Hochschule Kempten
University of Applied Sciences

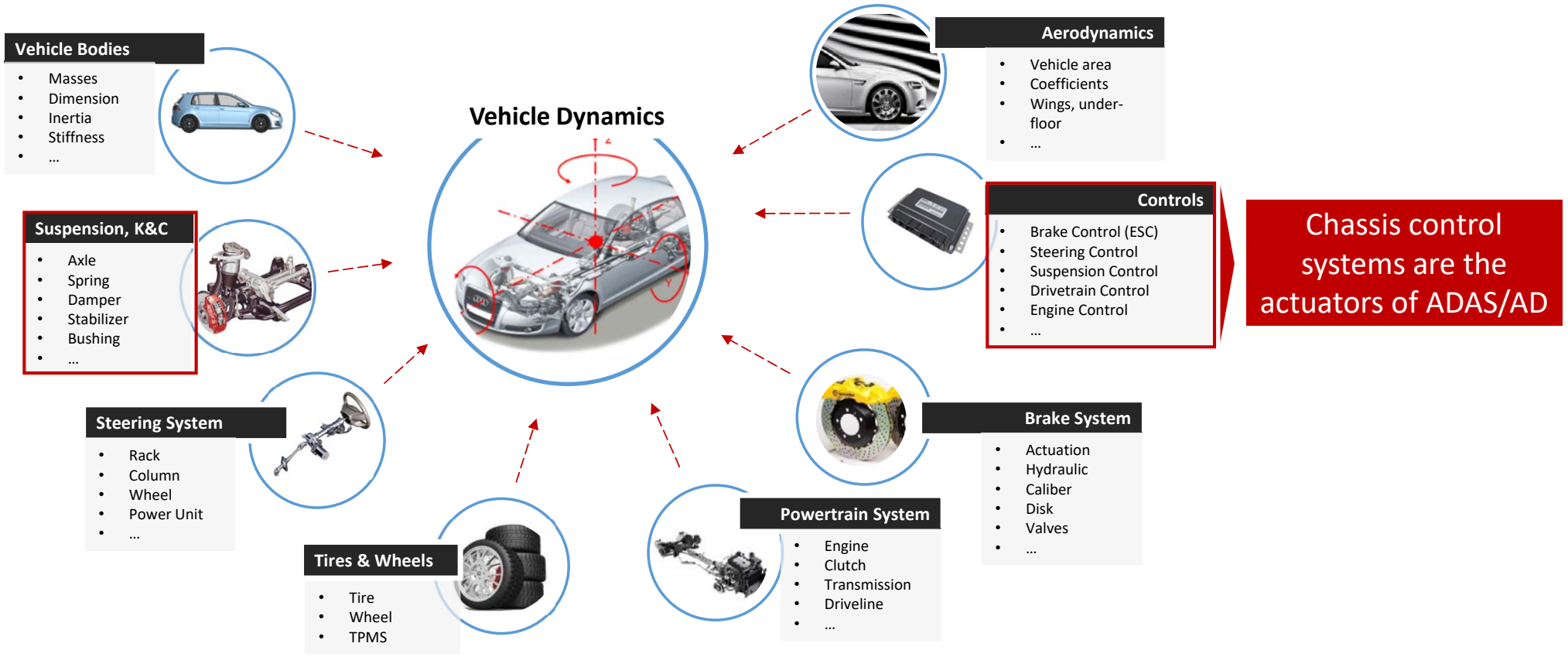
drive livinglab

ADAS Master WS 20/21
Lecture 10

Vehicle Dynamics in context of Advanced Driver Assistance Systems and Automated Driving.

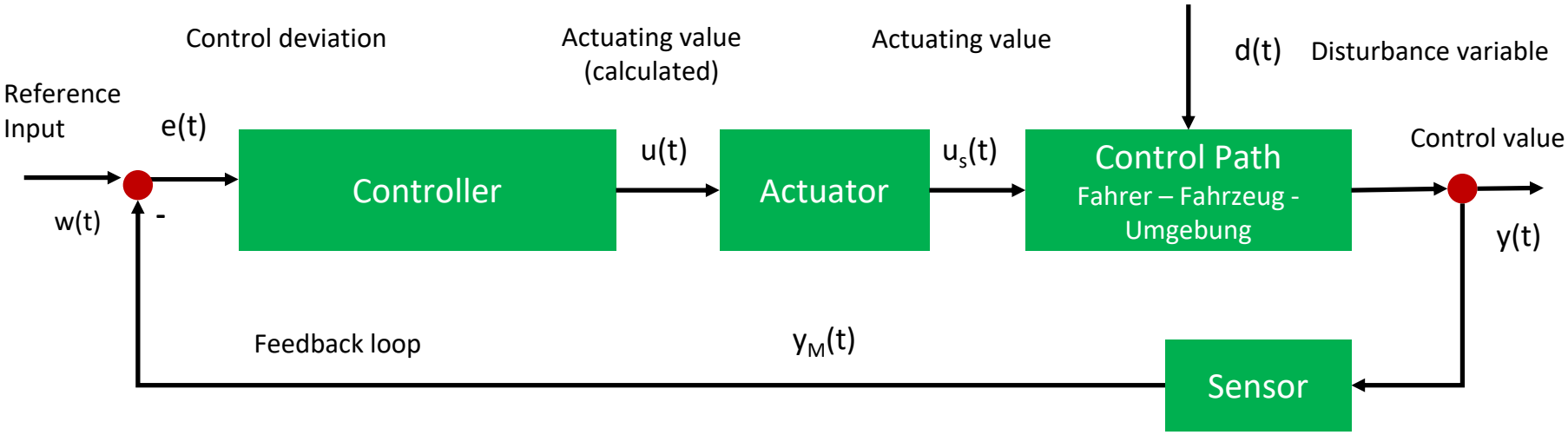
Chassis controls and functions (1)

Vehicle dynamics behavior is impact by numerous components



Chassis controls and functions (1)

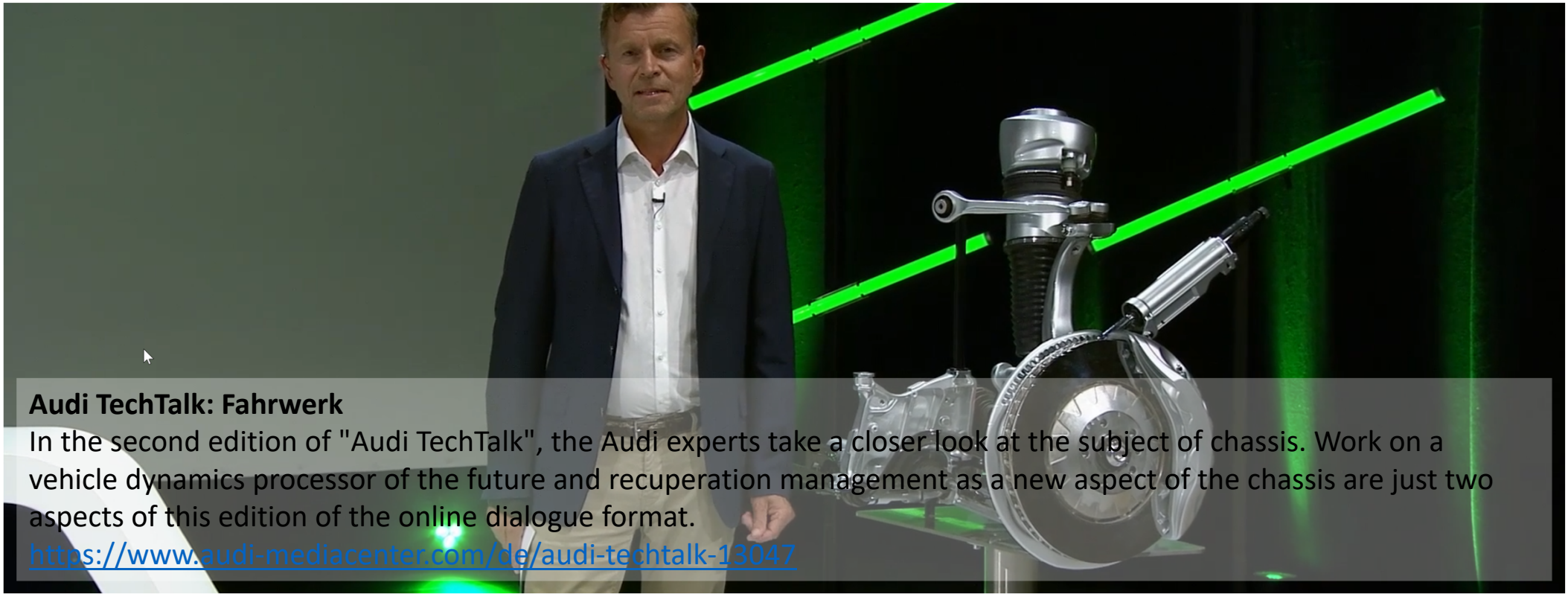
Chassis control principle and systems



- Antilocking System (ABS) → longitudinal control
- Traction Control (ASR) → longitudinal control
- Electronic Stability Program (ESP) → lateral control
- Steering Control (EPS) → lateral control
- Roll Bar Control (ARS) → Vertical / lateral control

- Air Suspension Control (→ Vertical control
- Continuous Damper Control (CDC) → Vertical control
- Electronic Differential (EDC) → Long/ lat control
- Torque Vectoring Control (TVC) → Long/ lat control

Audi Talk – Chassis technologie from rigid axle to intelligent chassis



Audi TechTalk: Fahrwerk
In the second edition of "Audi TechTalk", the Audi experts take a closer look at the subject of chassis. Work on a vehicle dynamics processor of the future and recuperation management as a new aspect of the chassis are just two aspects of this edition of the online dialogue format.
https://www.audi-mediacenter.com/de/audi-techtalk-13047

Hydraulik Brake system and brake control systems

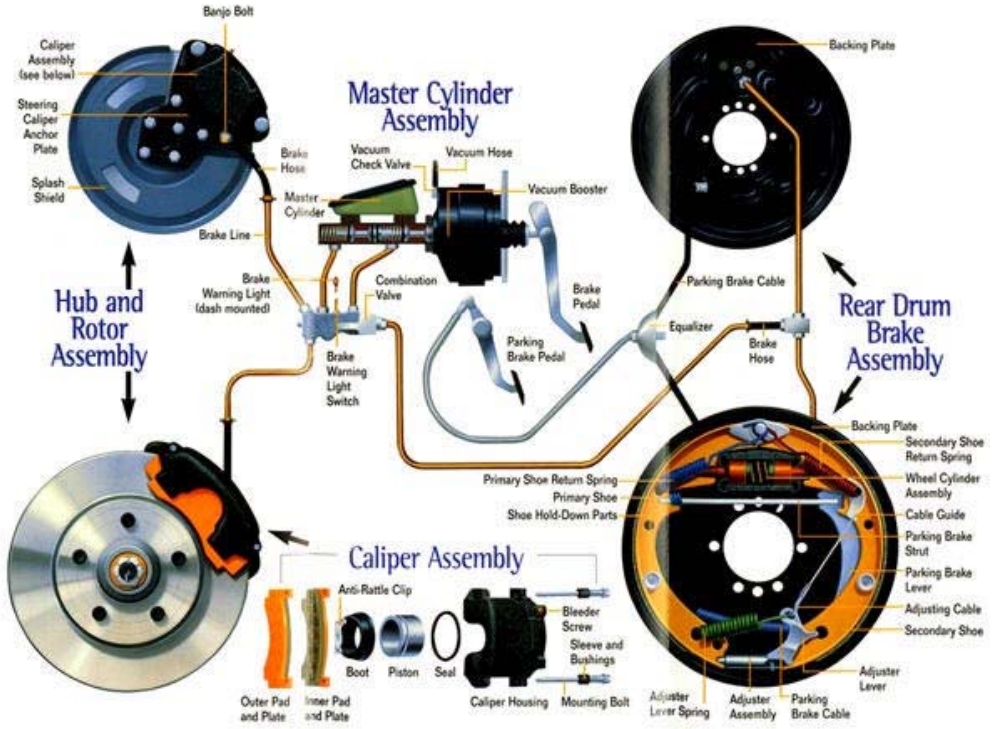
Classification of braking systems

- **Service brake system (BBA - Betriebsbremsanlage)**
  The service brake system must be operated in steps can and usually consists of two brake circuits.

- **Auxiliary braking system (HBA-Hilfsbremsanlage)**
  The deceleration achievable with the secondary braking system must be at least half the size of the BBA.

