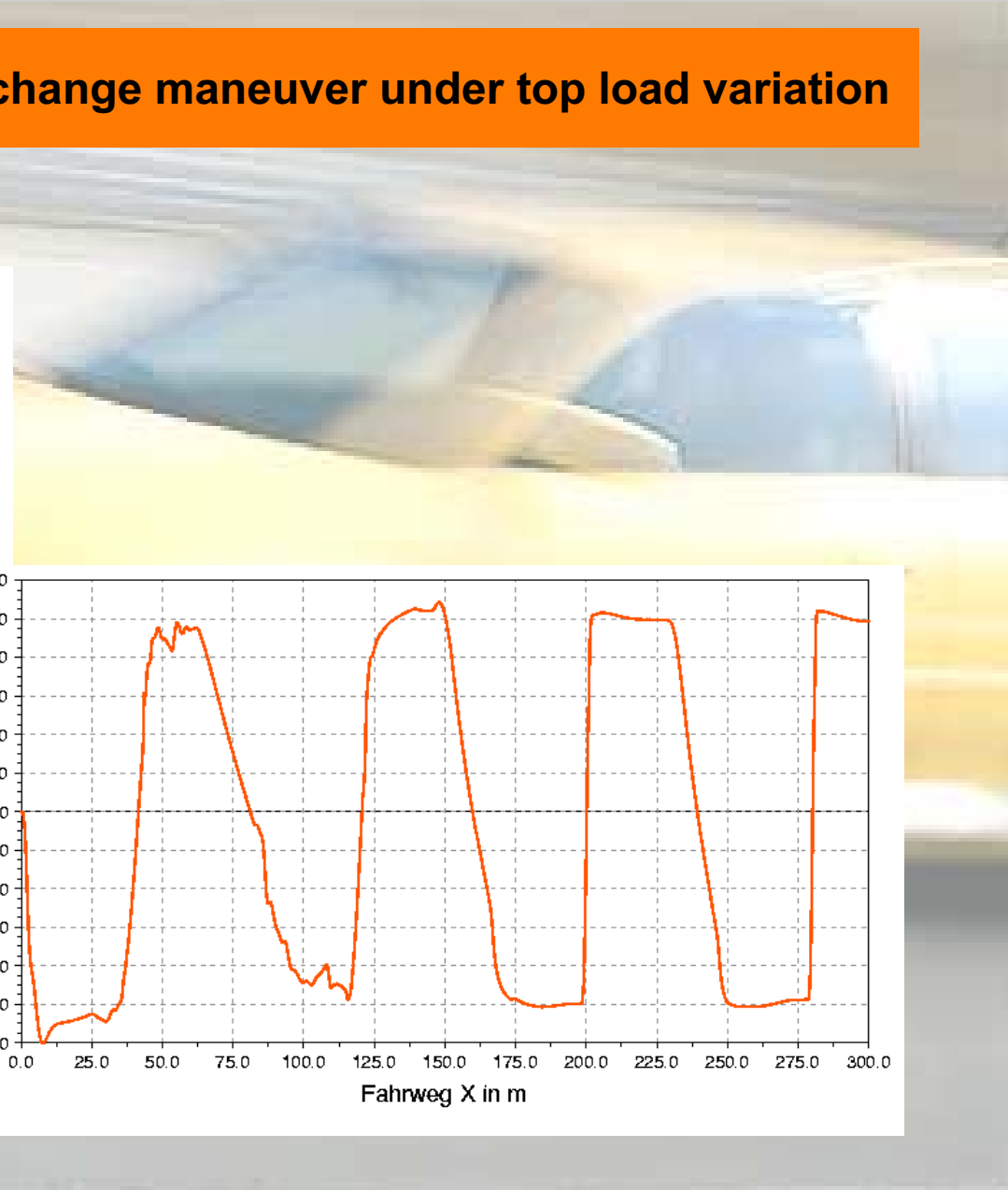
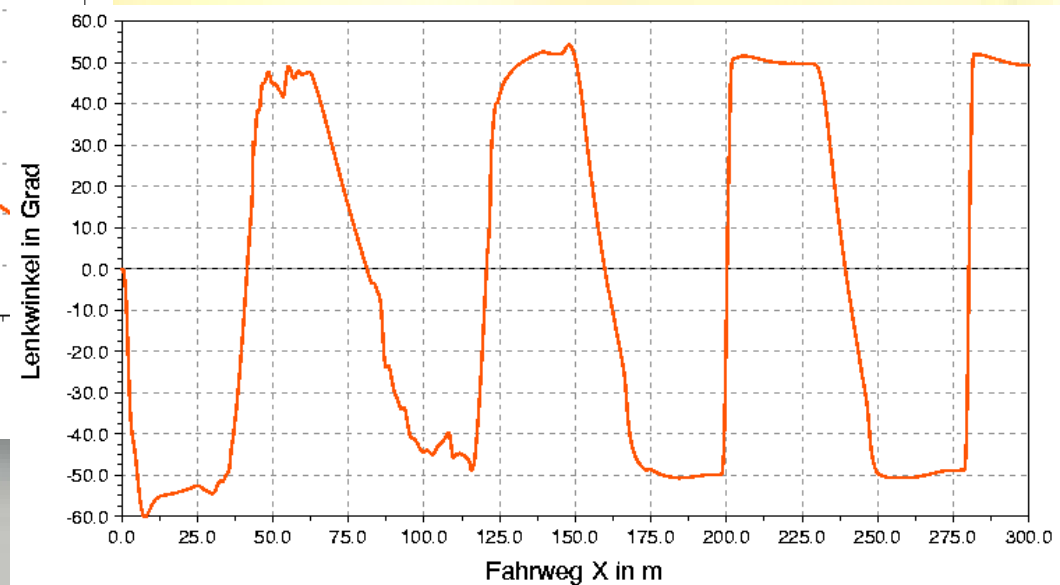
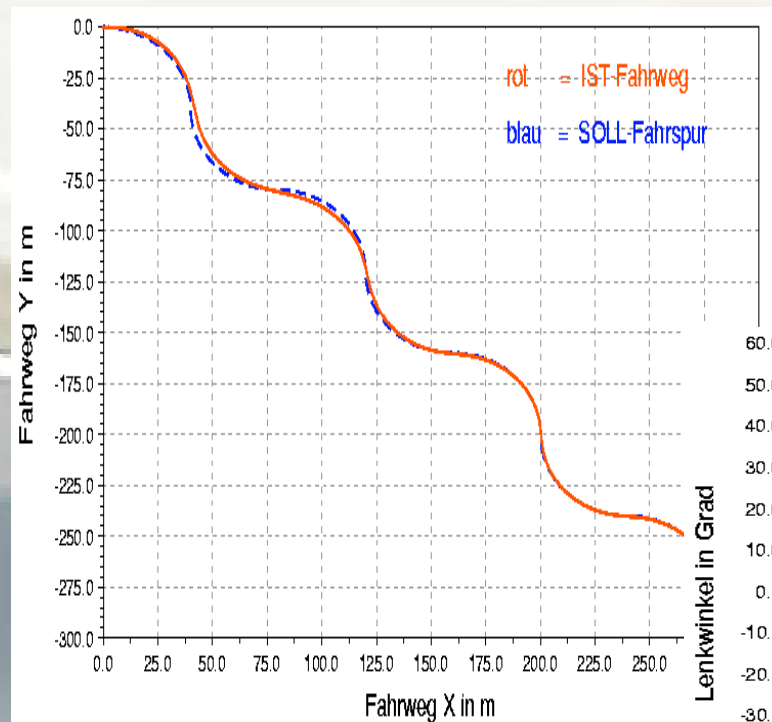
Source: Volkswagen AG

Closed-loop: ISO double lane change maneuver under top load variation



Closed-loop: ISO double lane change maneuver under top load variation

Learning phase



Closed-loop: ISO double lane change maneuver under top load variation

Results

