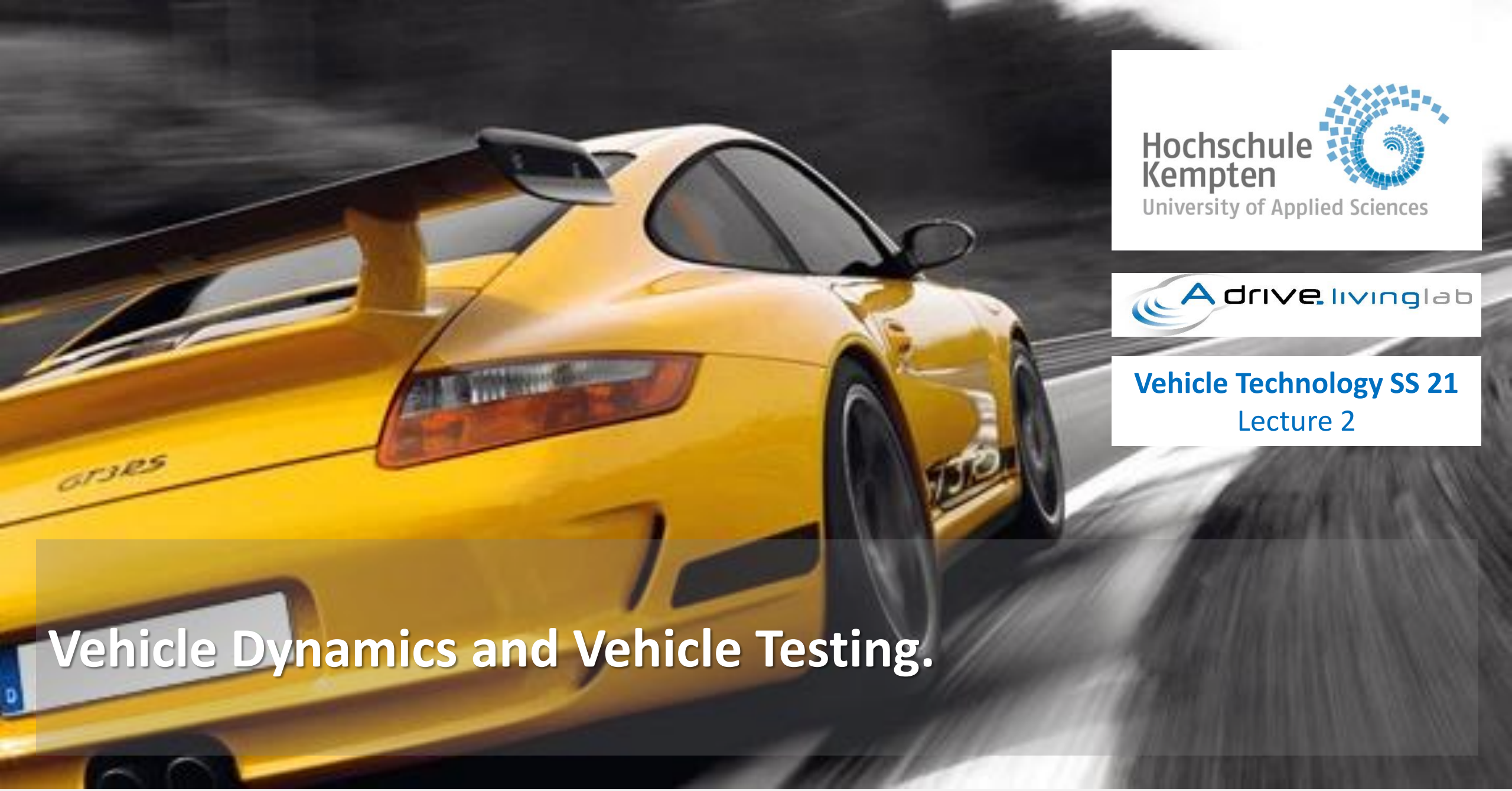


Hochschule Kempten
University of Applied Sciences

drive livinglab

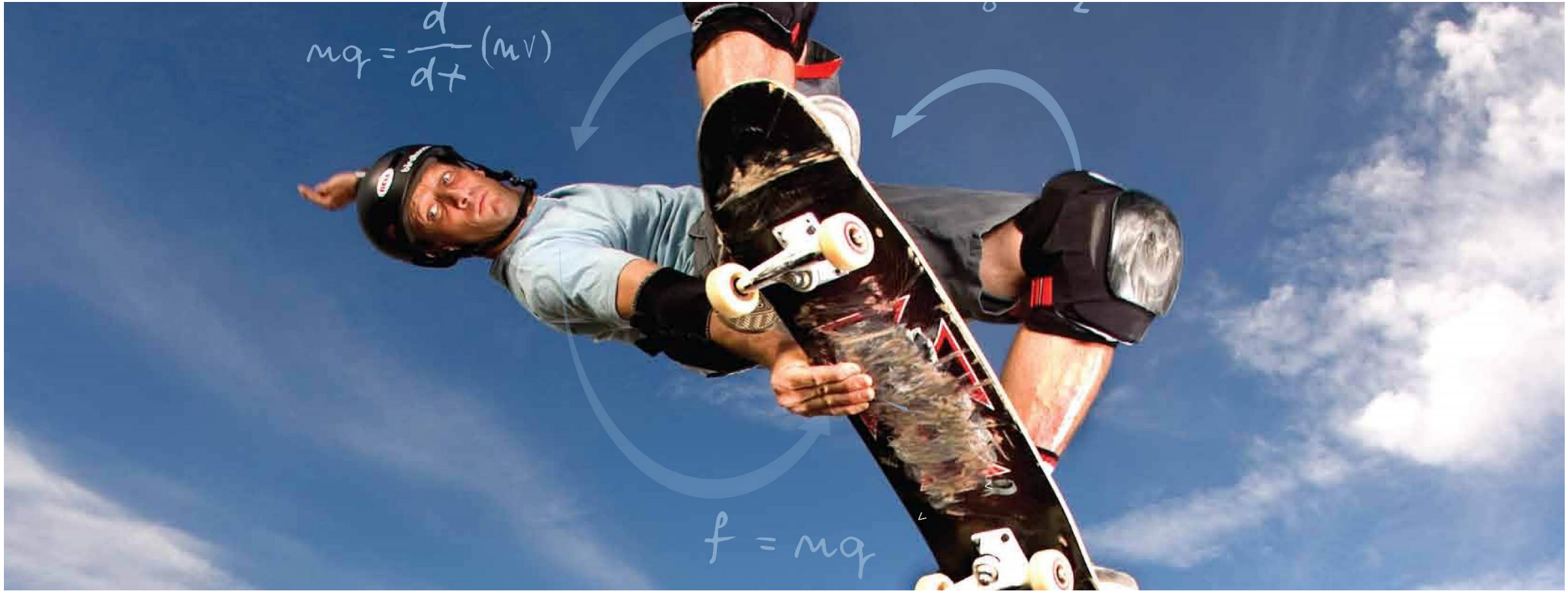
Vehicle Technology SS 21
Lecture 2

Vehicle Dynamics and Vehicle Testing.

Agenda

Nr.	Datum	Inhalt
1	19.03.	Introduction Vehicle dynamics
2	**26.03**	**Practical Training Vehicle Dynamics Simulation and Evaluation**
3	09.04.	Test and evaluation methods for vehicle attributes with practical simulation
4	16.04.	Chassis components and functions with practical simulation
5	30.04.	Basic vehicle dynamics calculation and vehicle models
6	**18.06**	**Track Day**
7	25.06.	ESP–Functions & Application & Process
8	**02.07.**	**ESP–Application & Hands-On Workshop**
9	09.07.	Project Day

What is a maneuver?



Test and evaluation methods for vehicle attributes

Maneuver (French *manœuvre*, latin: *manuopera* „Handdienst“) stands for:

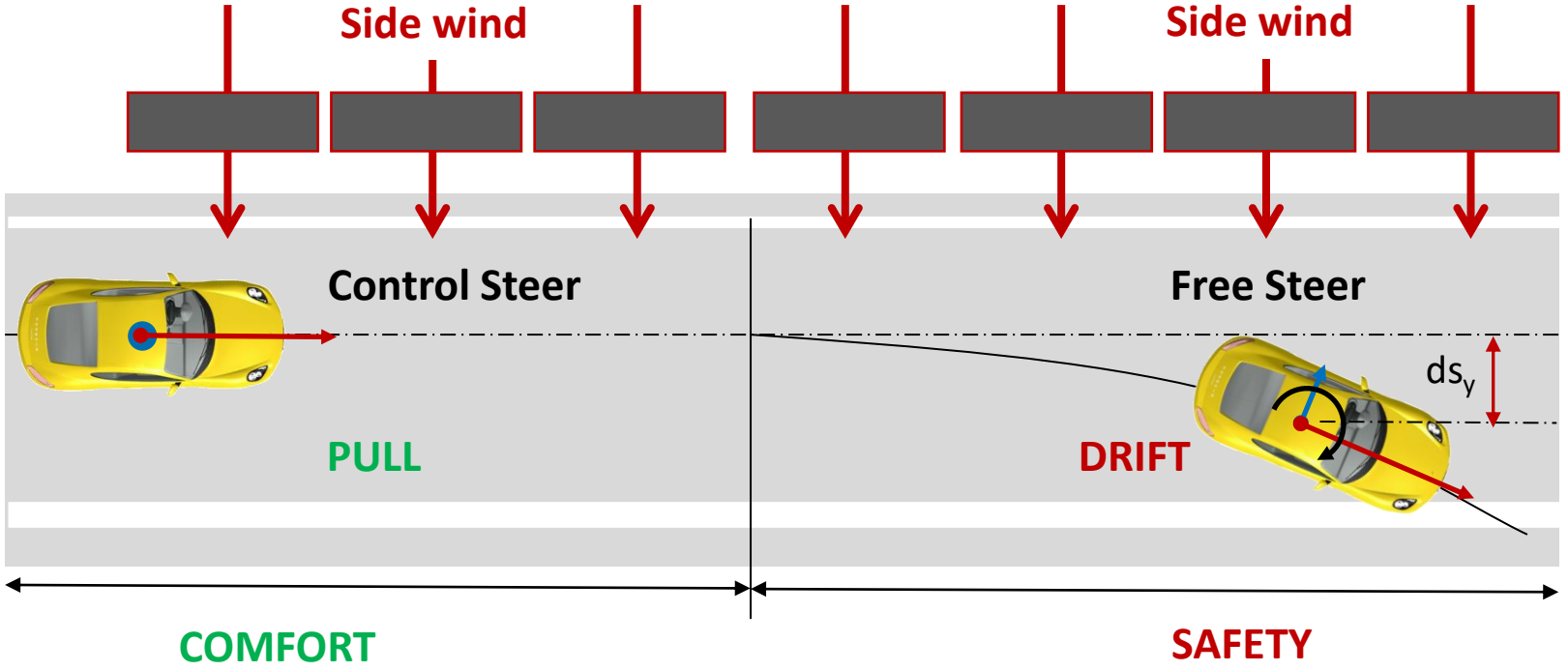
- **Generally: a maneuver is a smart executed change of direction**
- **Military:** Troops or fleet exercises under warlike conditions or tactical movement of troops associations
- **Shipping:** Course change in shipping
- **Flying:** a flyable change in direction or figure in aviation
- **Vehicle test: Reconstruction of a real driving situation!**

Test and evaluation methods for vehicle attributes

Testing Principle: Looking for trouble before it looks for you!

Road testing are still a very high effort.