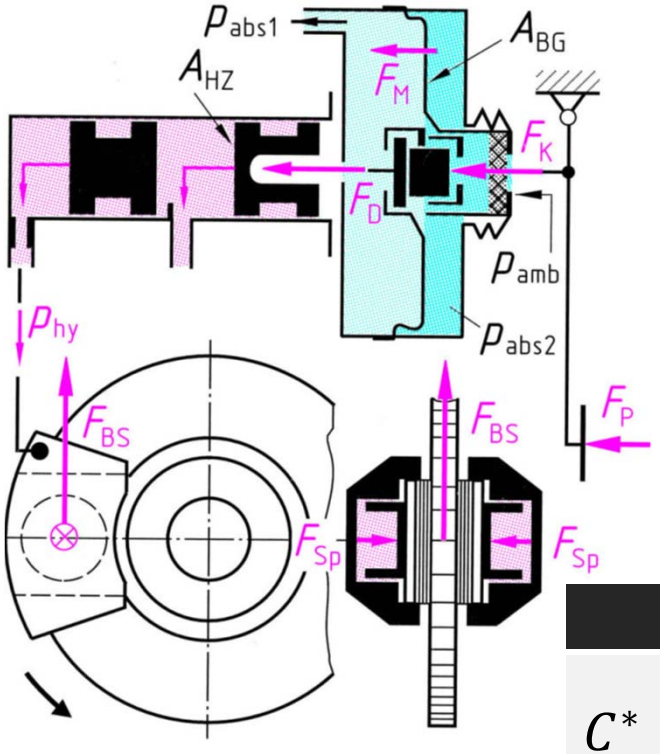
- **Parking brake system (FBA-Feststellbremsanlage)**
  The parking brake system must be able tocan maintain a slope of 20%.

- **Continuous braking system (DBA -Dauerbremsanlage)**
  Continuous braking systems are wear-free brakes for longer steady-state braking of commercial vehicles and buses.



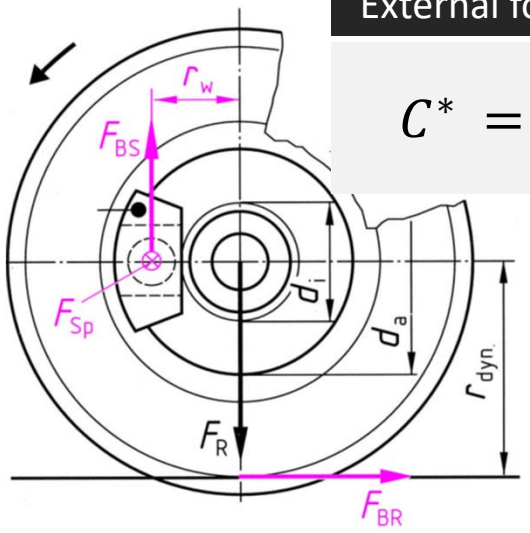
https://www.youtube.com/watch?v=ugtrRmyPSfE

External and internal force ratio of a brake system



External force ratio

$$i_{ext} = \frac{F_{SP}}{F_P}$$



External force ratio

$$C^* = \frac{F_{BS}}{F_{SP}}$$

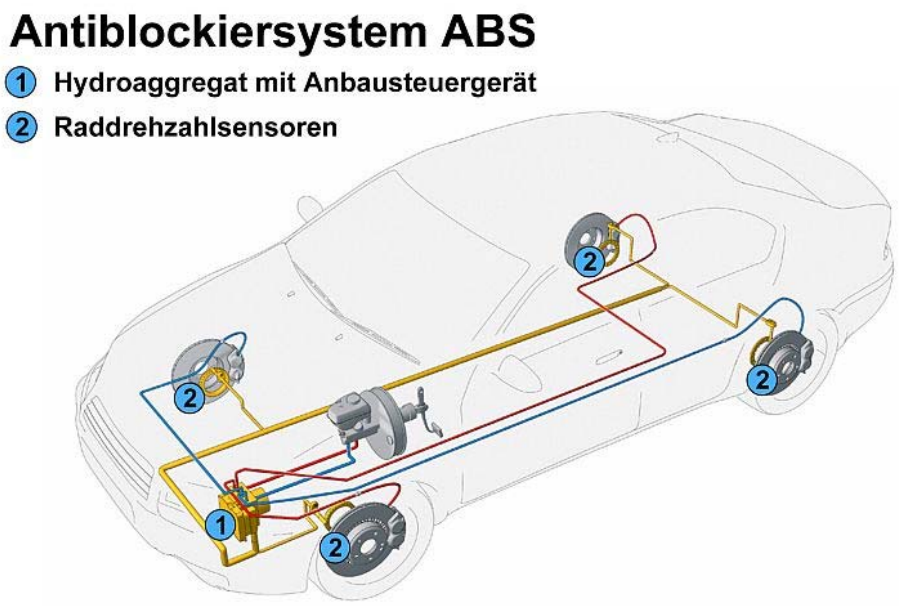
Brake disk characteristics

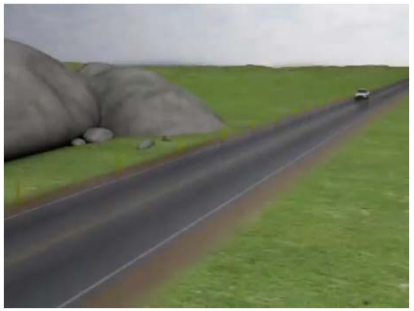
$$C^* = \frac{F_{BS}}{F_{SP}} = \frac{2\mu * F_{SP}}{F_{SP}} = 2\mu$$

Wheel brake force

$$F_{BR} = F_P * i_{ext} * C^* \frac{r_w}{r_{dyn}}$$

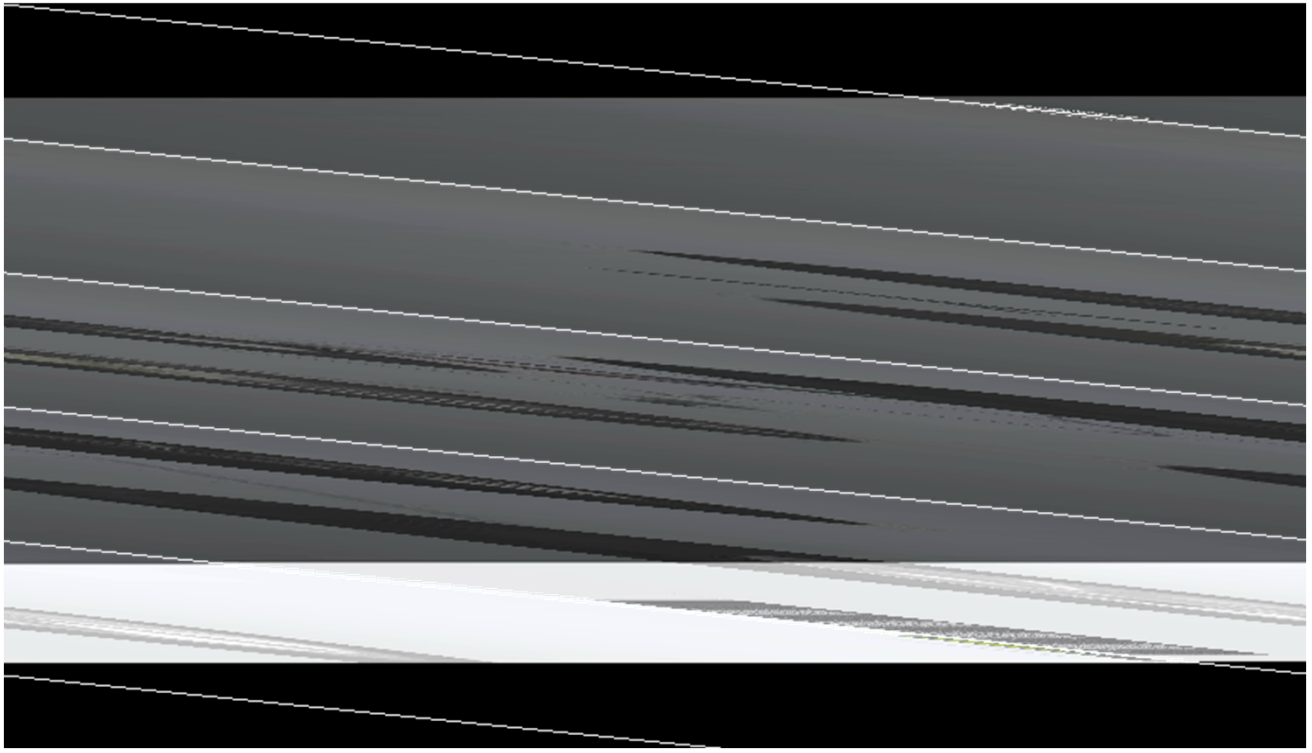
ABS – Antiblockiersystem (Antilocking System)





Chassis controls and functions (1)

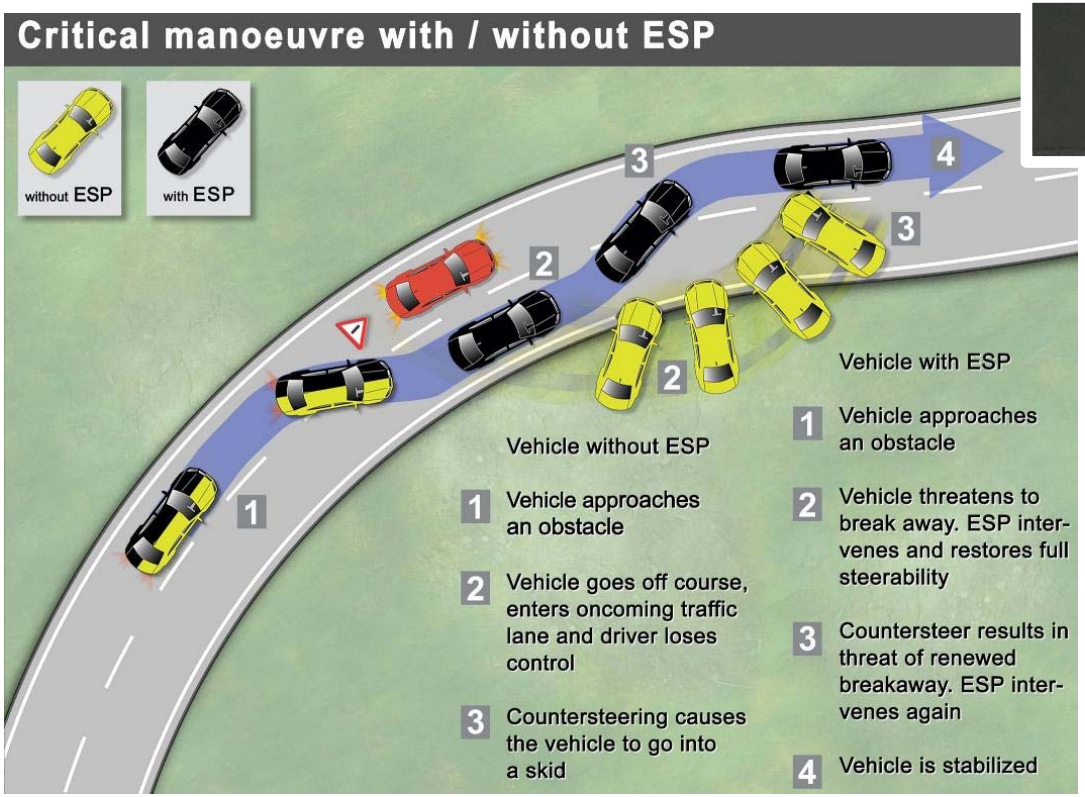
Hydraulik Brake system and brake control systems



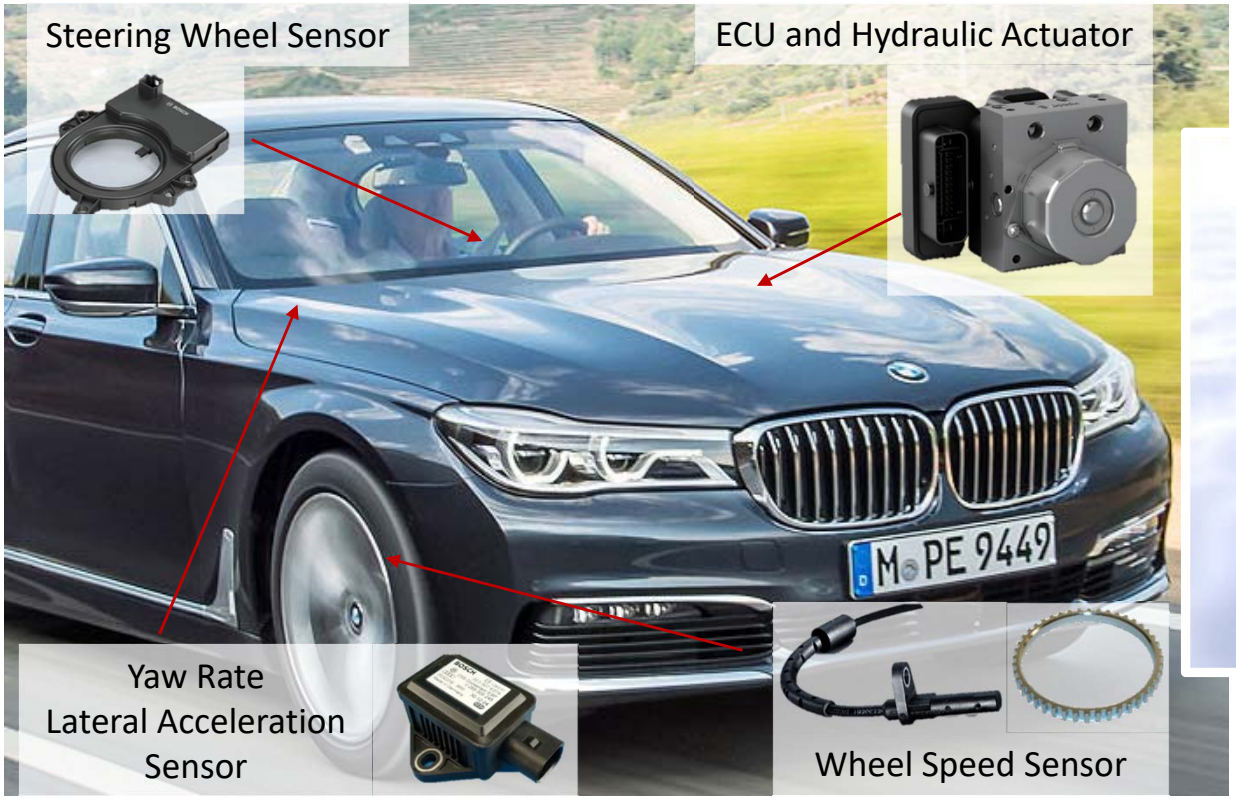
https://www.youtube.com/watch?v=GHt0u_7abvs

https://www.youtube.com/watch?v=CzEBVdZeyQs

Electronic Stability Program (ESP)



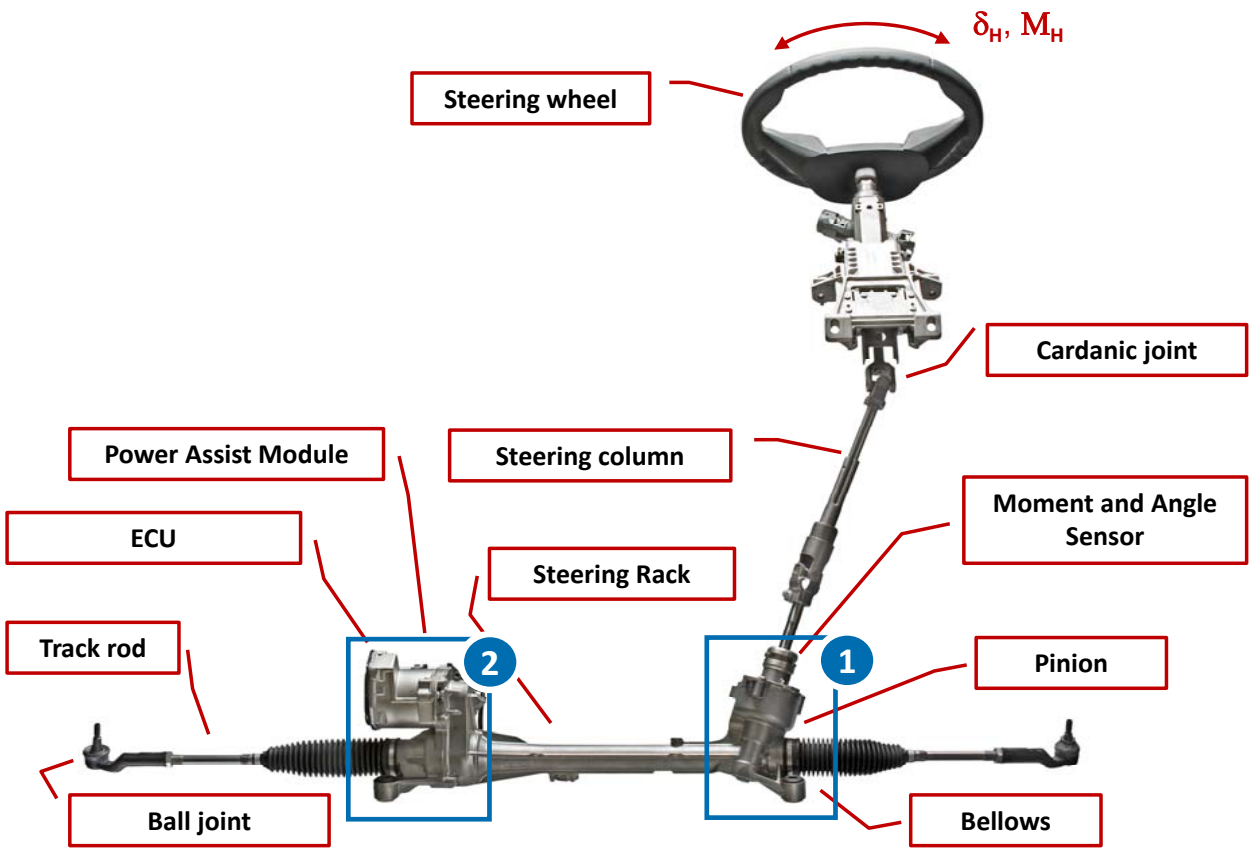
Electronic Stability Program (ESP)

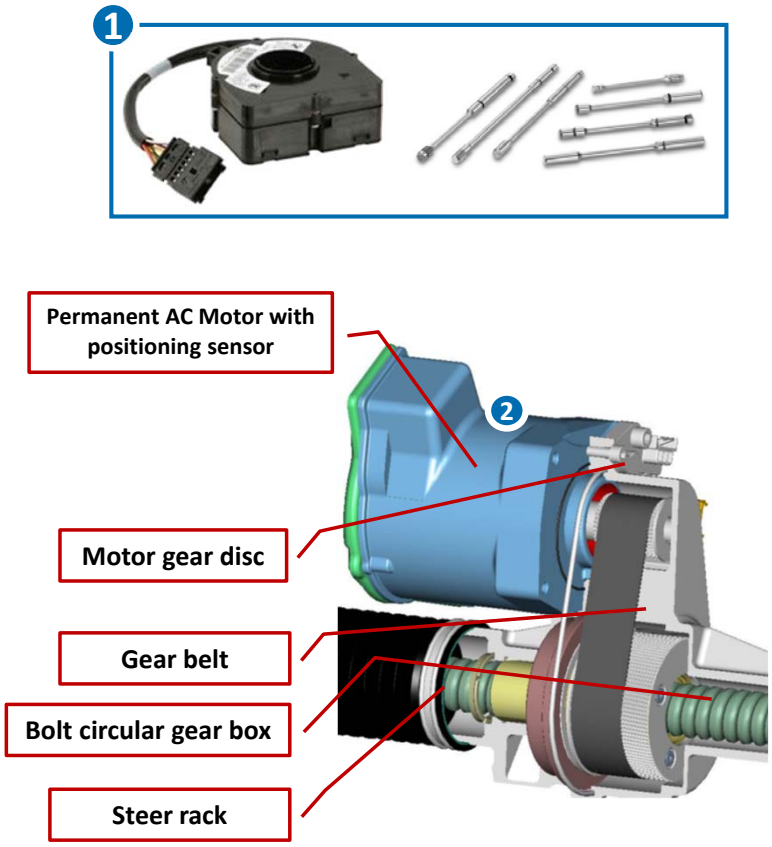


Sample “Added Value Functions”

Steering System

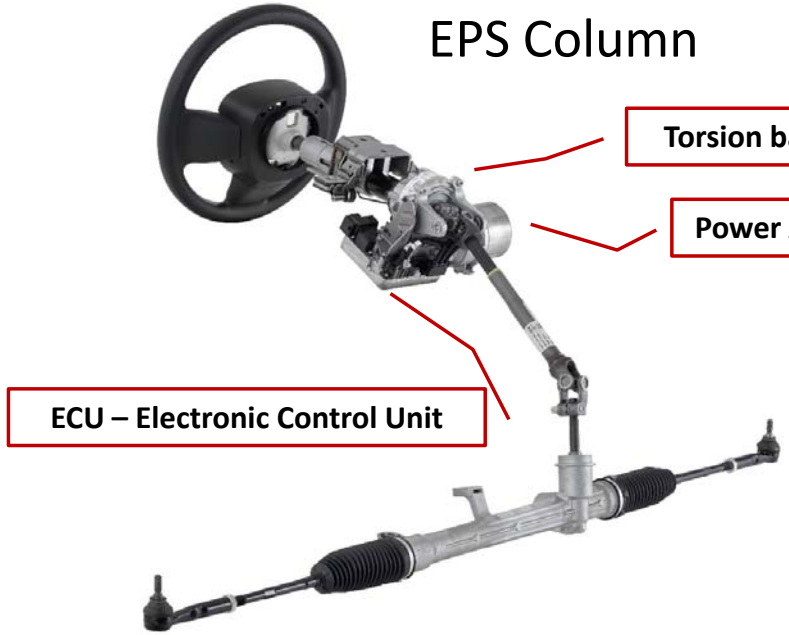
Steering system – Electrical Power Steer (EPS) EPS apa (axle parallel)



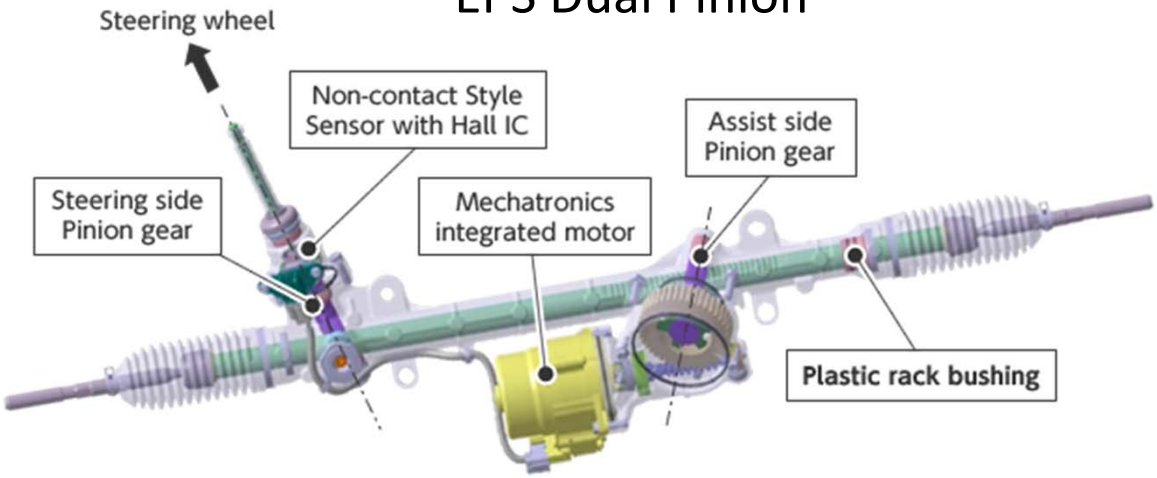


Steering system – Electrical Power Steer (EPS)

EPS Column



EPS Dual Pinion



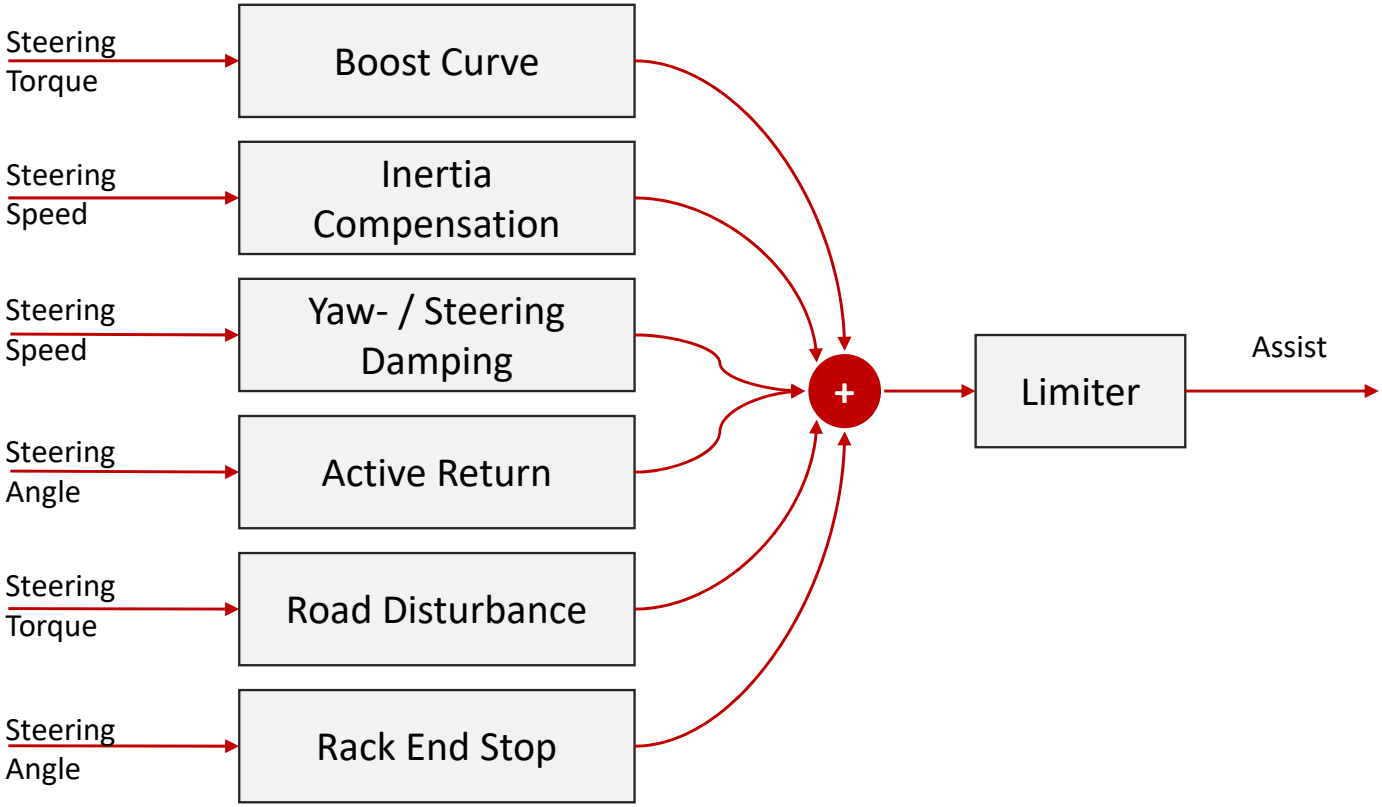
Chassis controls and functions (1)