Sample: Driving maneuver and objective & subjective evaluation criteria



- **Subjective:** Steering effort at side wind (SWA/SWT)
- **Objective:** SWT / SWA Effort at YawRate = 0

- **Subjective:** Straight running behavior at side wind
- **Objective:** Lateral displacement, YawRate Response

SWT = Steering wheel torque SWA = Steering wheel angle

Vehicle Dynamics Attribute Evaluation

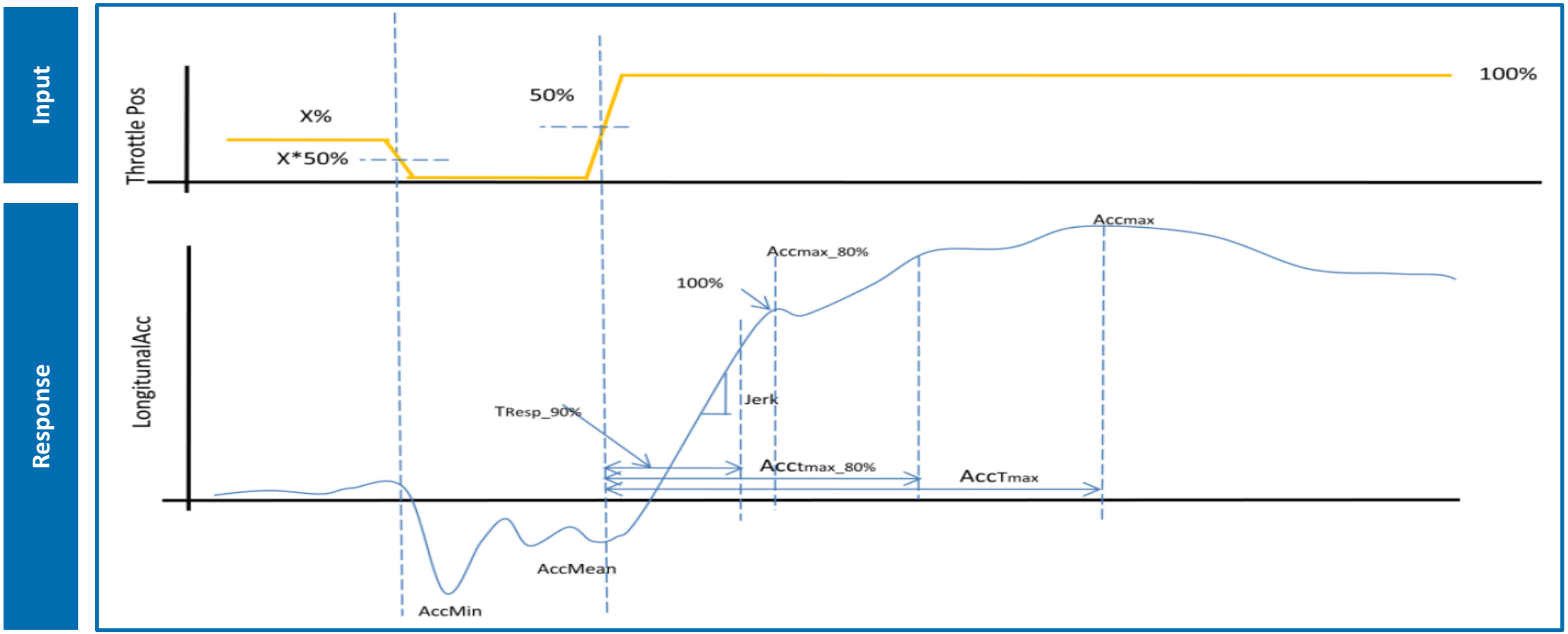
Driving Maneuver Catalogue (Open/Closed Loop)

- Steady state circular (ISO)
- Frequency response test (ISO)
- Slowly increase steer (ISO)
- Weave test (ISO)
- Transition test (ISO)
- Step input test (ISO)
- Slalom
- Lane change test (ISO 3888)

Simulation Demo

- Handling Course - Nürburgring
- Braking during cornering (ISO)
- Power-Off Test (ISO)
- µ-Split Braking (ISO)
- Steering Return Ability Test
- Braking test
- Acceleration Test
- …

Objective evaluation via key performance indicators – KPI's



Test and evaluation methods for vehicle attributes

Standardization of driving maneuver and evaluation criteria's

ISO-Standards		
1982	ISO 4138	Road vehicles - Steady state circular test procedure
1988	ISO 7401	Road vehicles - Lateral transient response test methods
1991	ISO 8855	Road vehicles - Vehicle Dynamics road holding ability – Vocabulary
1985	ISO 7975	Road vehicles - Braking in a turn - „open-loop“ test procedure
1991	ISO 9815	Road vehicles - Passenger Car-Trailer combination lateral stability test procedure
1990	ISO 10392	Road vehicles with two axles - Determination of center of gravity
1993	ISO 9816	Passenger Cars - Power-off reactions of a vehicle in turn- “open-loop“ test method
1975	ISO/TR 3888	Road vehicles - Test procedure for a severe lane-change manoeuvre

VDA Verband der Automobilindustrie

DIN

ISO International Organization for Standardization

Standardization of driving maneuver and evaluation criteria's

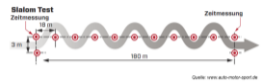
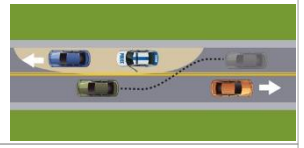
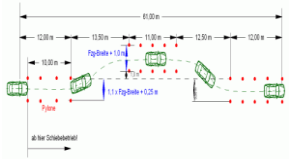
ISO-Technical-Reports		
1986	ISO/TR 8349	Road vehicles - Measurement of road surface friction
1986	ISO/TR 8350	Road vehicles - High-friction test track surface-Specifications
1988	ISO/TR 8725	Road vehicles - Transient „open-loop“ response test method with one period of sinusoidal input
1989	ISO/TR 8726	Road vehicles - Transient „open-loop“ response test method with pseudo-random steering input
2010	ISO 12021	Road vehicles -- Sensitivity to lateral wind -- Open-loop test method using wind generator input
2010	ISO 13674-1	Road vehicles -- Test method for the quantification of on-centre handling -- Part 1: Weave test
2016	ISO 13674-2	Road vehicles -- Test method for the quantification of on-centre handling -- Part 2: Transition test

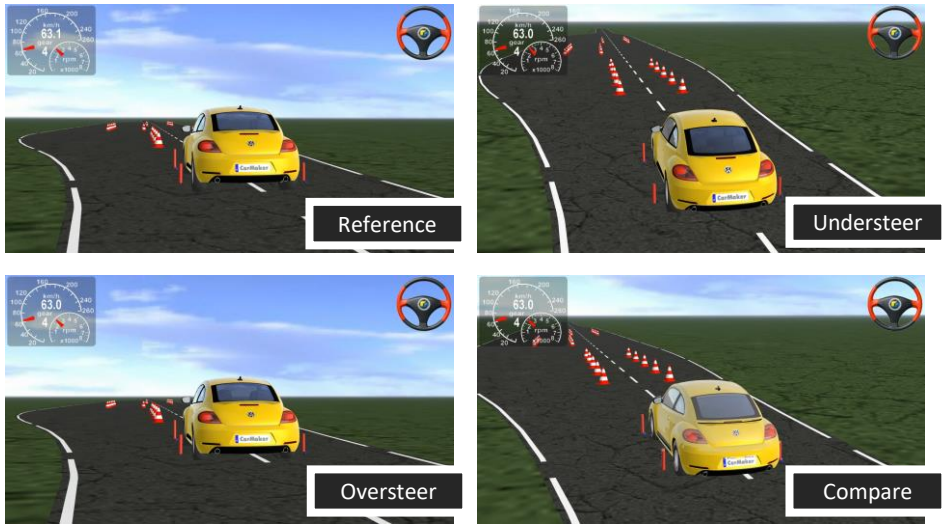
Standardization of driving maneuver and evaluation criteria's

ISO-Technical-Reports		
1999	ISO 14512	Passenger cars -- Straight-ahead braking on surfaces with split coefficient of friction -- Open-loop test procedure
2011	ISO 17288-1	Passenger cars -- Free-steer behavior -- Part 1: Steering-release open-loop test method
2011	ISO 17288-2	Passenger cars -- Free-steer behavior -- Part 2: Steering-pulse open-loop test method
2007	ISO 21994	Passenger cars -- Stopping distance at straight-line braking with ABS -- Open-loop test method
2006	ISO 15037	Road vehicles -- Vehicle dynamics test methods -- Part 1: General conditions for passenger cars
2016	ISO 19365	Passenger cars -- Validation of vehicle dynamic simulation -- Sine with dwell stability control testing

Test and evaluation methods for vehicle attributes

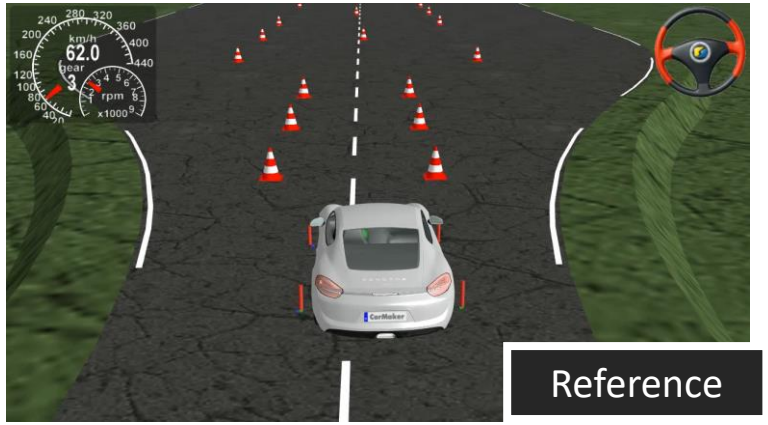
Typical driving maneuvers

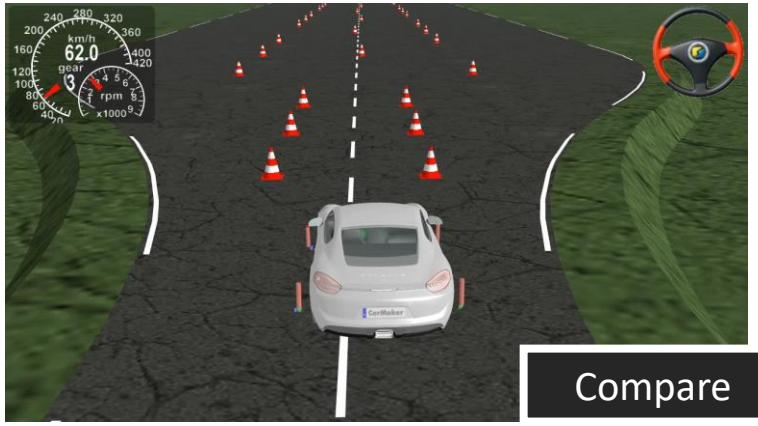
Driving Maneuver	Evaluation	Open Loop	Closed Loop	Picture
Handling Course	Evaluation of the driving behavior in extreme corning situations		X	
Slalom 10x18m 10x36m	Evaluation of the driving behavior in very fast course directions.		X	
Single Lane Change	Simulation of a evasive maneuver at the high way		X	
Double Lane Change 1 (FAST)	Simulation of a fast evasive maneuver with return to the lane (~120km/h; ISO 3888-1 Lane Change)		X	
Double Lane Change 2 (SLOW)	Simulation of a intensive evasive (obstacle avoidance) maneuver with return to the lane (~70km/h; ISO-3888-2 [VDA] Lane Change or „Elk Test“)		X	



Test and evaluation methods for vehicle attributes

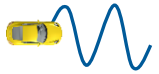
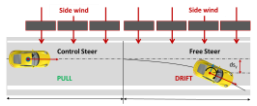
10x18m Slalom & most important maneuver: “Steady State Circular Driving”