Rack an pinion steering system

https://www.youtube.com/watch?v=DC6Opx_3EUo

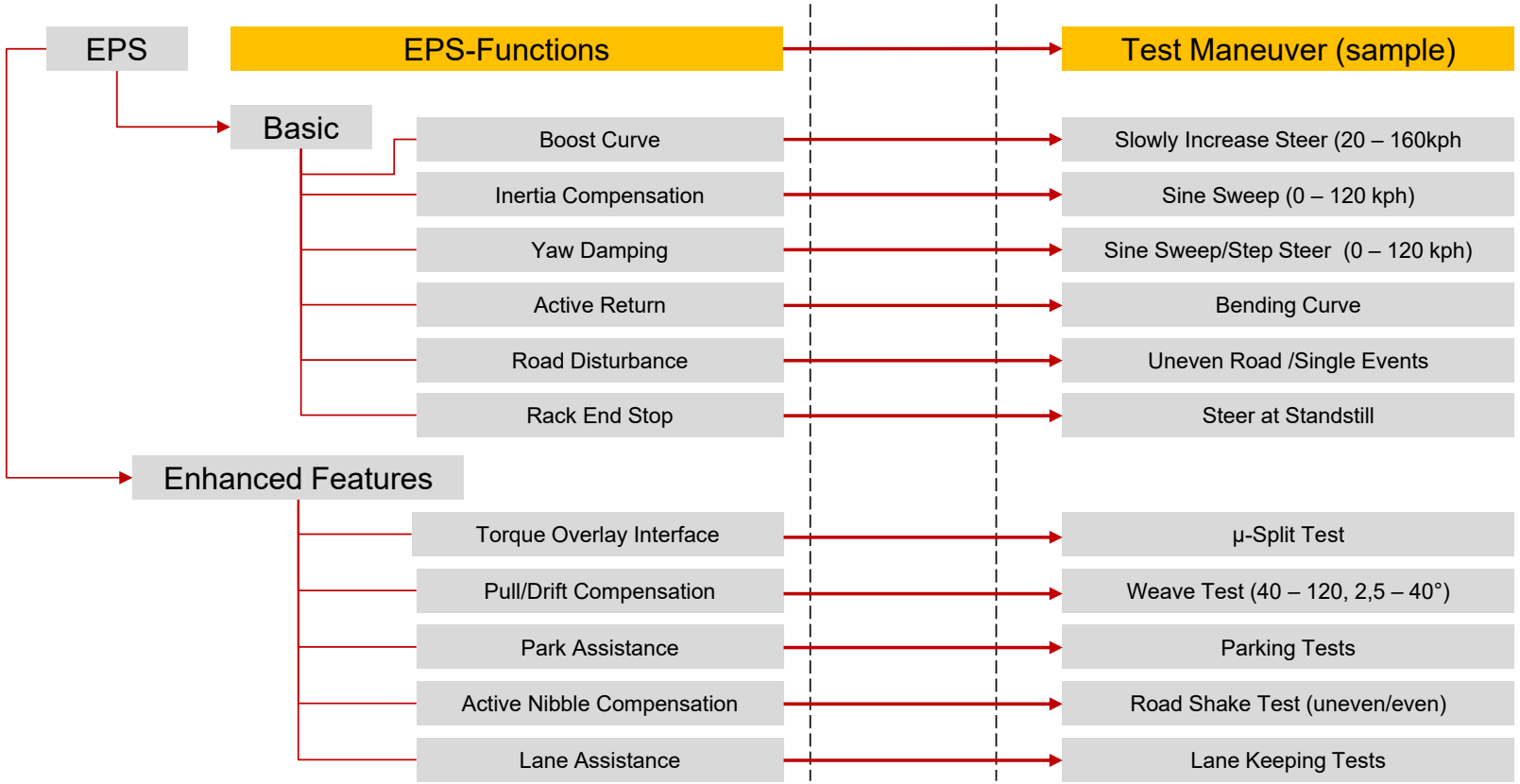
Chassis controls and functions (1)

EPS Basic Functions



Chassis controls and functions (1)

EPS functions and test maneuver for validation



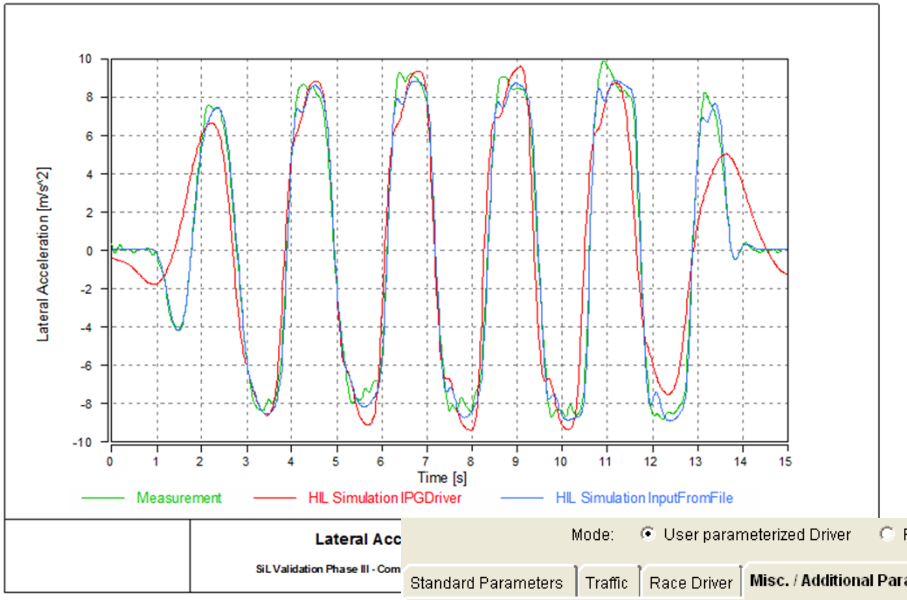
Chassis controls and functions (1)

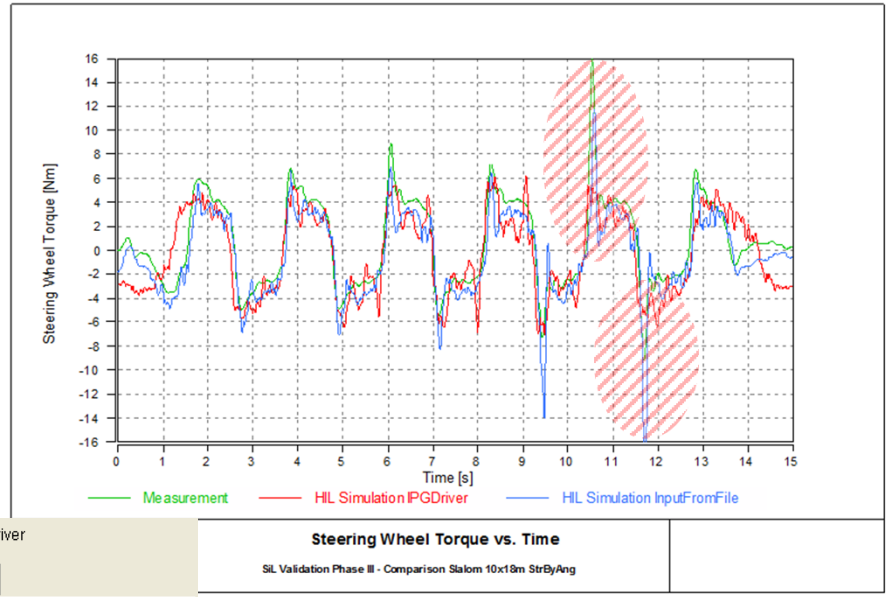
EPS functions and test maneuver for validation

FailSafeTests	Function Tests	Performance Tests
▪ High/Low Voltage ▪ Controller stability in different situations ▪ Sensor signal cut / interrupt ▪ Sensor offset / drift error ▪ Sensor noise error ▪ Sensor signal jump ▪ Failure moment ▪ CAN failure ▪ Starting condition ▪ Short cycle ▪ Loose contact ▪ Diagnostic messages ▪ Interface and (lost) communication ▪ …	▪ end stop control ▪ high speed damp control ▪ motor save function ▪ on- center control ▪ active friction controller ▪ active return control ▪ active inertia comp. ▪ pull & drift control ▪ active road slope control ▪ side wind control ▪ road disturbance rejection ▪ active nibble compensation ▪ active steering support (e.g. µ split) ▪ park assist functions… ▪ ….	▪ Power tests of steering support ▪ Turn-in ability ▪ On-center handling ▪ Pull behavior ▪ Drift behavior ▪ Straight running precision ▪ Steering wheel return ability ▪ Torque cut off ▪ Parking comfort ▪ Slalom performance ▪ Lane change performance ▪ Nuerburgring test (Fuchsröhre) ▪ Catch-up behavior ▪ Starting behavior ▪ ….

Chassis controls and functions (1)

Sample Function and Test: Catch-up during virtual vehicle test → Slalom





Mode: User parameterized Driver Racing Driver

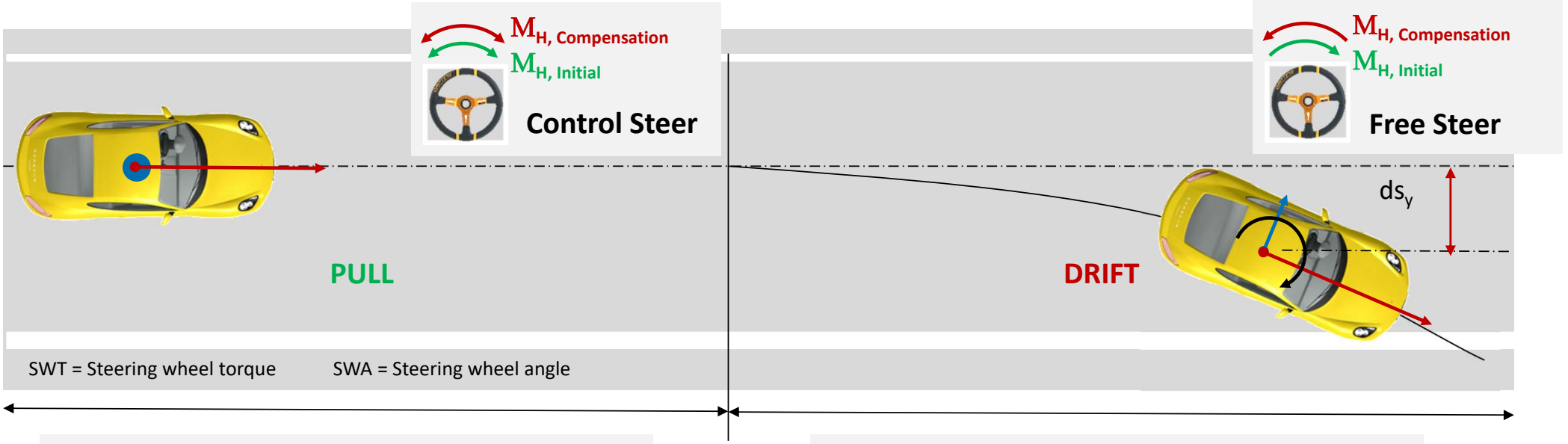
Standard Parameters | Traffic | Race Driver | **Misc. / Additional Parameters**

	long.	lateral
Tolerated Deviation	0.0 km/h	0.0 m
Reaction Time	0.0 s	0.0 s
Max. Steering Wheel Angle		630 deg
Max. Steering Wheel Velocity		1200 deg/s
Max. Steering Wheel Accel.		4000 deg/s²

Additional Parameters

Chassis controls and functions (1)

Sample Function and Test: Pull-Drift Compensation (PDC)

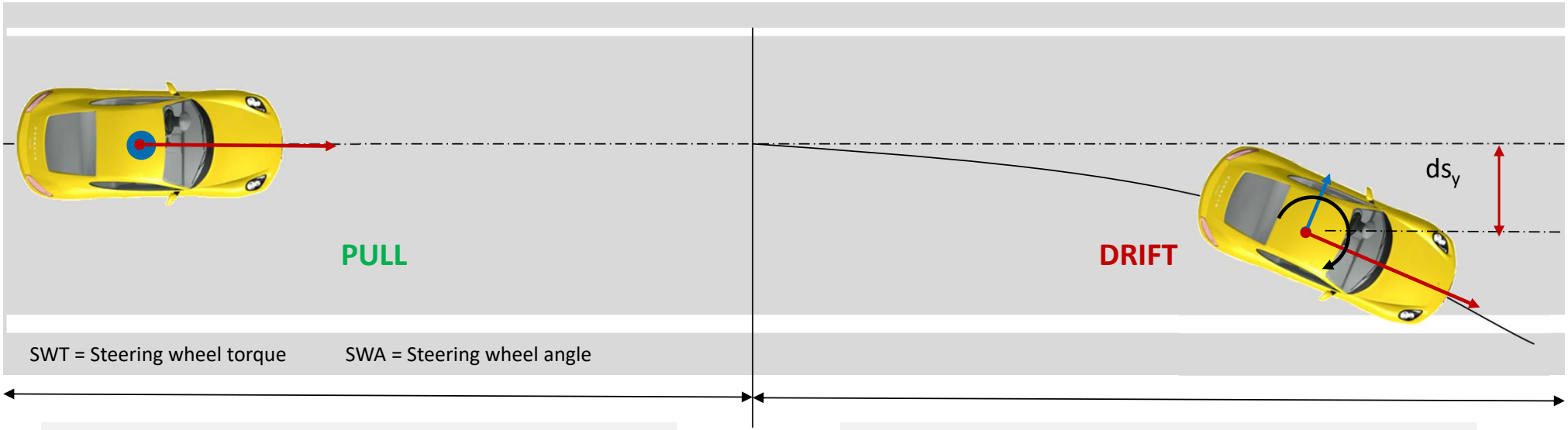


- The driver has to pull steering torque to drive straight ahead
- This steering torque is measured and automatically supported to reduce the drivers effort

- The vehicle is drift off the center line. The vehicle response with a yaw rate
- The yaw rate is measured and a steering angle support is applied to reduce the yaw rate to zero.

Chassis controls and functions (1)

On-Center Steering Behavior



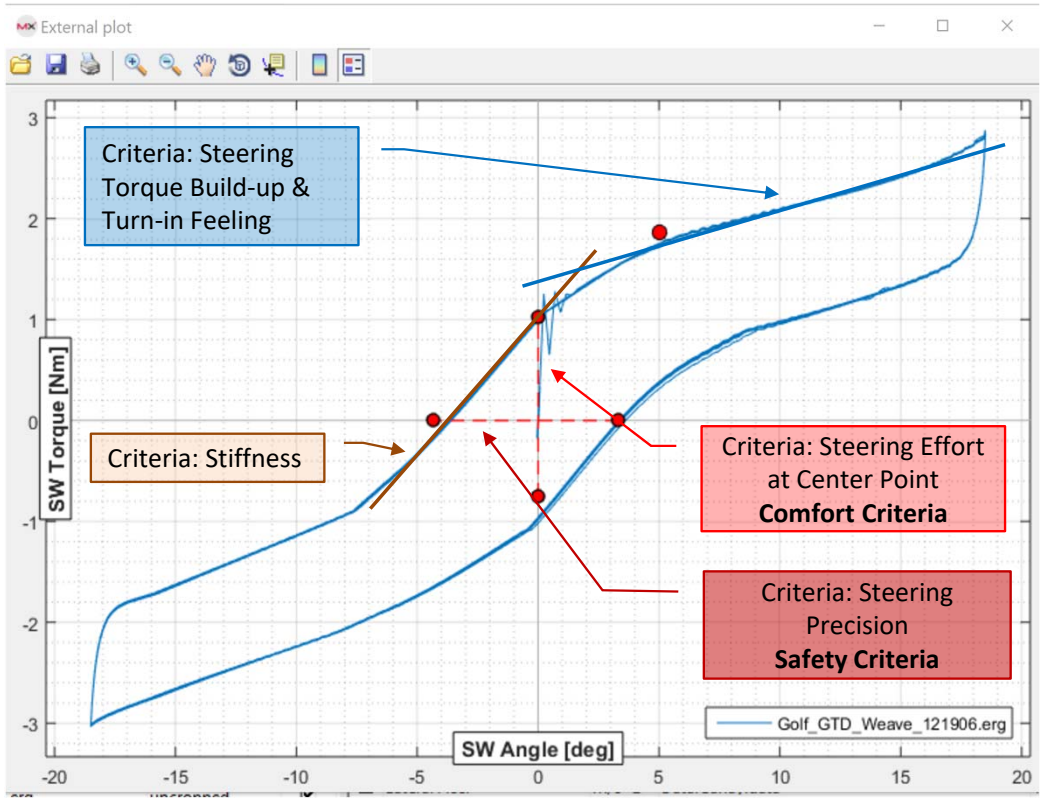
COMFORT

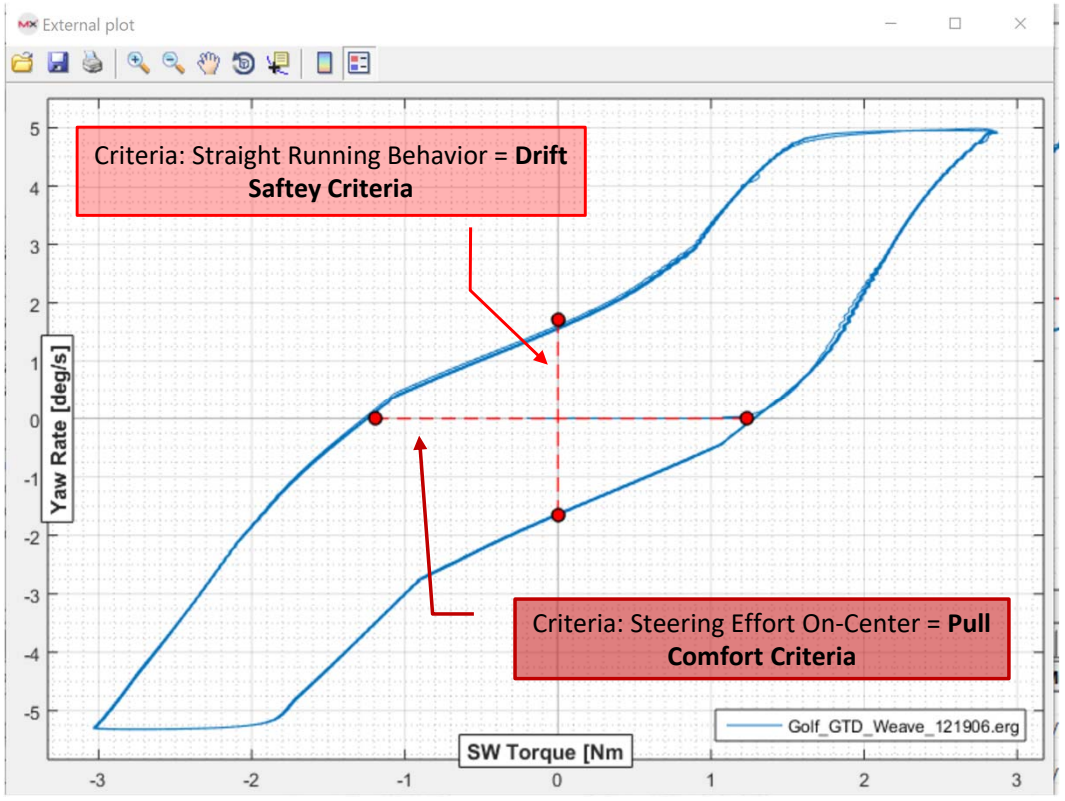
- **Subjective:** Steering Effort Center Point
- **Objective:** SWT / SWA Effort at YawRate = 0

SAFETY

- **Subjective:** Straight running behavior
- **Objective:** YawRate Response at SWT = 0

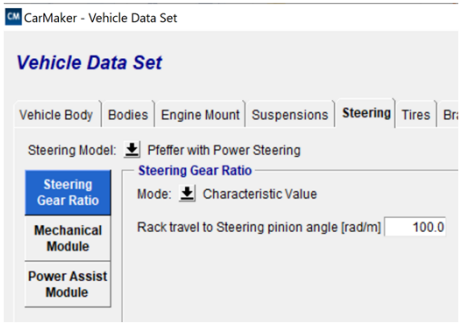
Steering On-Center Evaluation: On-Center Handling Test (ISO 13674)

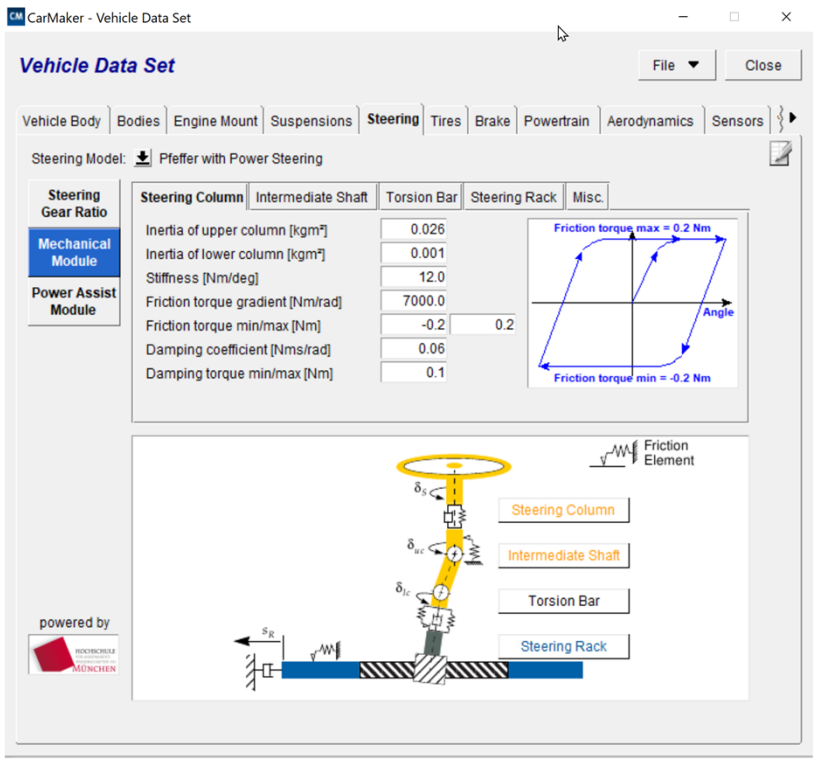


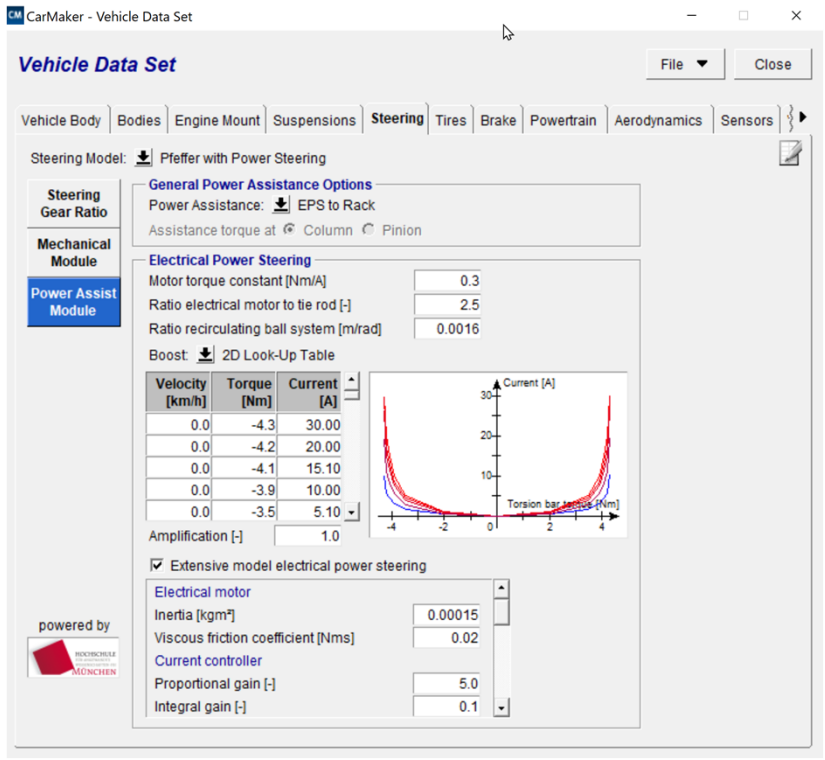


Chassis controls and functions (1)