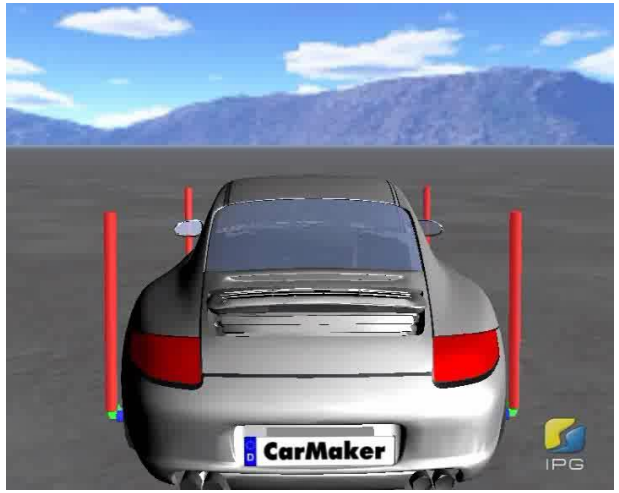





SR60 Torus Steering Robot
Swept sine

Test and evaluation methods for vehicle attributes

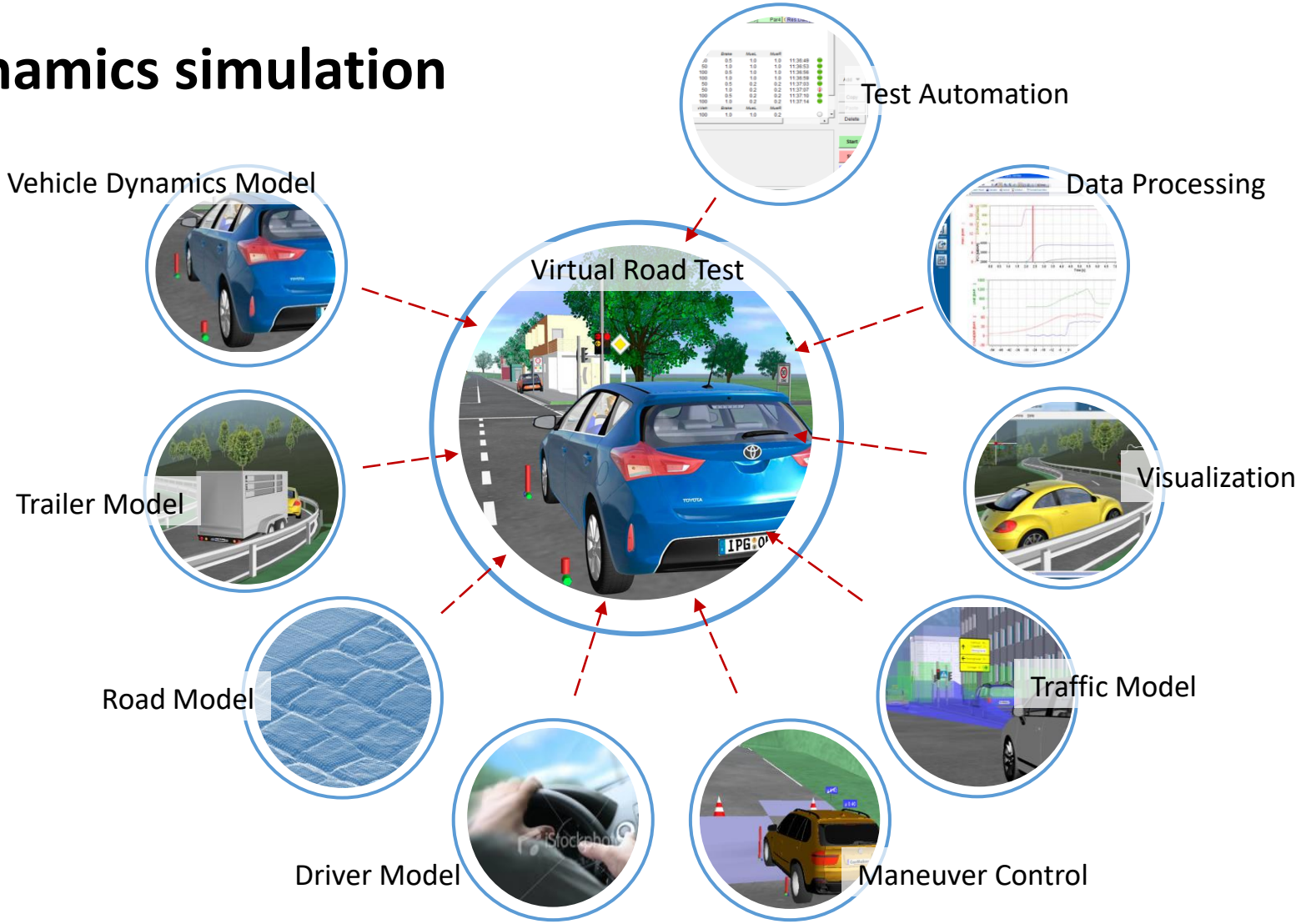
Driving Maneuver	Evaluation	Open Loop	Closed Loop	Picture
Step Steer	Sudden steer input to a defined value - ISO 7401.	X		
Sine Steer	Harmonic steering in from of a sine or sine sweep with defined amplitude – ISO 8725.	X		
pseudo-random steer	Irregular steer input – ISO 8726.	X		
Steer return-ability test	Evaluation of steering wheel return-ability within a turn-off maneuver	X		
Side wind test	Evaluation of vehicle behavior such as course deviation thru side wind - ISO 12021.	X		
Traction/ acceleration test	Evaluation of the traction and acceleration performance		X	
Car-trailer Stability test	Evaluation of the vehicle and trailer stability - ISO 9815.	X		



Agenda

1. **Introduction Vehicle Dynamics**
2. **Introduction in die CarMaker Virtual Test Driving**
   - Main GUI
   - Project
   - IPG Movie
   - IPG Control
   - Instruments
   - **Exercise 1:** Sample TestRuns from Product Examples
     - Vehicle Dynamics
     - ADAS
   - **Exercise 2:** Sample from Projects → Golf_GTD_SlowlyIncreaseSteer
     - Start Simulation
     - Save of data
     - Evaluation with Mxeval
3. **Driver – Vehicle – Environment**
   - Vehicle Model
   - Load
   - Tire
   - **Exercise 3:** Golf_GTD_SteadyCircular_100m
     - 3 Reifenvarianten – Sim – Save - Eval
   - Road Model
   - Maneuver Control
   - Driver Model
   - **Exercise 4:** New TestRun from the scratch
     - Vehicle – Road – Maneuver - Driver
   - Traffic
   - **Exercise 5:** µ-Split braking test
   - **Exercise 6:** Handling Course / Racetrack
3. **Architecture und Special Functions**
   - Vehicle Data Set Generator
   - RealTimeExpressions
   - **Exercise 7:** Event based Maneuver
   - DVA
   - **Exercise 8:** Manuel Manipulation/Overwrite of Variables/Quantities
   - Maneuver Command Language
   - **Exercise 9:** Automatic Manipulation/Overwrite of Variables/Quantities within the Maneuver
   - Input from File
   - Test Manager
   - **Exercise 10:** Build-up of a test series with variation of parameters

Vehicle dynamics simulation

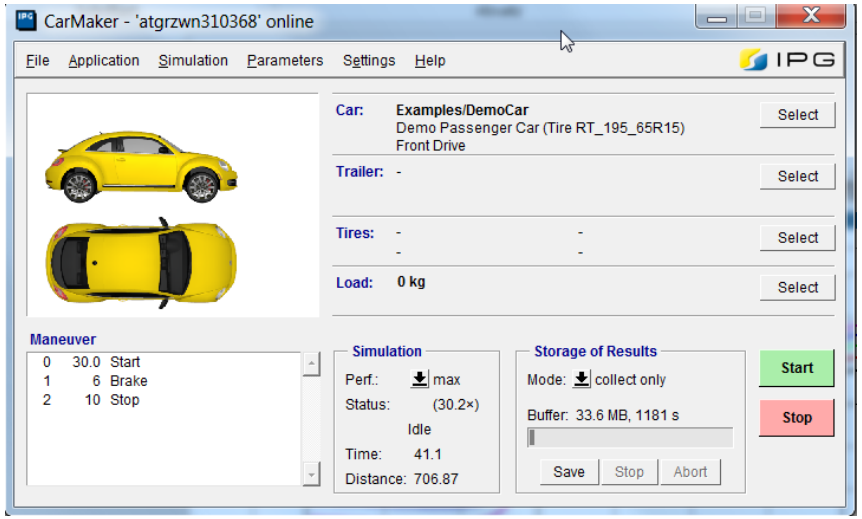


CarMaker command center give access to all functions

Access menu to all functions extendable by user

Control display of vehicle loads

Online display of **maneuver status**



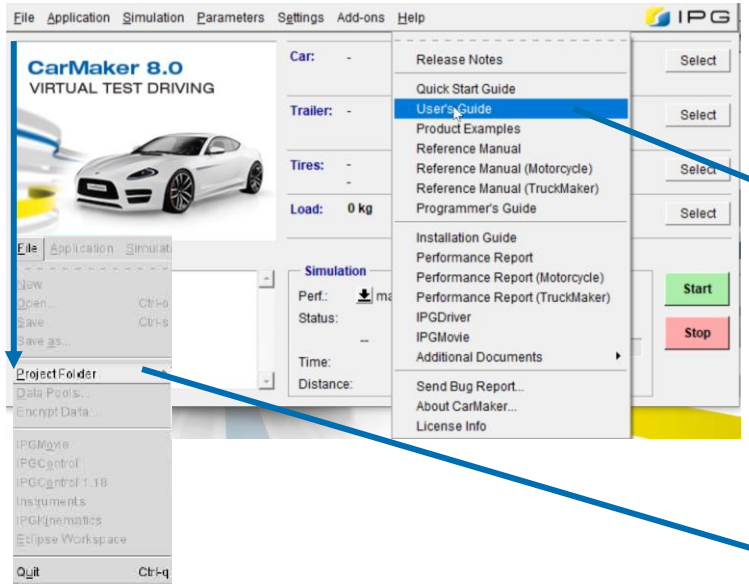
Selection of **parameter files**
Vehicle – Trailer – Tires – Loads

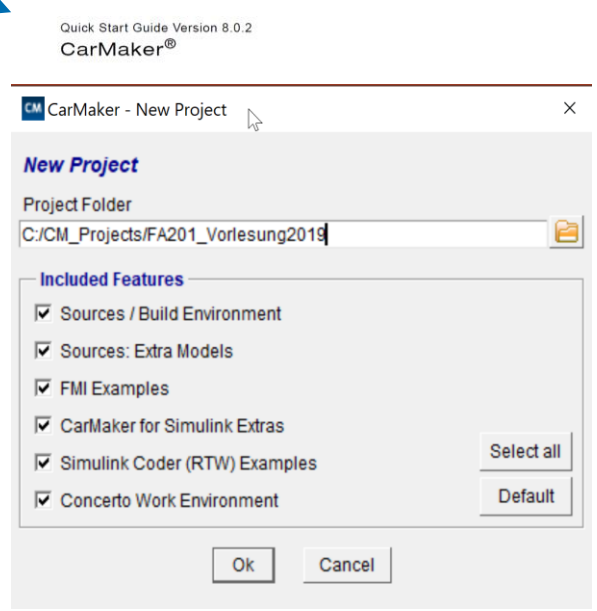
Online **Start & Stop** function of the simulation

Simulations speed and status
0.2, 0.5, 1, 2, 5 x RT up to max

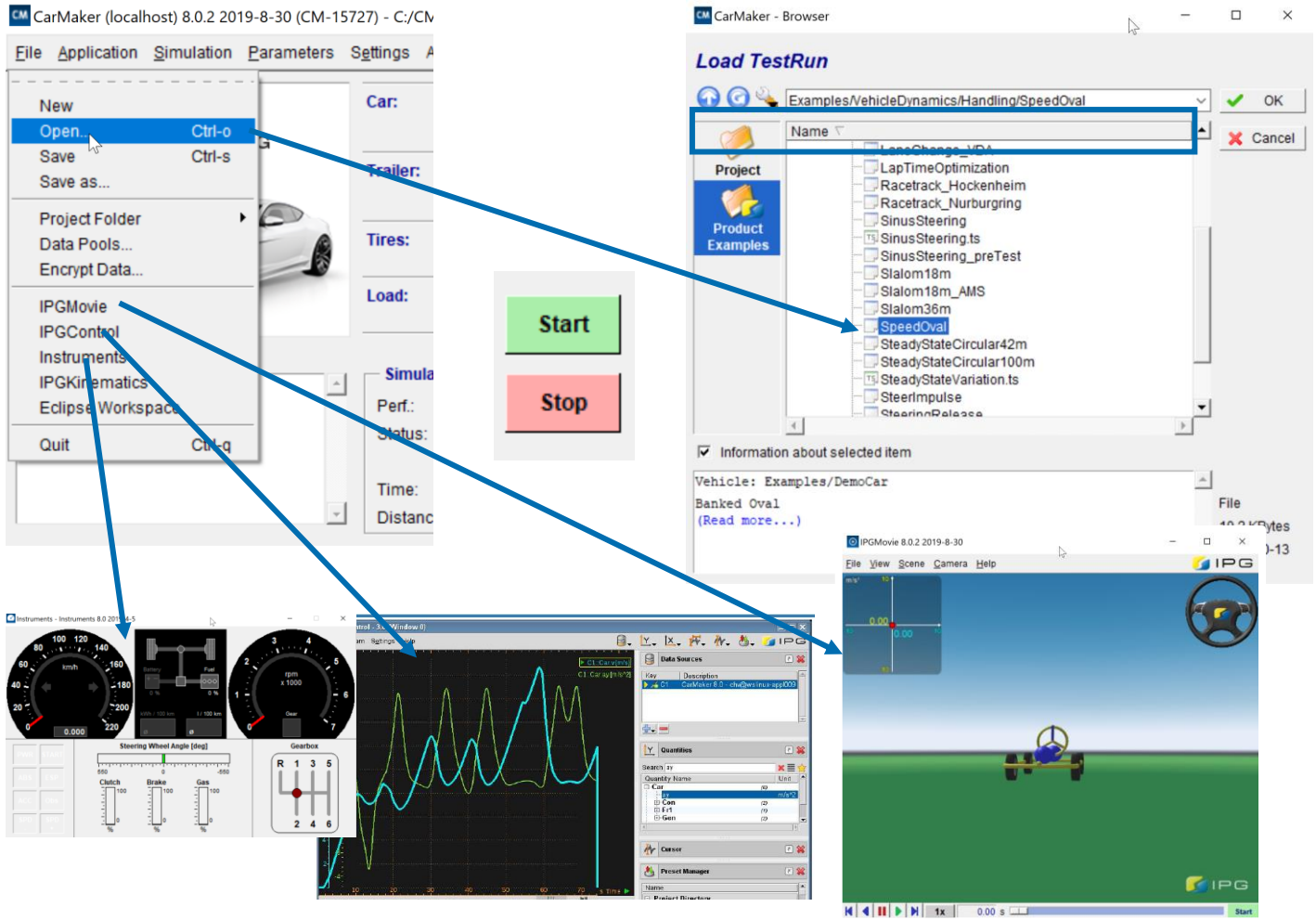
Interactive **storage functions** and buffer view