EPS Steering Model and related parameter

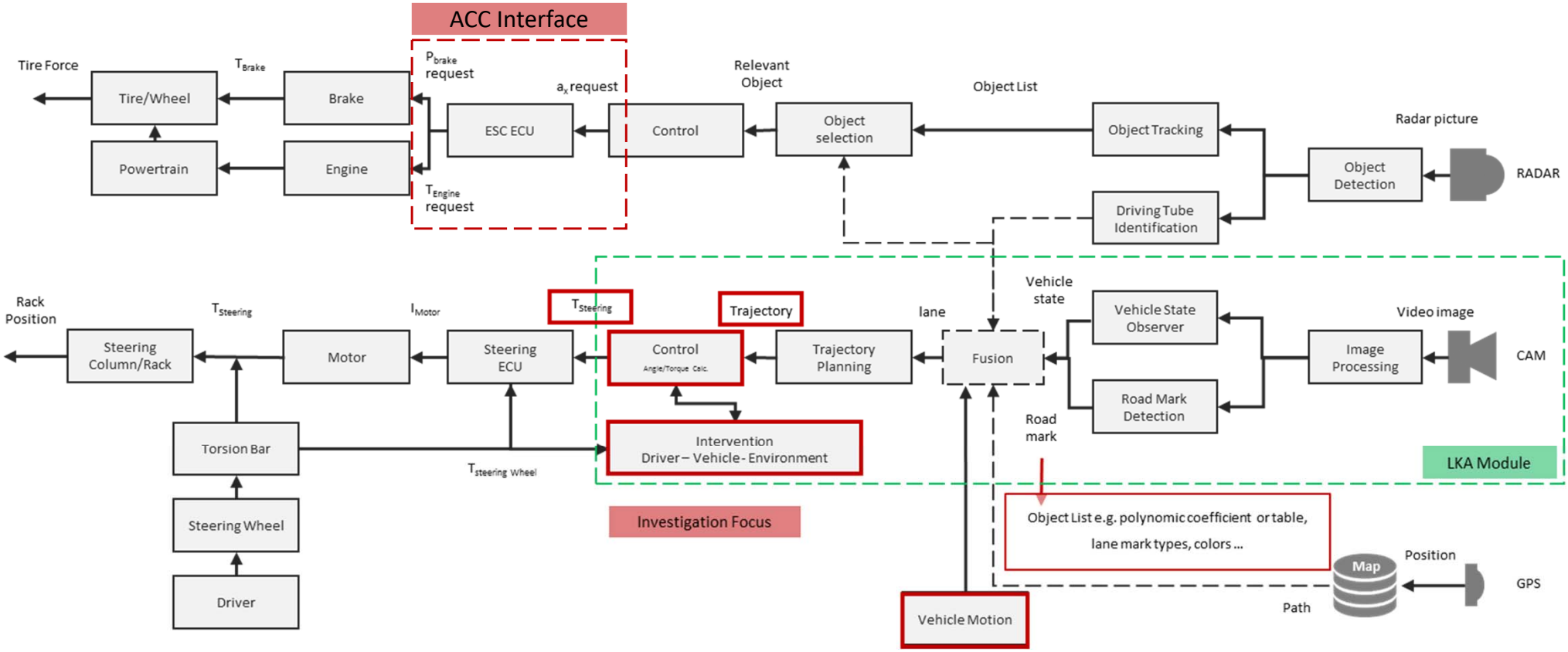




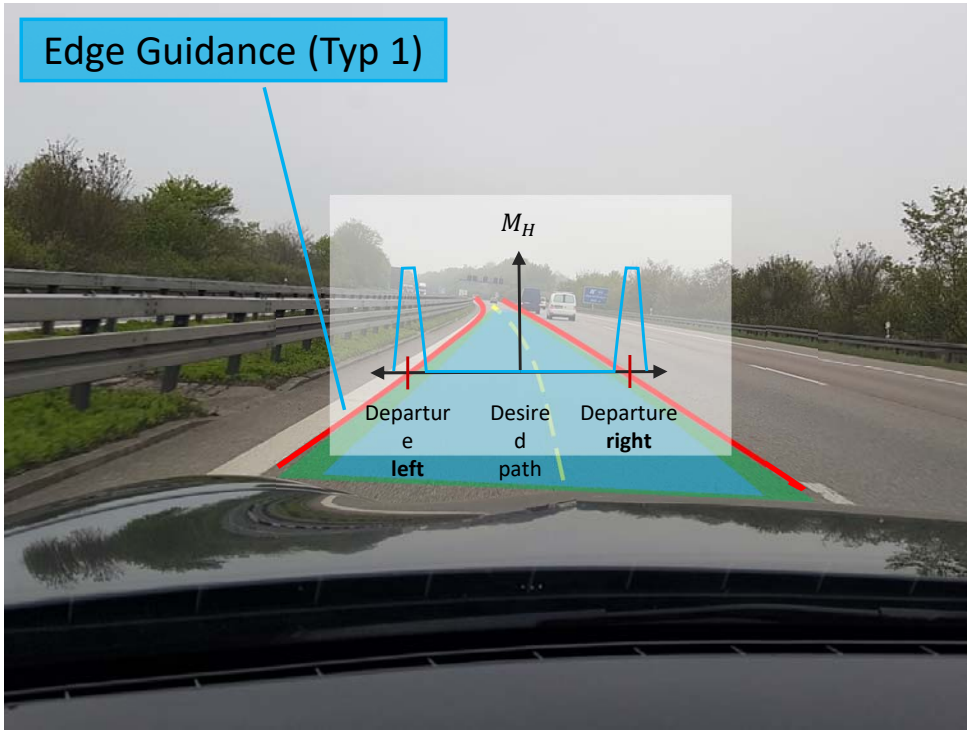


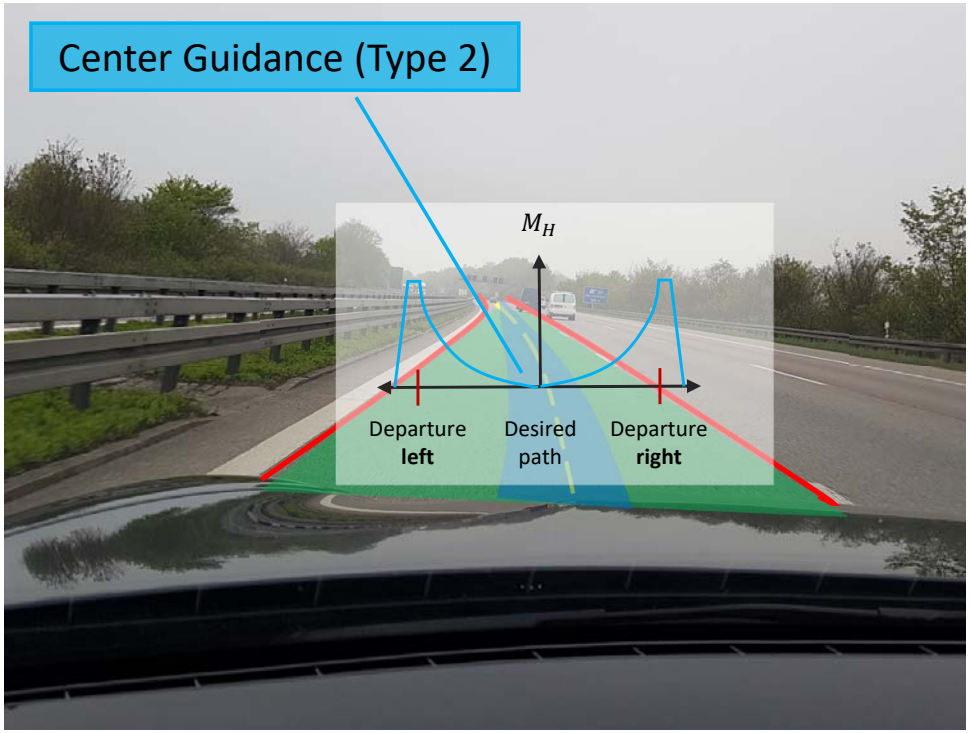
Chassis controls and functions (1)

Lateral Control Function: Lane Keeping Assistance Systems



Lateral Control Function: Lane Keeping Assistance Systems

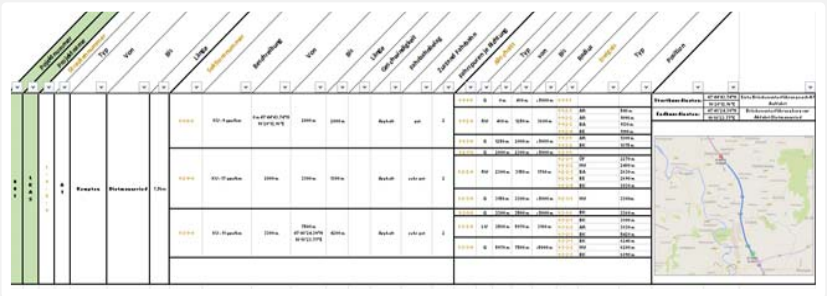


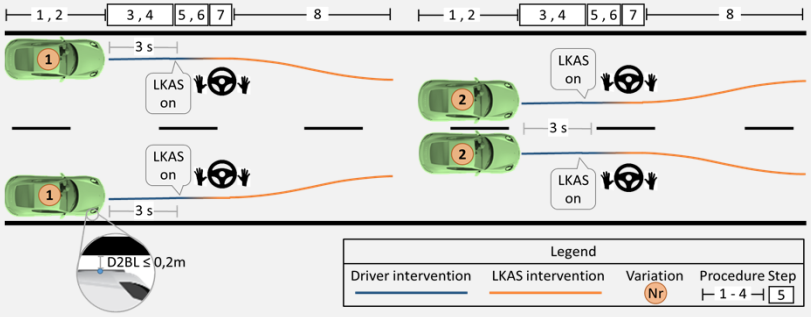


Chassis controls and functions (1)

LKAS driving maneuver catalogue for public road and proving ground

Road Catalogue & Maneuver Definition





Driving Maneuver

- Free Ride Test
- Lane Change Test
- Transient Test
- Hands-Off Test at FSB
- Driver Feedback Test
- Stationary Cornering as Drop and Performance Test
- On-Center Handling Test
- Step Steer Test

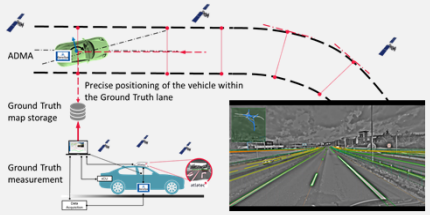
Vehicle Measurement

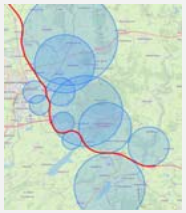
<u>Benchmark vehicles w/o bus access:</u>

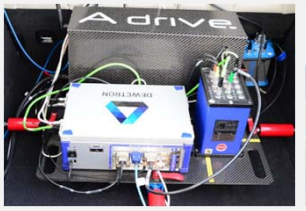
- Genesys ADMA IMU
- Kistler Steering Measurement Wheel
- System Status at Instruments