Vehicle dynamics simulation



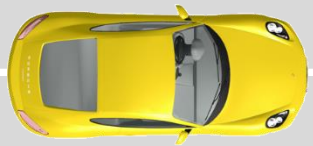


Vehicle dynamics simulation

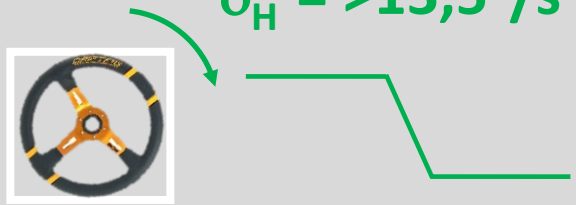


Exercise 2: Slowly increase steer test (SIS) and an identifying maneuver

V = 100 km/h



$\dot{\delta}_H$ = >13,5°/s

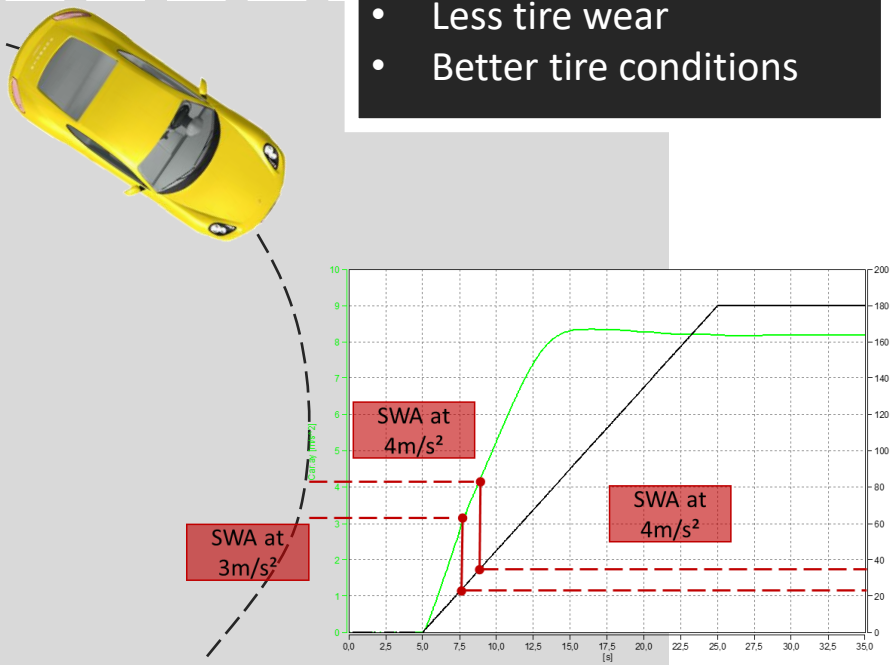


SWA at 4m/s² used for steering angle identification

- Step steer (4m/s²)
- Sine steer (4m/s²)
- Sine with Dwell (3m/s²)
- …

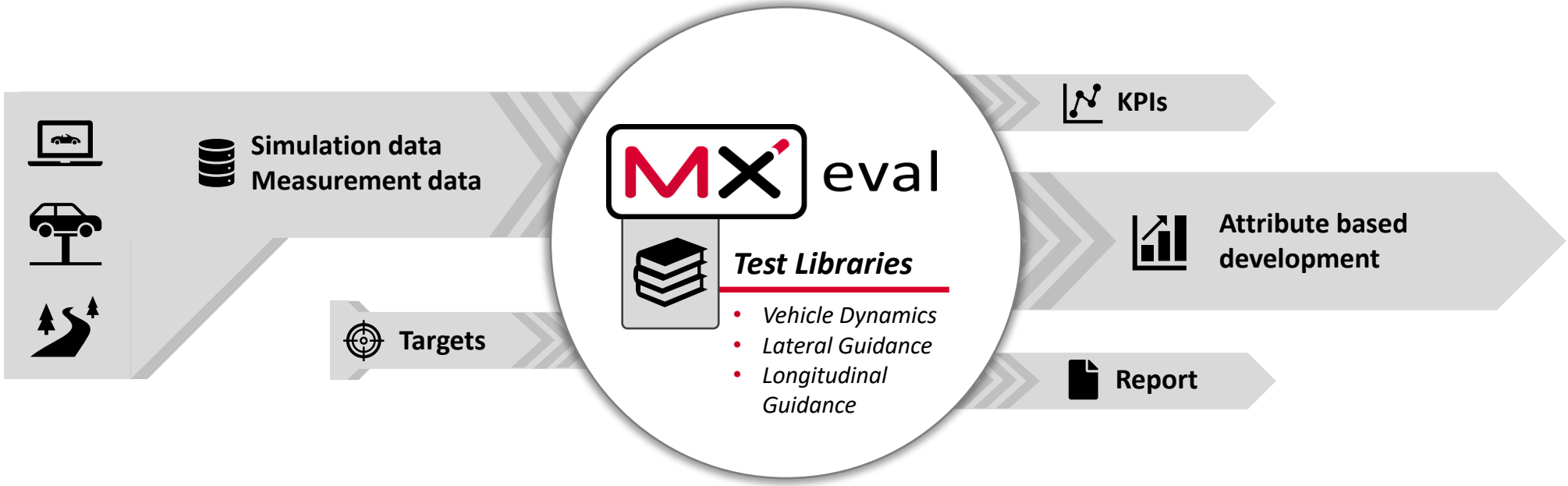
Advantages:

- Smaller test track size
- Less time consumption
- Less tire wear
- Better tire conditions



Vehicle Dynamics Attribute Evaluation

Mxeval for your quick evaluation and right decisions



CONSITENT DEVELOPMENT OF DRIVING PERFORMANCE

Vehicle Dynamics Attribute Evaluation

Target Management with MXeval

Options

Settings
- General
  - Update
  - Data Processing
- Test Setup
  - ACC
  - LKAS
  - Vehicle Dynamics
    - VD: Frequency Response Test
    - VD: Quasi Static Test
    - VD: Sine with Dwell
    - VD: Single Sine Test
    - VD: Slalom
    - VD: Steady State Circular Test
    - VD: Step Input Test
    - VD: Weave Test
- View
  - General
  - KPI
  - Visualization
- Channels
  - LK-FR: Boundaries

KPI Assessment | Custom KPIs | Namespace Conversion | Channels | Plots

#	KPI	Unit					Assess
1	SteeringStiffness	Nm/deg	0.05	0.16	0.39	0.5	☑
2	SteeringStiffness_at_Zero_Steer	Nm/deg	0.1	0.14	0.23	0.27	☑
3	SteeringFriction	Nm					☐
4	AngleHysteresis	deg					☐
5	StiffnessTorque/Angle	Nm/deg	0.08	0.21	0.47	0.6	☑
6	LossAngleTorque/Angle	-					☐
7	5DegreeValueofSteeringTorque	Nm					☐
8	YawRateResponseGain	(deg/s)/deg					☐
9	YawRateTimeDelay	s					☐
10	YawStiffness_at_zero_SteerAngle	(deg/s)/deg	0.1	0.2	0.4	0.5	☑
11	StiffnessYawRate/Angle	(deg/s)/deg	0.2	0.28	0.43	0.5	☑
12	LossAngleYawRate/Angle	-					☐
13	ResponseDeadband	Nm					☐
14	YawRateResponseDeadband	deg/s					☐
15	StiffnessYawRate/Torque	Nm/deg					☐
16	LossAngleYawRate/Torque	-					☐
17	SteeringSensitivity	(m/s^2)/deg	0.05	0.07	0.12	0.14	☑
18	MinimumSteeringSensitivity	(m/s^2)/deg					☐
19	SteeringSensitivity_at_1m/s^2	(m/s^2)/deg					☐
20	SteeringSensitivity_at_0deg	(m/s^2)/deg					☐
21	LateralAccelerationDeadband	m/s^2					☐
22	AngleDeadband	deg	2.2	3.08	4.83	5.7	☑
23	SteeringHysteresis	deg	2	2.93	4.78	5.7	☑
24	LateralAccelerationTimeDelay	s					☐
25	Stiffness_latAcceleration/Angle	(m/s^2)/deg	0.08	0.1	0.14	0.16	☑
26	LossAngle_latAcceleration/Angle	-					☐
27	Area	(m/s^2)deg					☐
28	Torque_at_0m/s^2_positive	Nm					☐
29	Torque_at_0m/s^2_negative	Nm					☐
30	Torque_at_1m/s2_positive	Nm	1	1.68	3.03	3.7	☑
31	Torque_at_1m/s^2_negative	Nm	-3.7	-3.03	-1.68	1	☑

Some changes only take effect after the next evaluation!