<u>Vehicles with bus access:</u>

- CAN/FR Bus Signals e.g. Object List

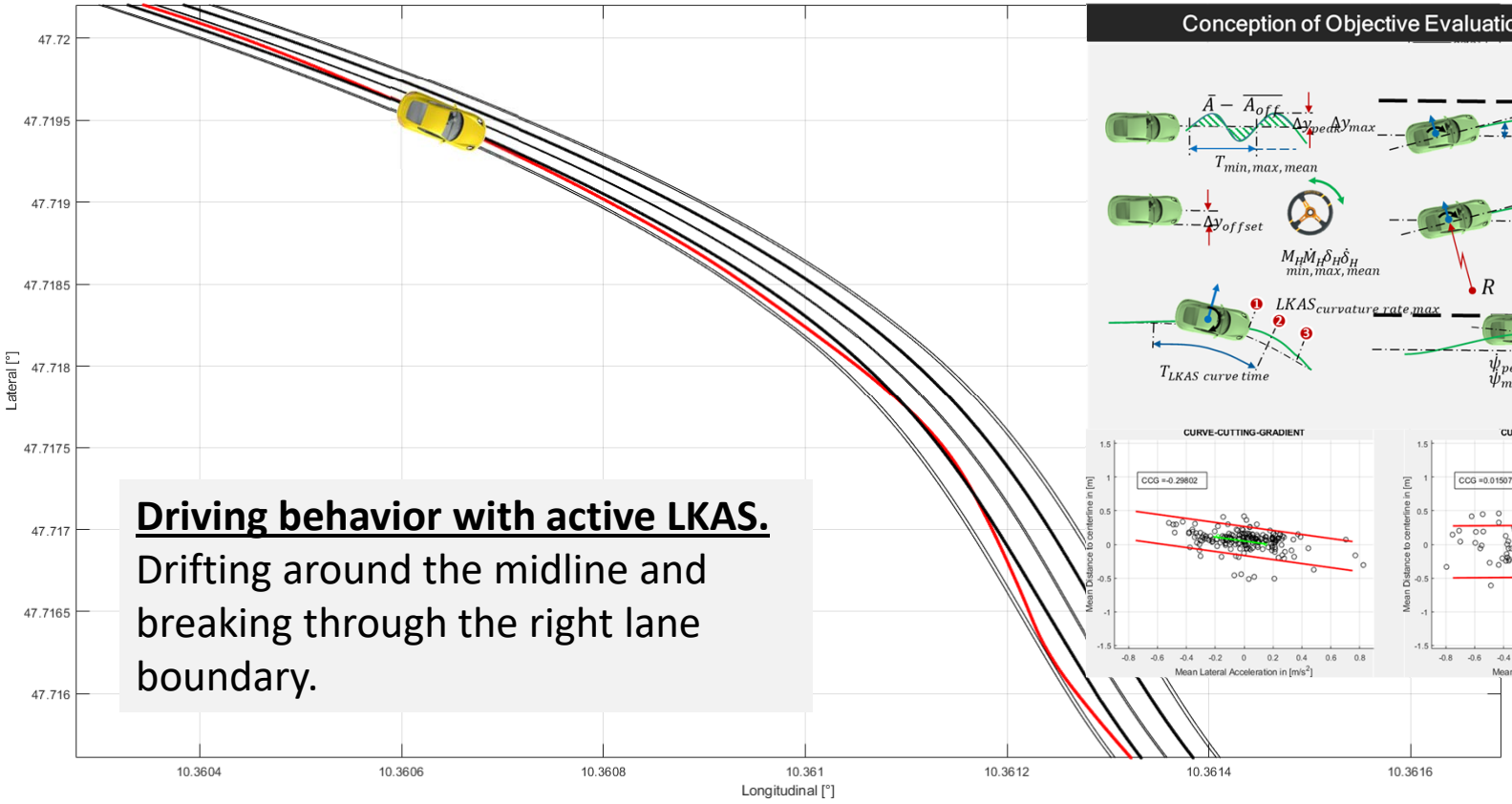




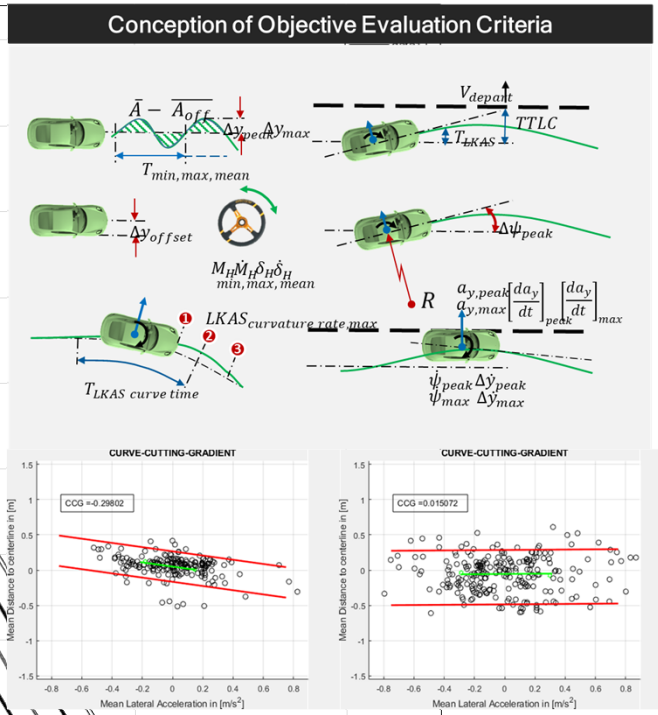


Chassis controls and functions (1)

Accurate location of the vehicle in the lanes and vehicle motion evaluation



Driving behavior with active LKAS.
Drifting around the midline and breaking through the right lane boundary.



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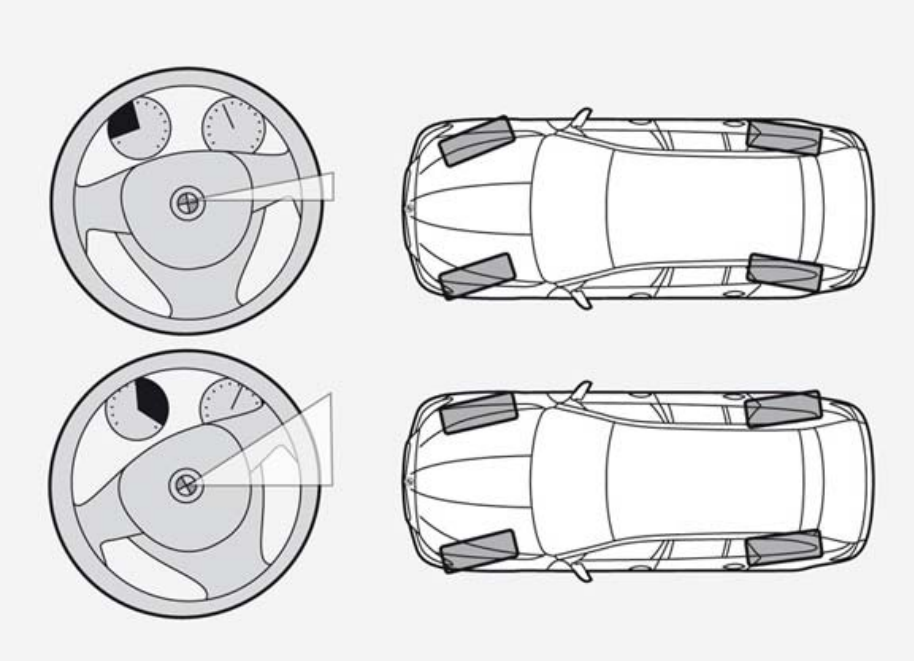
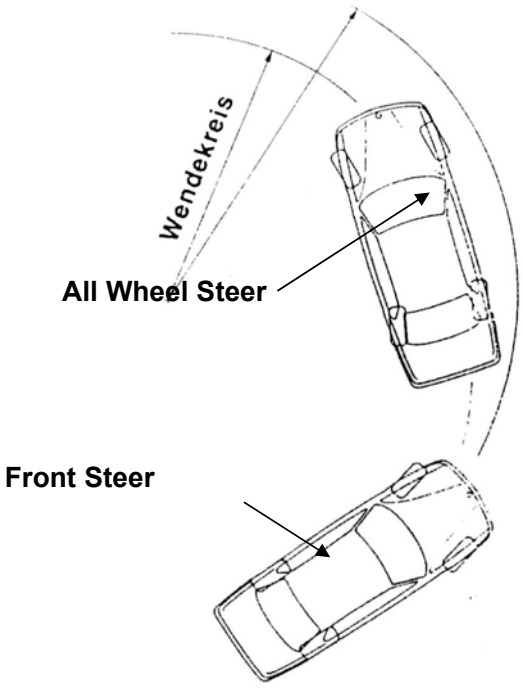
All Wheel Steering System

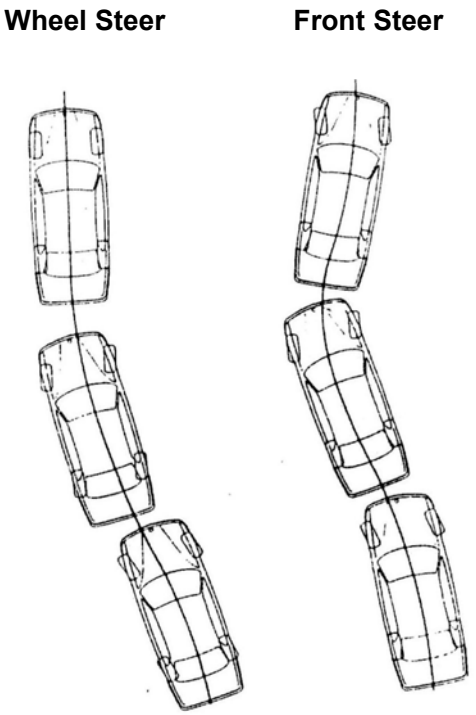


All Wheel Steering System

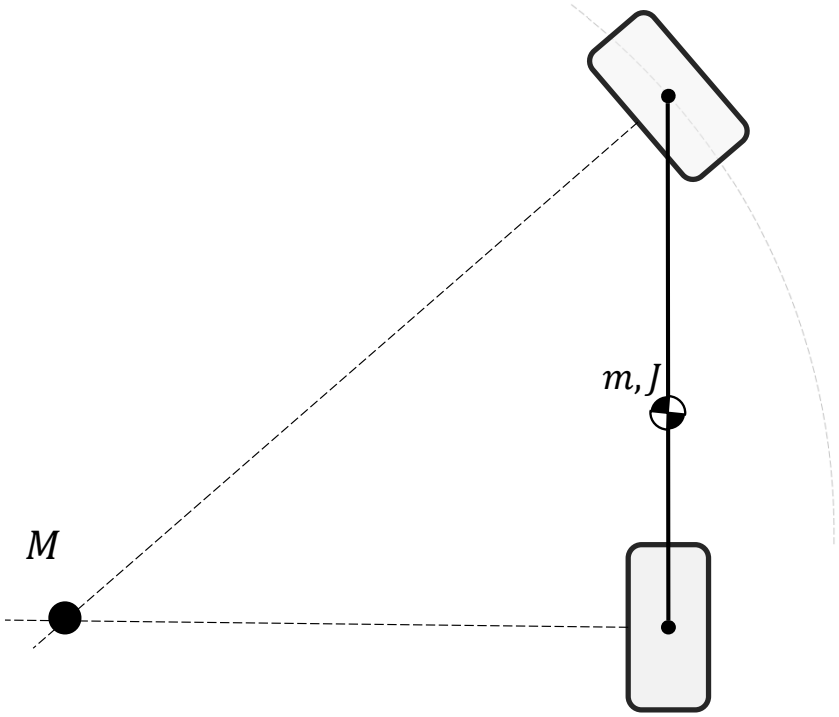
Steering in the opposite direction of rear wheels to achiev a small turning circle

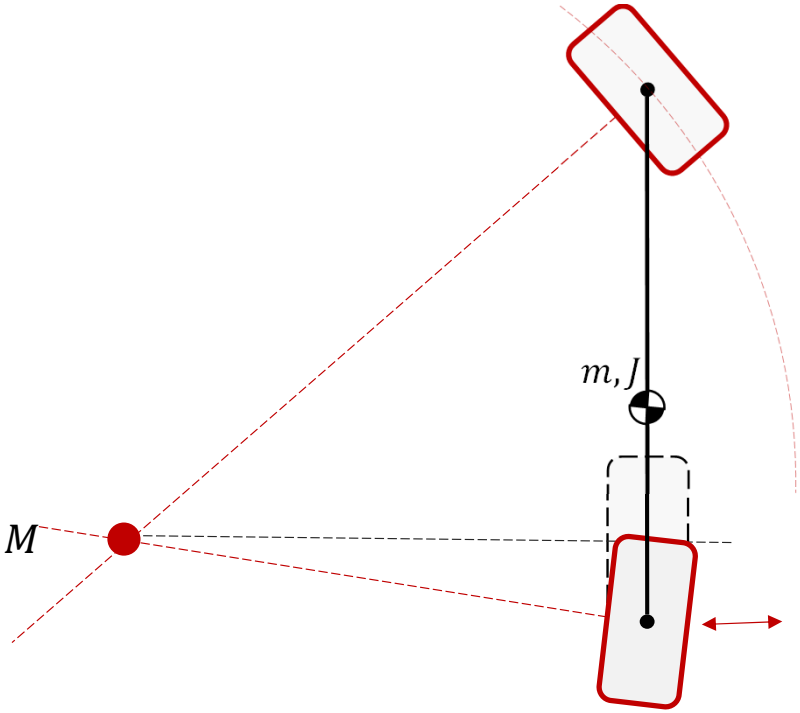


Steering in the same direction of rear wheels to achiev stability



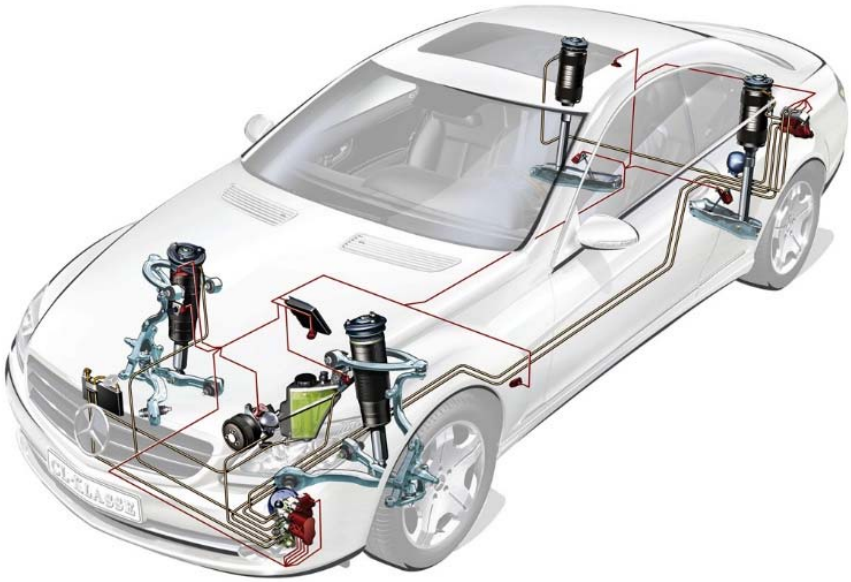
All Wheel Steering System - Principle of Action