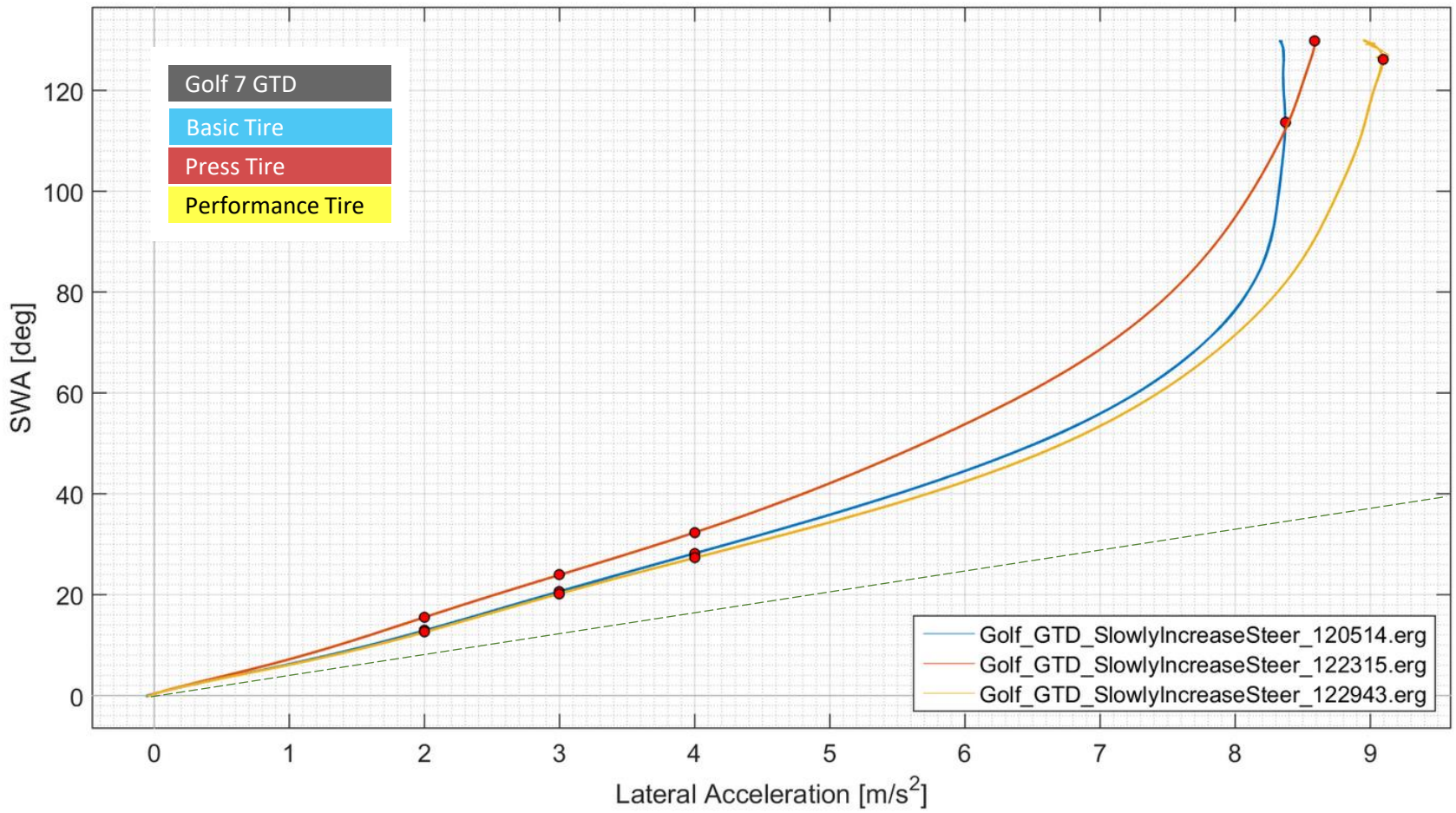
Apply | Cancel

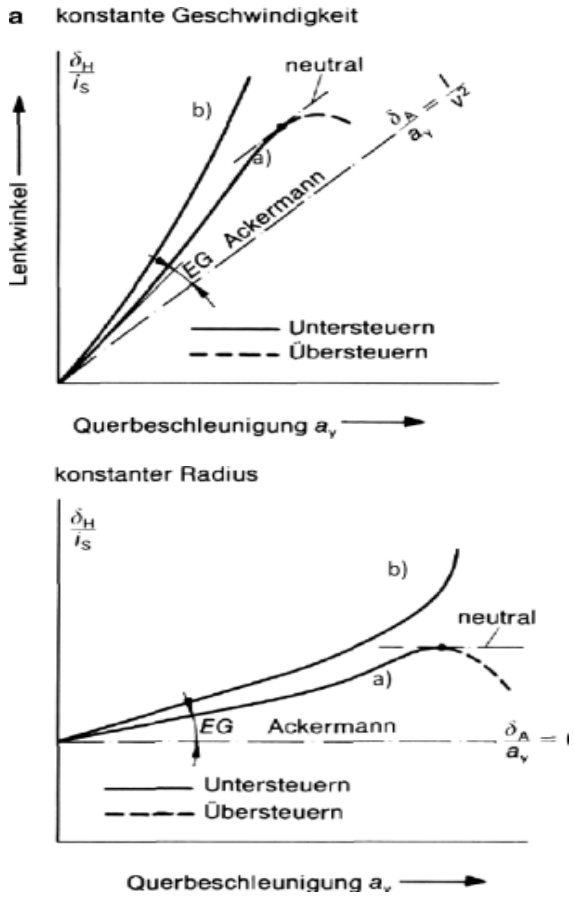
MX eval

drive livinglab

Vehicle Dynamics Attribute Evaluation

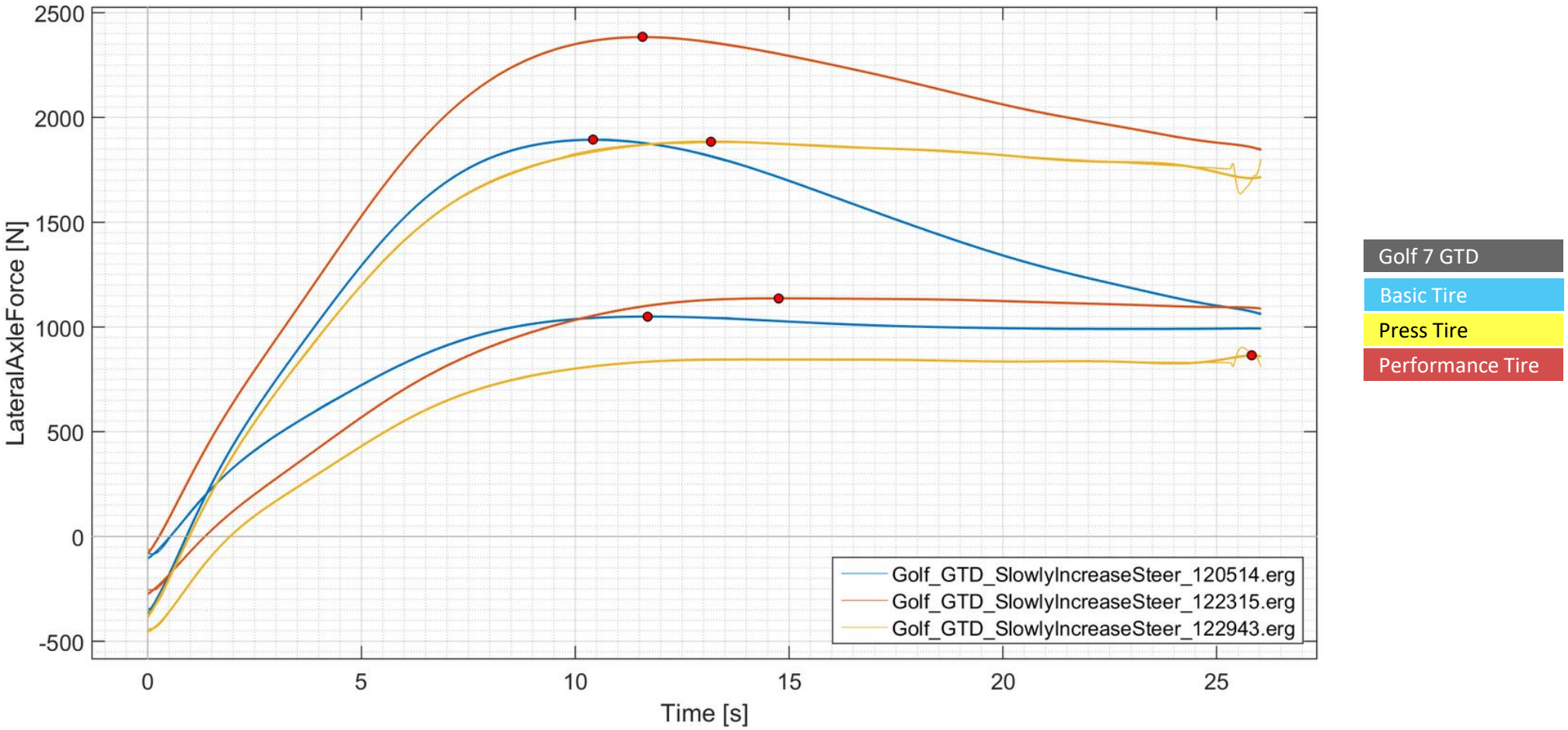
Exercise 2: Slowly increase steer test (SIS) and an identifying maneuver





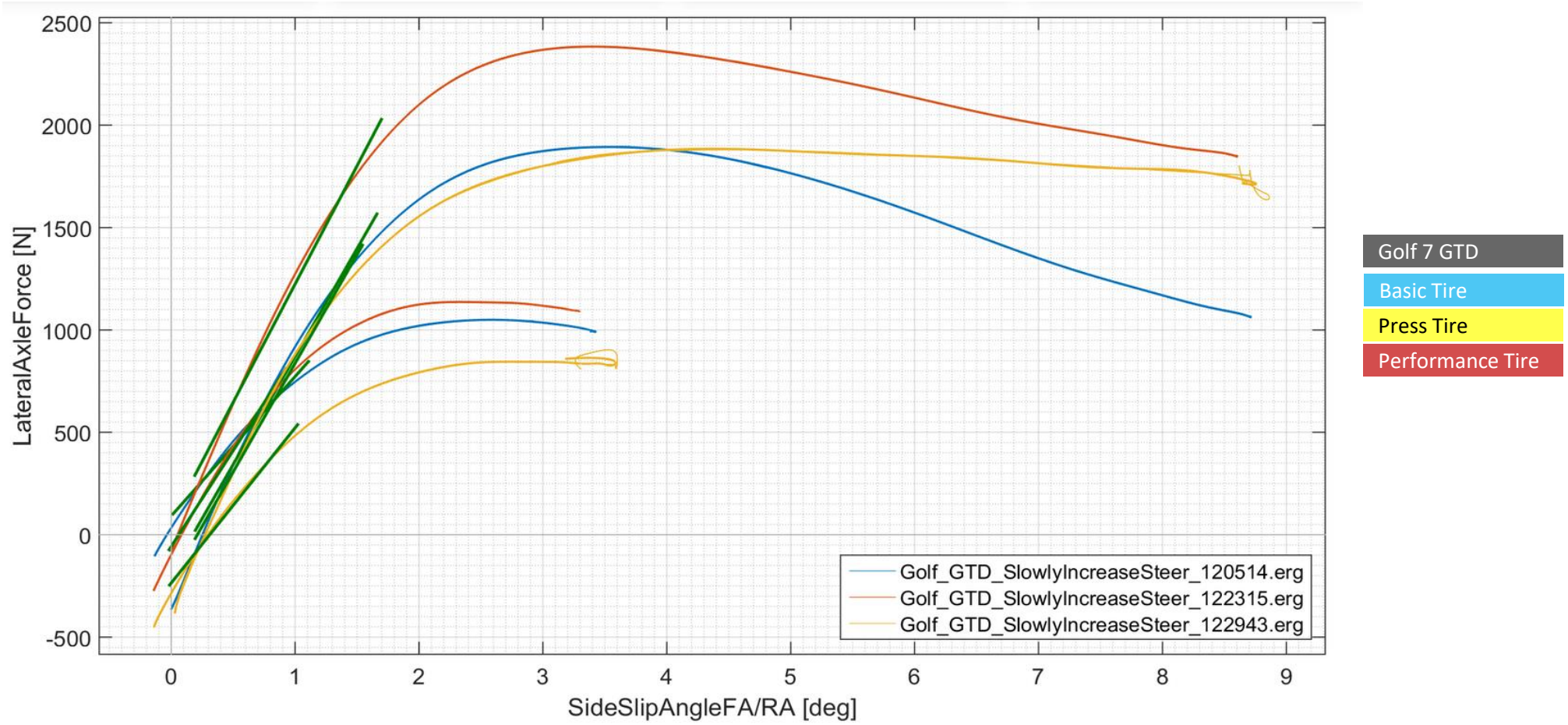
drive livinglab

Exercise 2: Lateral forces front left & right and rear left & right



Vehicle Dynamics Attribute Evaluation

Exercise 2: Lateral axle forces front & rear with side slip stiffness



Exercise 2: KPI – Summery Slowly increase steer test

No.	Unit	KPI	MEAN	RMS	STD	BEST_VA...	WORST_V...
1	Nm	SWTat5Degree	2.23	2.23	0.0717	NaN	NaN
2	Nm	SWTat10Degree	2.69	2.69	0.126	NaN	NaN
3	Nm	SWTat20Degree	3.77	3.77	0.144	NaN	NaN
4	Nm	SWTat30Degree	4.64	4.64	0.151	NaN	NaN
5	Nm	MaxSWT	5.39	5.39	0.0932	NaN	NaN
6	deg	SWAatSWTmax	60	60.3	6.76	NaN	NaN
7	Nm/deg	SteeringStiffnessLowG	0.12	0.12	0.00774	NaN	NaN
8	Nm/deg	SteeringStiffnessHighG	0.00623	0.00698	0.00386	NaN	NaN
10	m/s^2	AyAtMaximumSWT	7.05	7.05	0.199	NaN	NaN
11	Nm	SWTat3m/s^2	3.94	3.94	0.0942	NaN	NaN
12	m/s^2	MaxAy	8.68	8.69	0.37	NaN	NaN
13	Nm	SWTatMaxAy	4.65	4.65	0.165	NaN	NaN
14	%	AySafetyMargin	18.8	18.8	1.37	NaN	NaN
15	Nm	BreakawayTorque	1.24	1.24	0.0265	NaN	NaN
16	Nm/(m/s^2)	SWTGradientLowG	0.867	0.867	0.0292	NaN	NaN
17	Nm/(m/s^2)	SWTGradientHighG	0.0934	0.0975	0.0343	NaN	NaN
19	deg	SWAatMaxAy	123	123	8.44	NaN	NaN
20	deg	SWAat2m/s^2	13.7	13.7	1.61	NaN	NaN
21	deg	SWAat3m/s^2	21.6	21.7	2.04	NaN	NaN
22	deg	SWAat4m/s^2	29.3	29.4	2.68	NaN	NaN
23	(deg/s)/deg	MaxYawGain	0.337	0.338	0.0344	NaN	NaN
24	m/s^2	AyAtYawGainMax	1.02	1.02	0.047	NaN	NaN