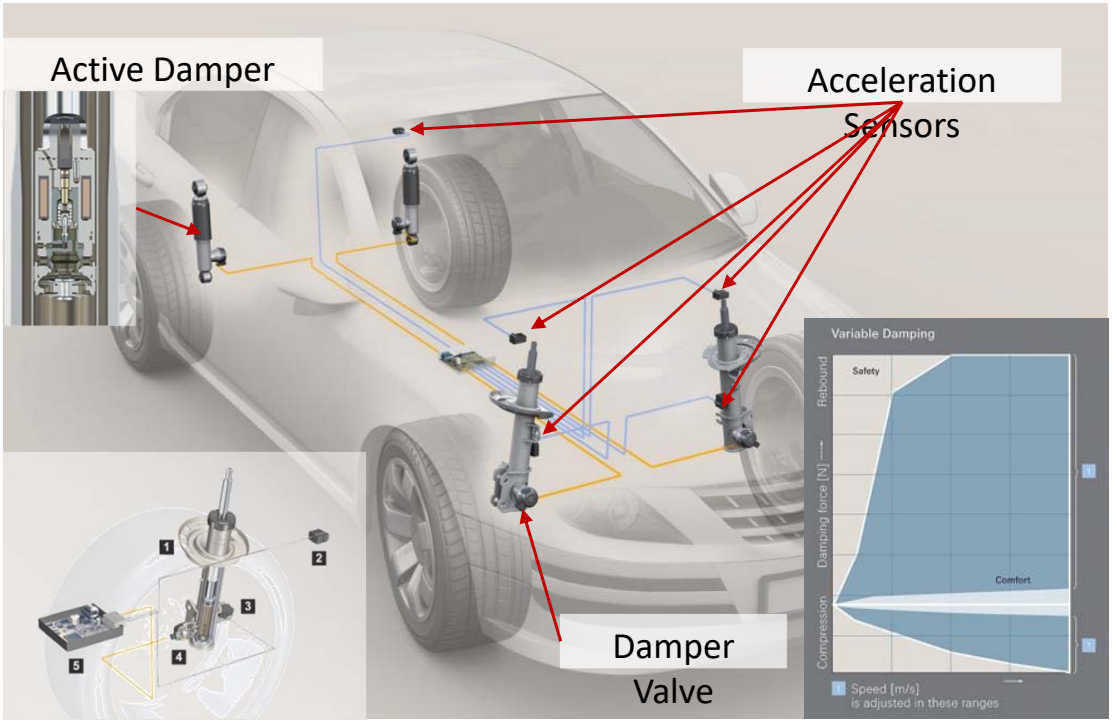




Chassis controls and functions (1)

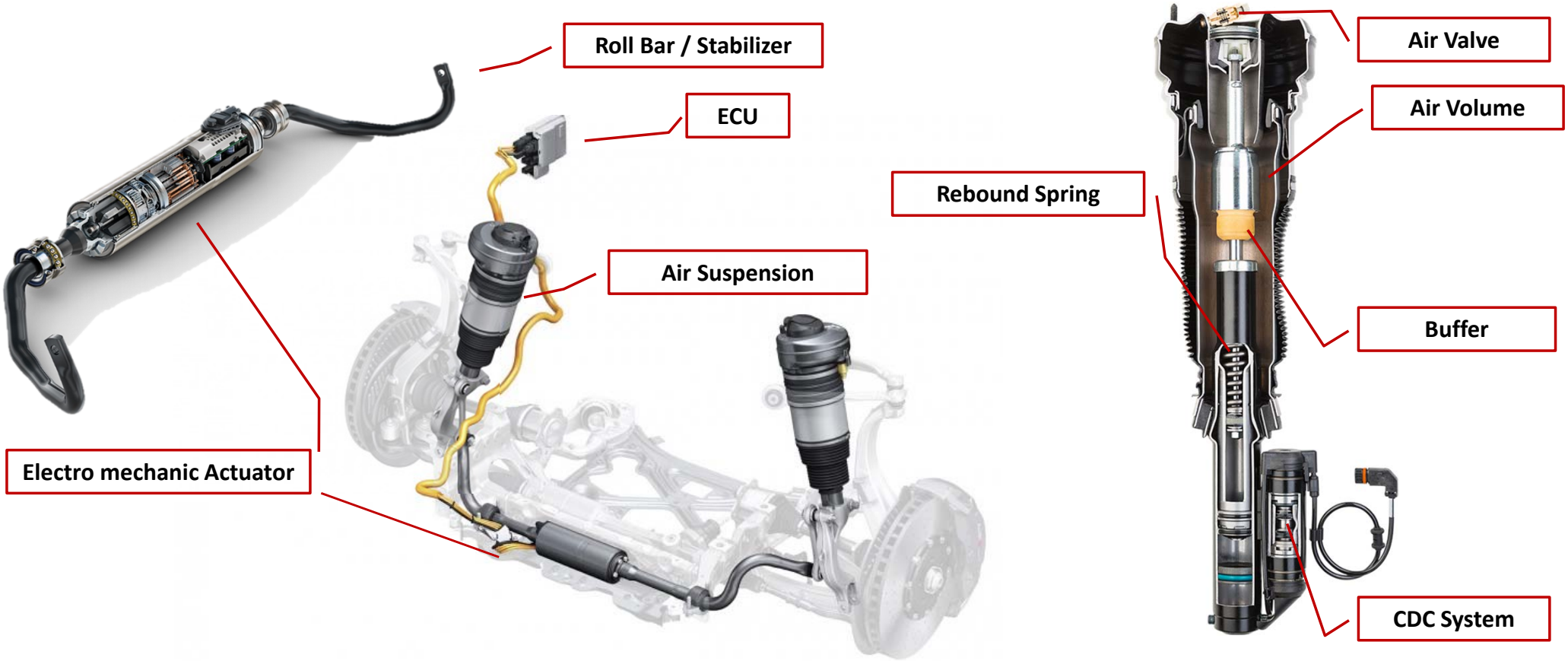
Active suspension control with CDC – Continuous Damping Control





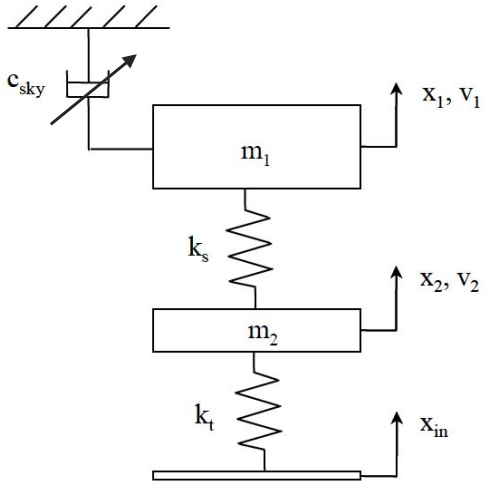
Chassis controls and functions (1)

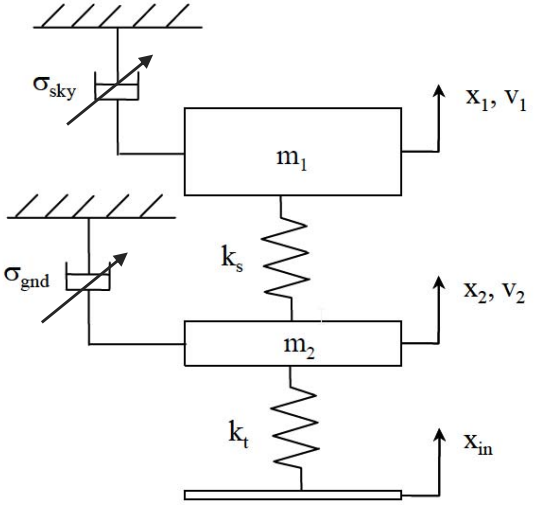
Active suspension control with CDC – Continuous Damping Control

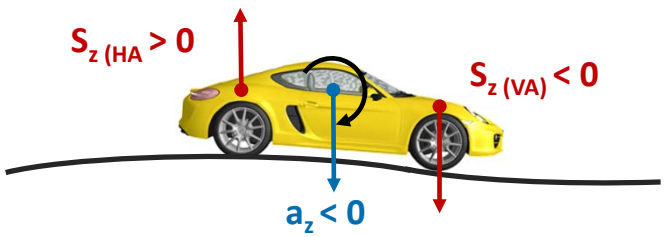


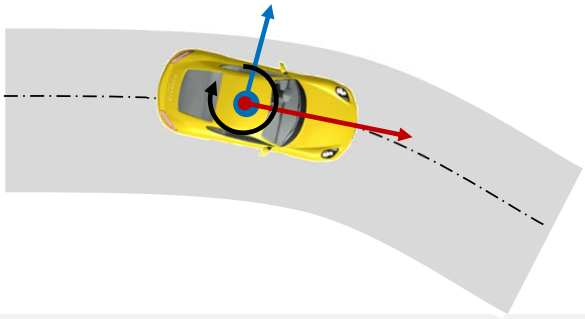
Chassis controls and functions (1)

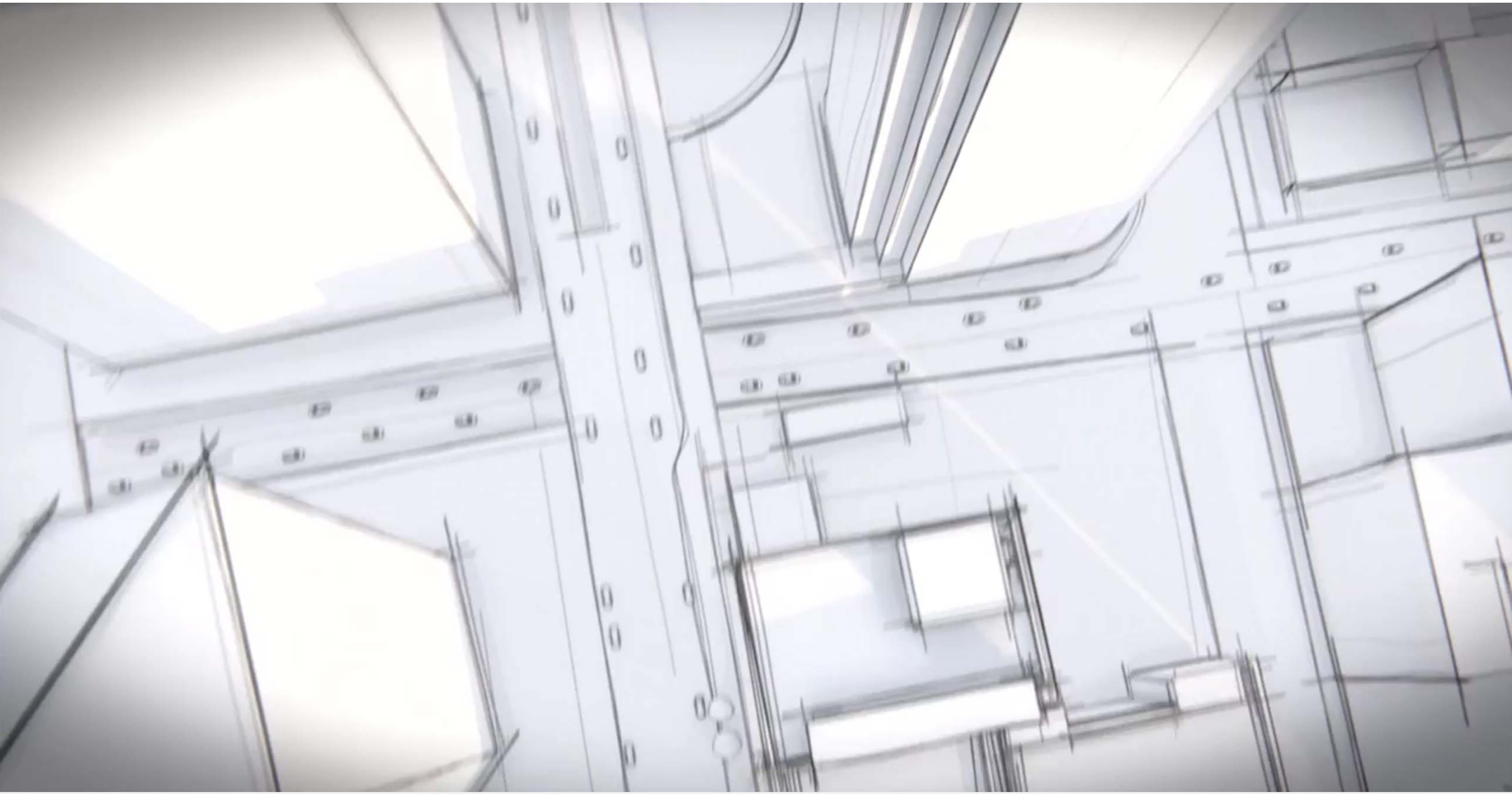
Groundhook principle for longitudinal & lateral dynamics











Chassis controls and functions (1)