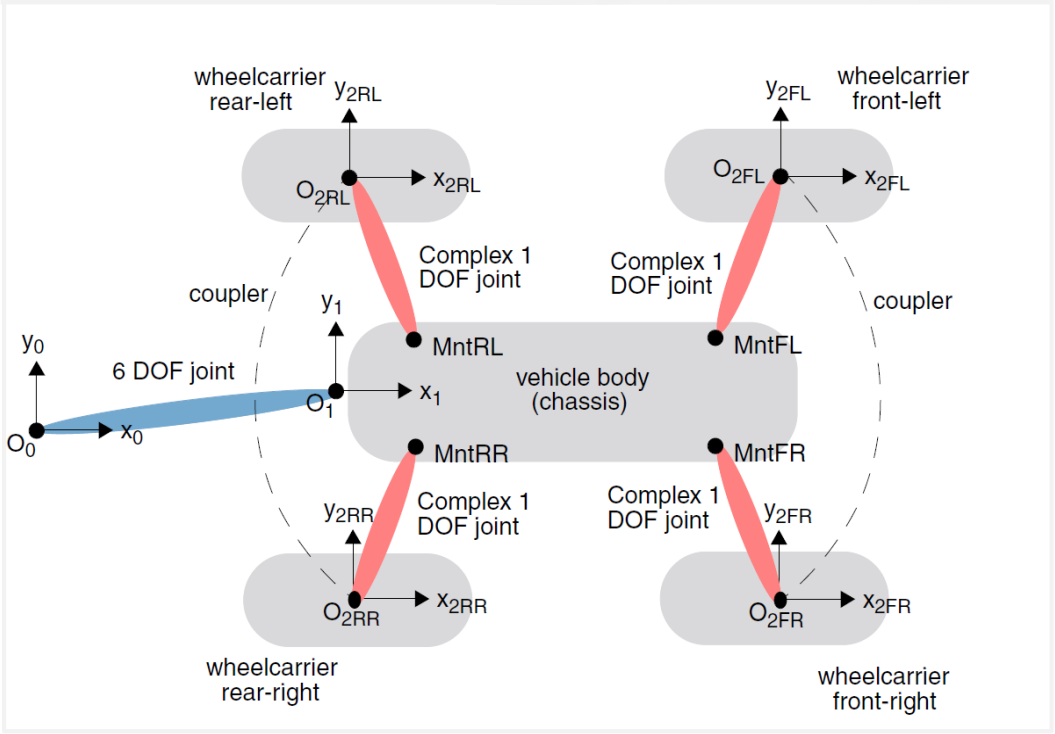
Basic Tire | Press Tire | Performance Tire

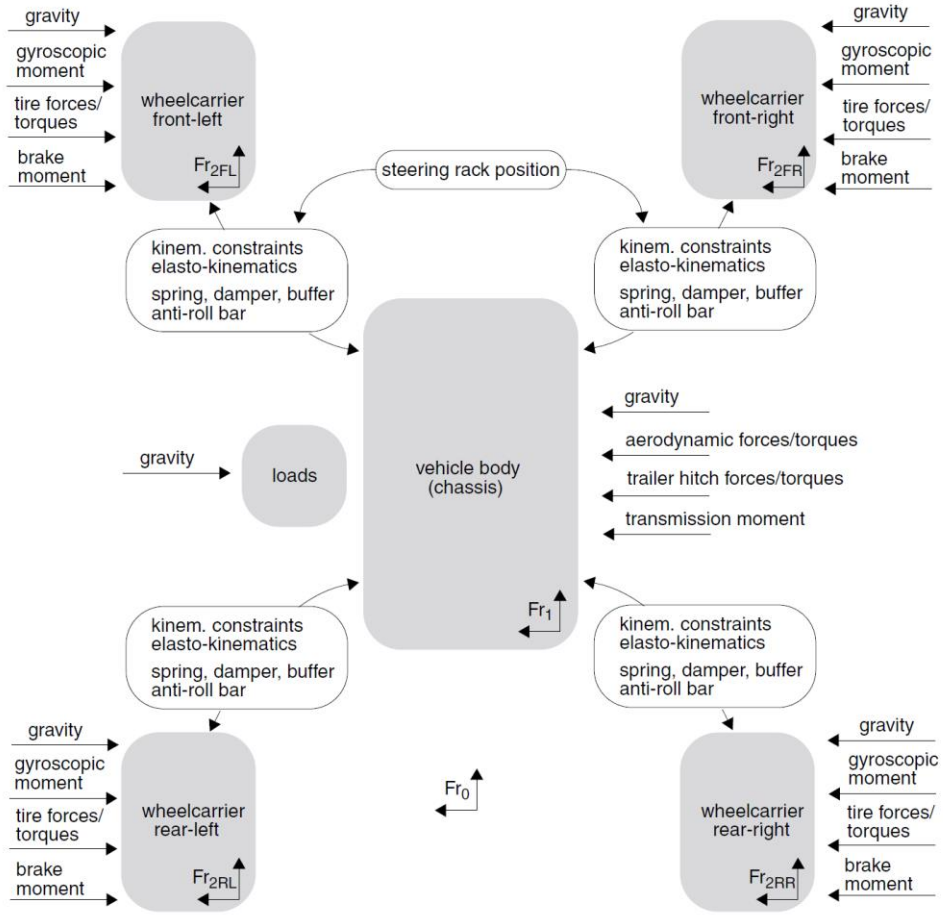
25	(deg/s)/deg	YawGainAt75%maxAy	0.261	0.263	0.0311	NaN	NaN
26	(deg/s)/deg	YawGainAt90%maxAy	0.219	0.22	0.028	NaN	NaN
27	(1/s)/(m/s^2)	YawGainGradient	-0.0108	0.0108	0.00108	NaN	NaN
28	(m/s^2)/deg	MaxAyGain	0.156	0.157	0.0144	NaN	NaN
29	m/s^2	AyAtAyGainMax	1.1	1.11	0.11	NaN	NaN
30	(m/s^2)/deg	AyGainAt75%maxAy	0.125	0.125	0.0147	NaN	NaN
31	(m/s^2)/deg	AyGainAt90%maxAy	0.105	0.105	0.0133	NaN	NaN
32	1/deg	AyGainGradient	-0.00472	0.00473	0.000382	NaN	NaN
33	(deg/s)/(m/s^2)	YawRateGradientAt1m/s^2	2.02	2.02	0.0327	NaN	NaN
34	(deg/s)/(m/s^2)	YawRateGradientAt3m/s^2	2.1	2.1	0.0255	NaN	NaN
37	(deg/s)/(m/s^2)	YawRateStiffness	2.08	2.08	0.00436	NaN	NaN
38	deg	RollAngleAt0.5m/s^2	0.204	0.204	0.00778	NaN	NaN
39	deg	RollAngleAt1m/s^2	0.408	0.408	0.0122	NaN	NaN
40	deg	RollAngleAt3m/s^2	1.23	1.23	0.0311	NaN	NaN
41	deg/(m/s^2)	RollAngleStiffnessLowG	0.408	0.408	0.00986	NaN	NaN
42	deg/(m/s^2)	RollAngleStiffnessHighG	0.45	0.45	0.00727	NaN	NaN
44	deg/(m/s^2)	SideSlipAngleStiffnessLowG	-0.141	0.142	0.023	NaN	NaN
45	deg/(m/s^2)	SideSlipAngleStiffnessHighG	-0.381	0.381	0.0147	NaN	NaN
47	N	MaxLatAxleForceFA	2.05e+03	2.07e+03	286	NaN	NaN
48	N	MaxLatAxleForceRA	1.02e+03	1.02e+03	140	NaN	NaN
49	N/deg	FAStiffness0-4m/s^2	1.09e+03	1.09e+03	55.1	NaN	NaN
50	N/deg	RAStiffness0-4m/s^2	792	799	131	NaN	NaN

Vehicle Dynamics Models & Simulation

3D Multi Body Simulation Model with Suspension Lock-up Tables

Suspension
3D Maps



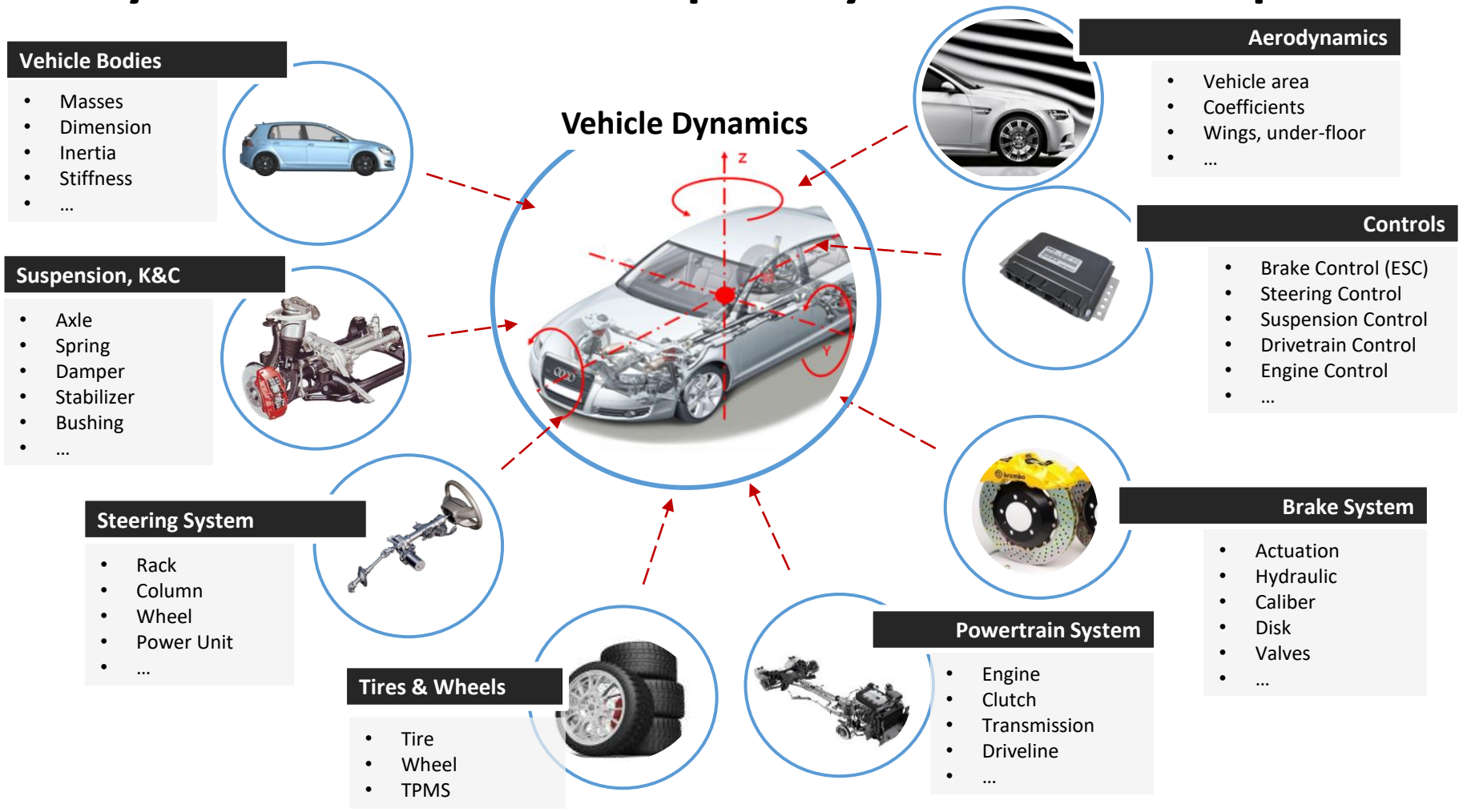


Source: CarMaker Reference Manuel

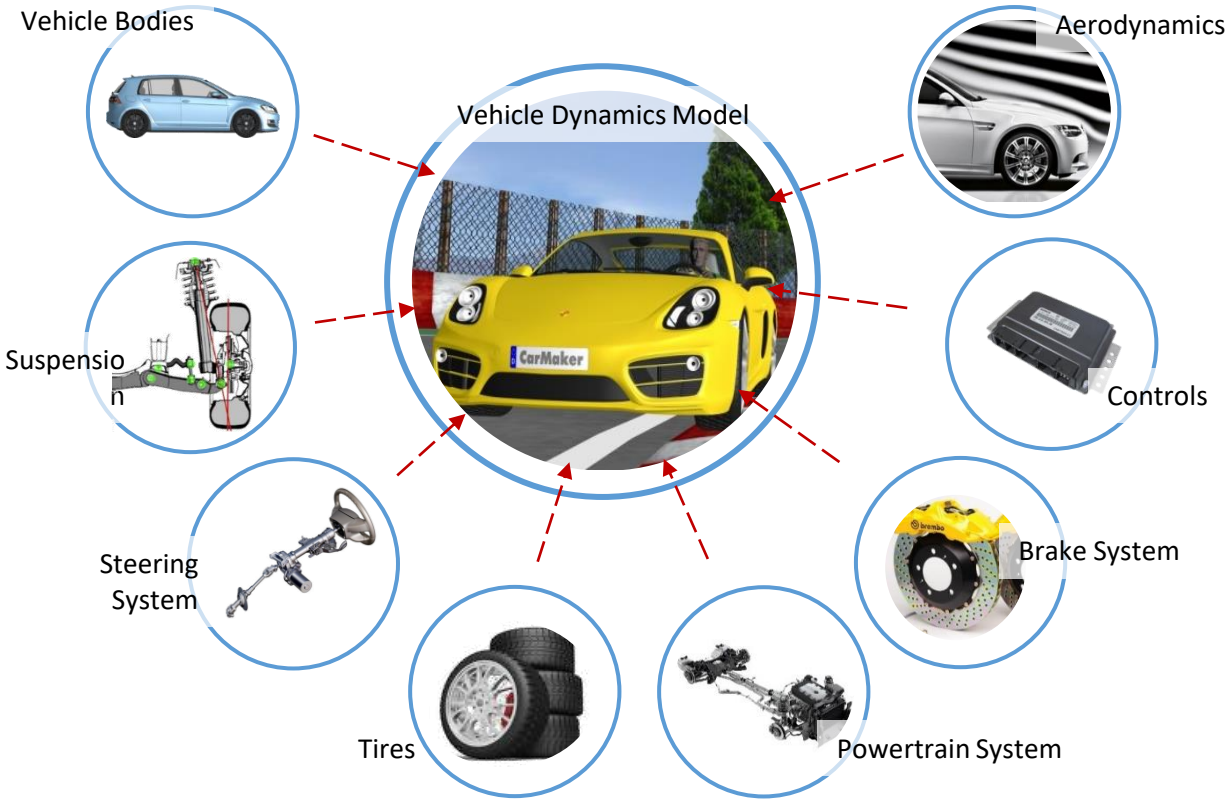
drive livinglab

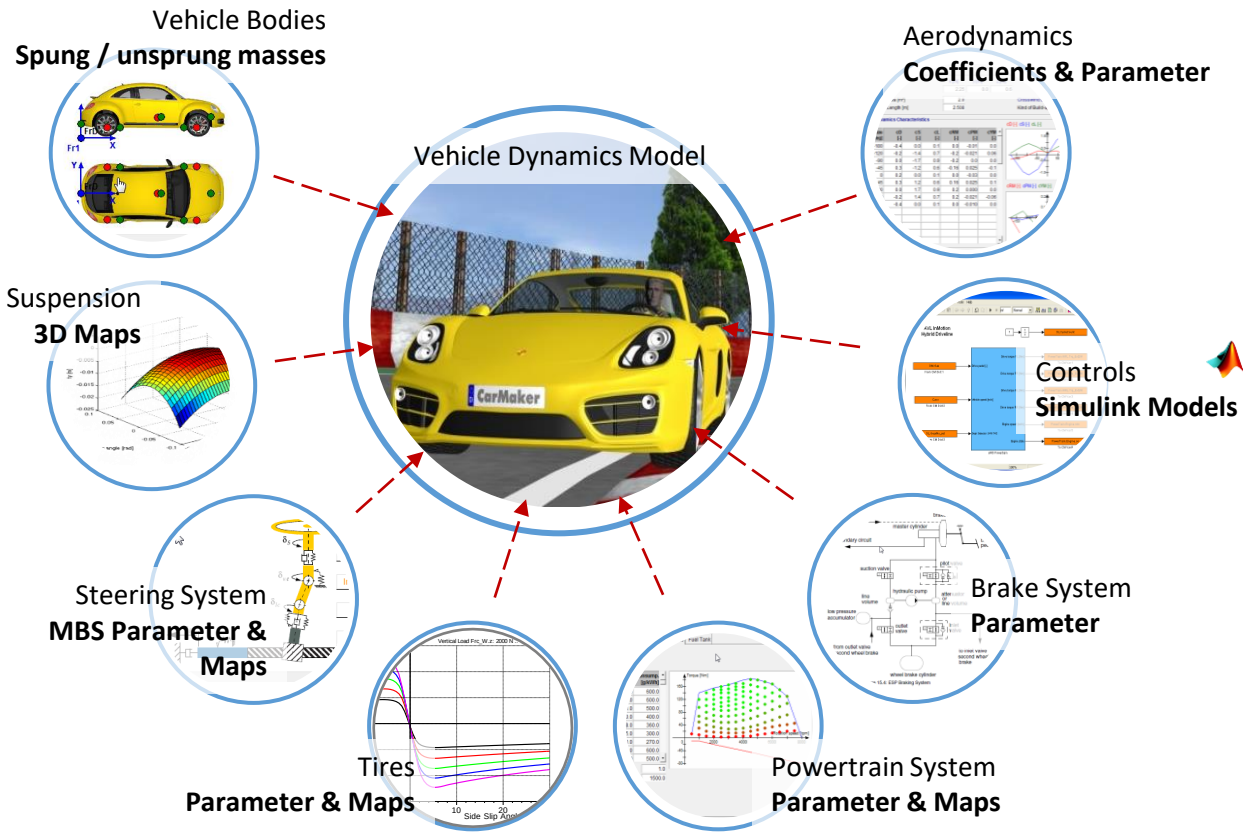
Kempten University of Applied Sciences

Vehicle dynamics behavior is impact by numerous components



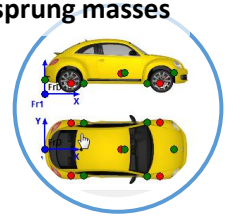
Vehicle Dynamics Models & Simulation



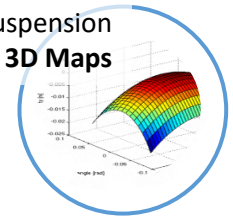


drive livinglab

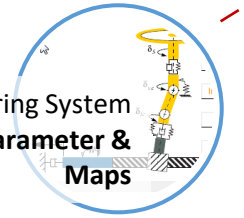
Vehicle Bodies
Spung / unsprung masses



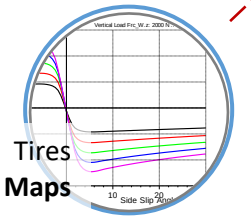
Suspension
3D Maps

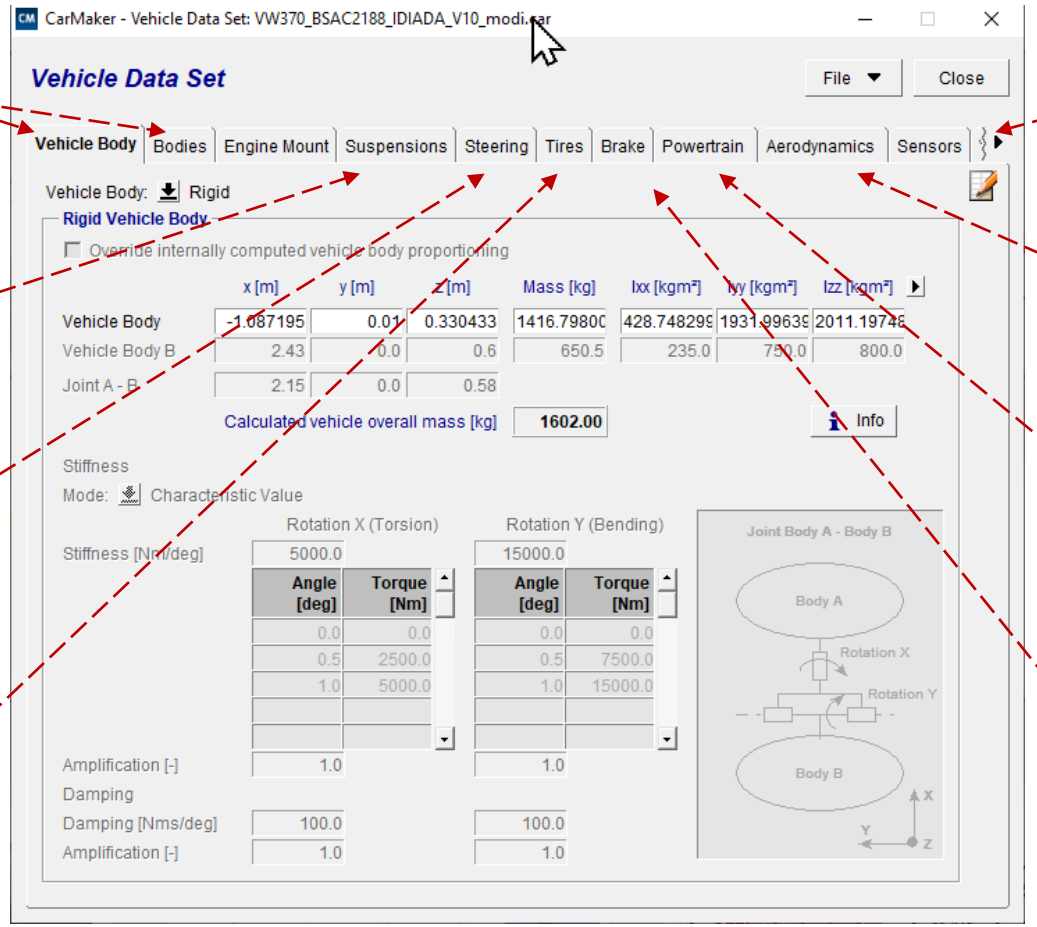


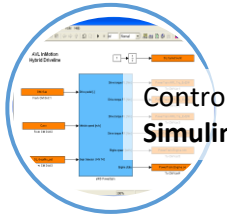
Steering System
MBS Parameter & Maps



Tires
Parameter & Maps

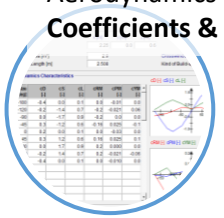


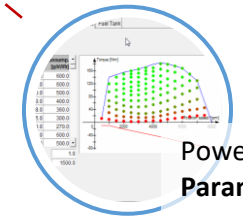




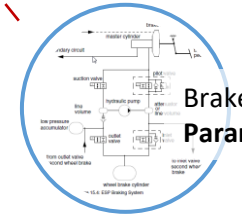
Controls
Simulink Models

Aerodynamics
Coefficients & Parameter



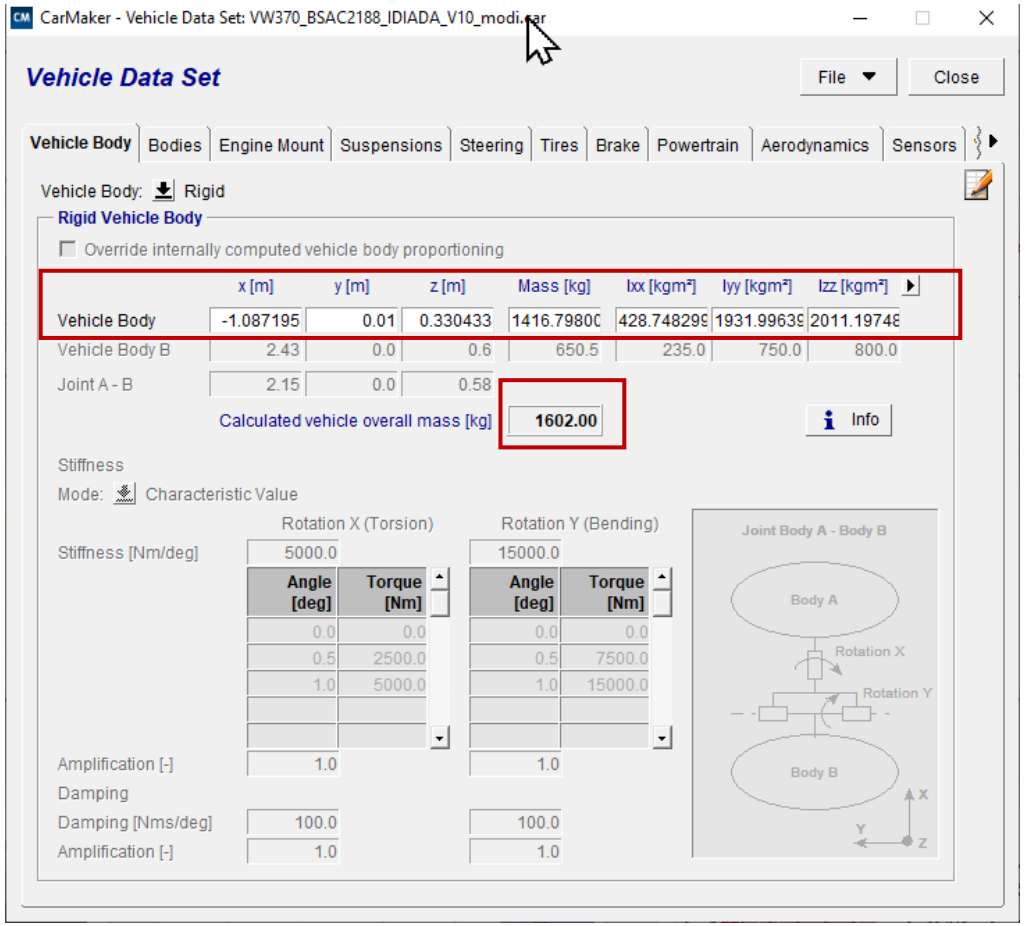


Powertrain System
Parameter & Maps

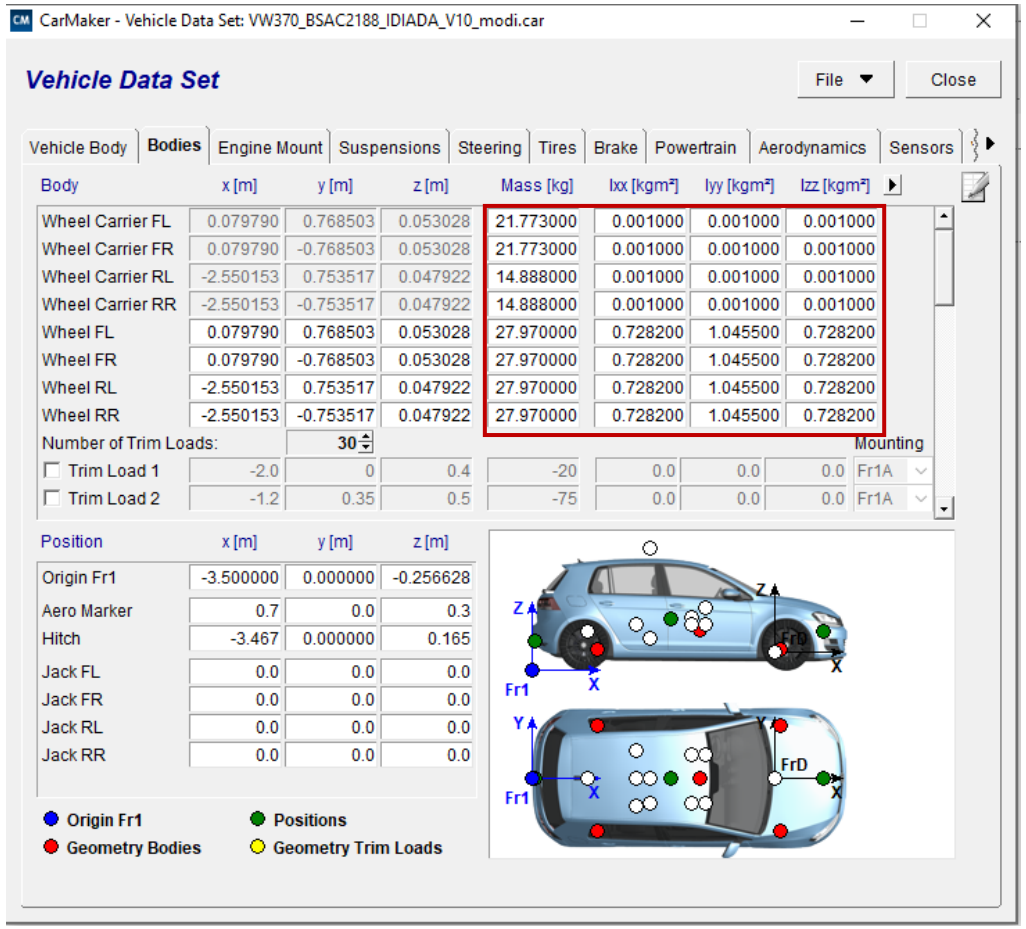


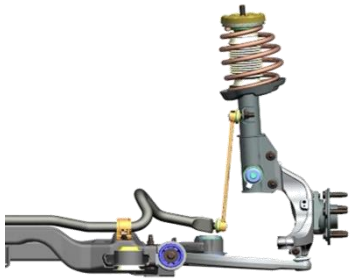
Brake System
Parameter

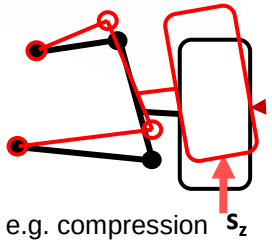
Sprung Mass

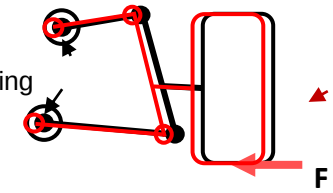


Unsprung Mass

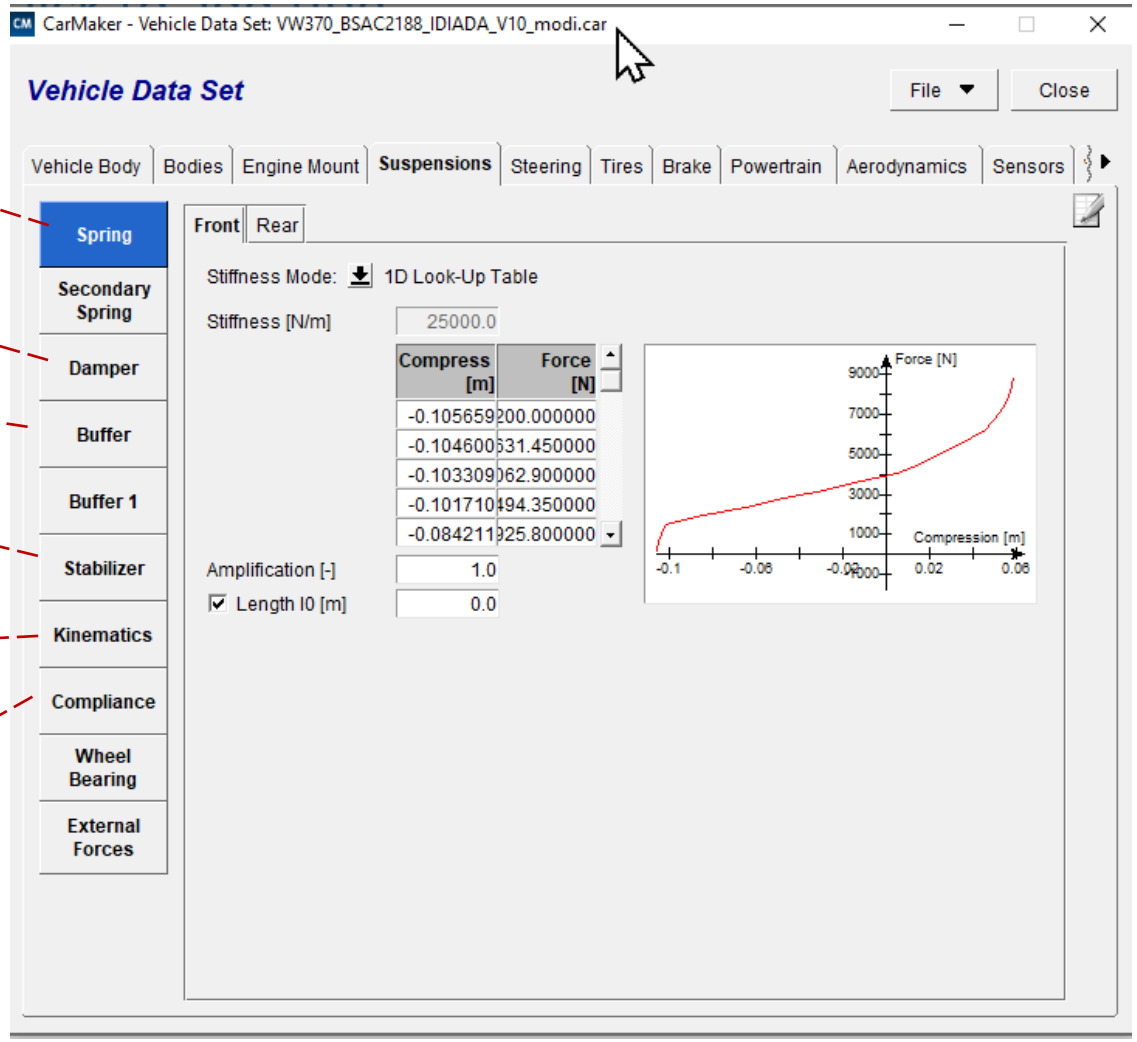


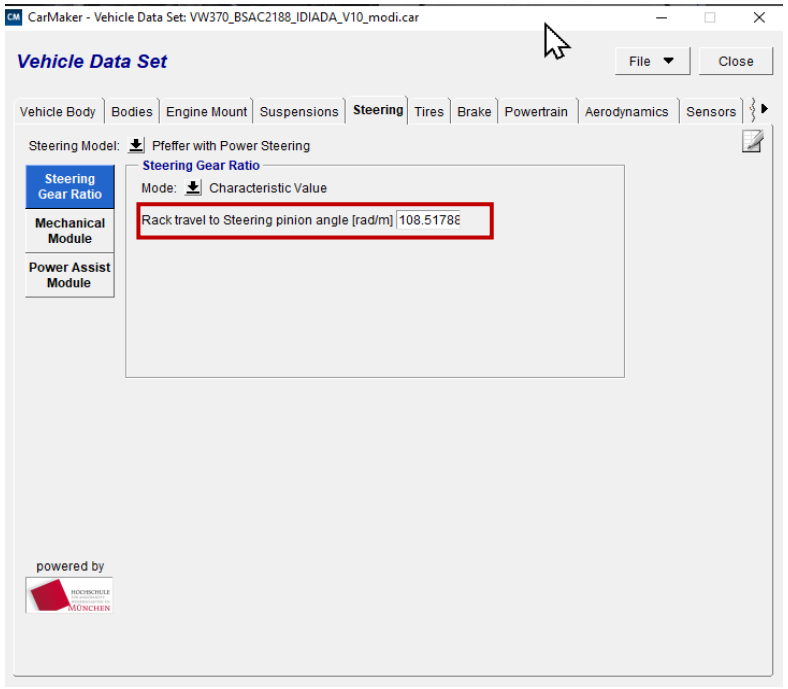


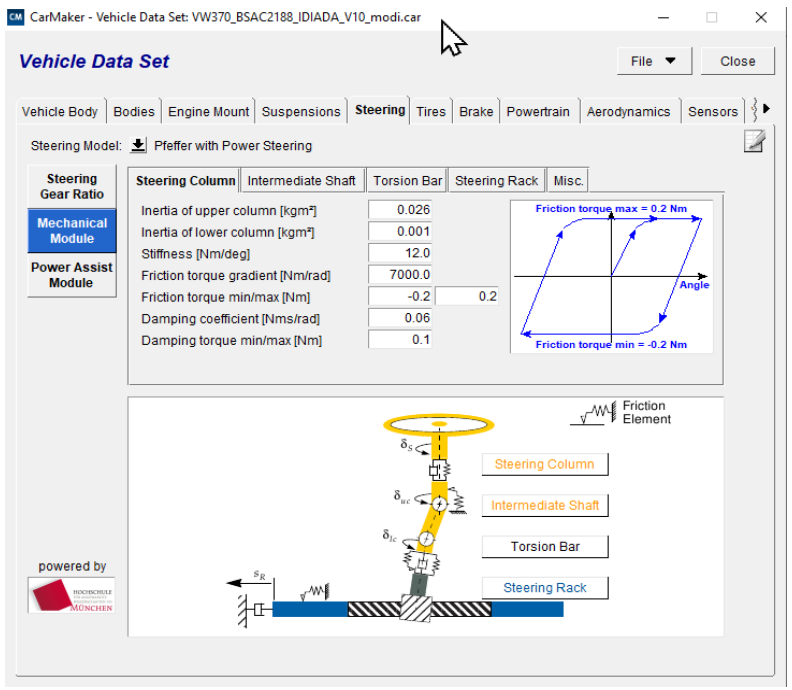


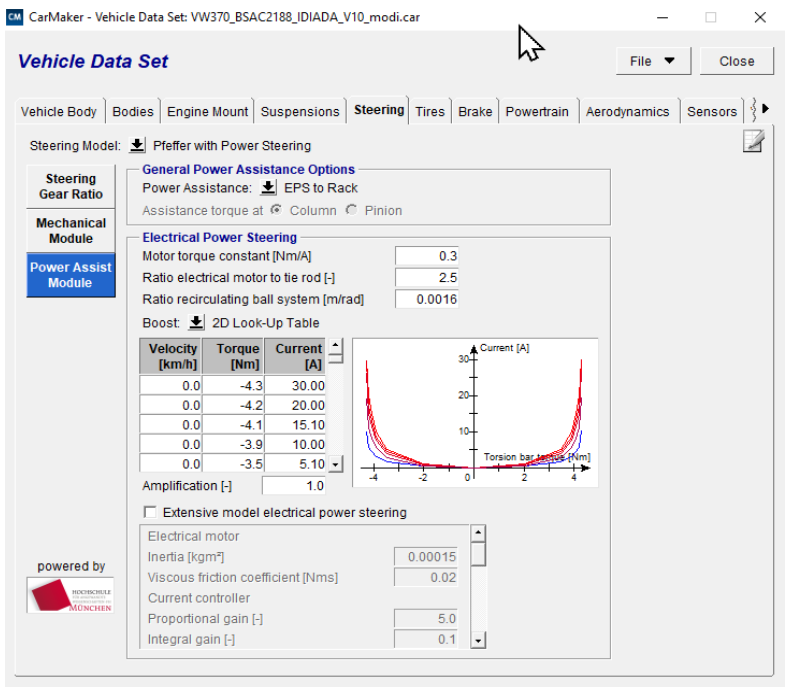


e.g. compliance under side forces $_y$







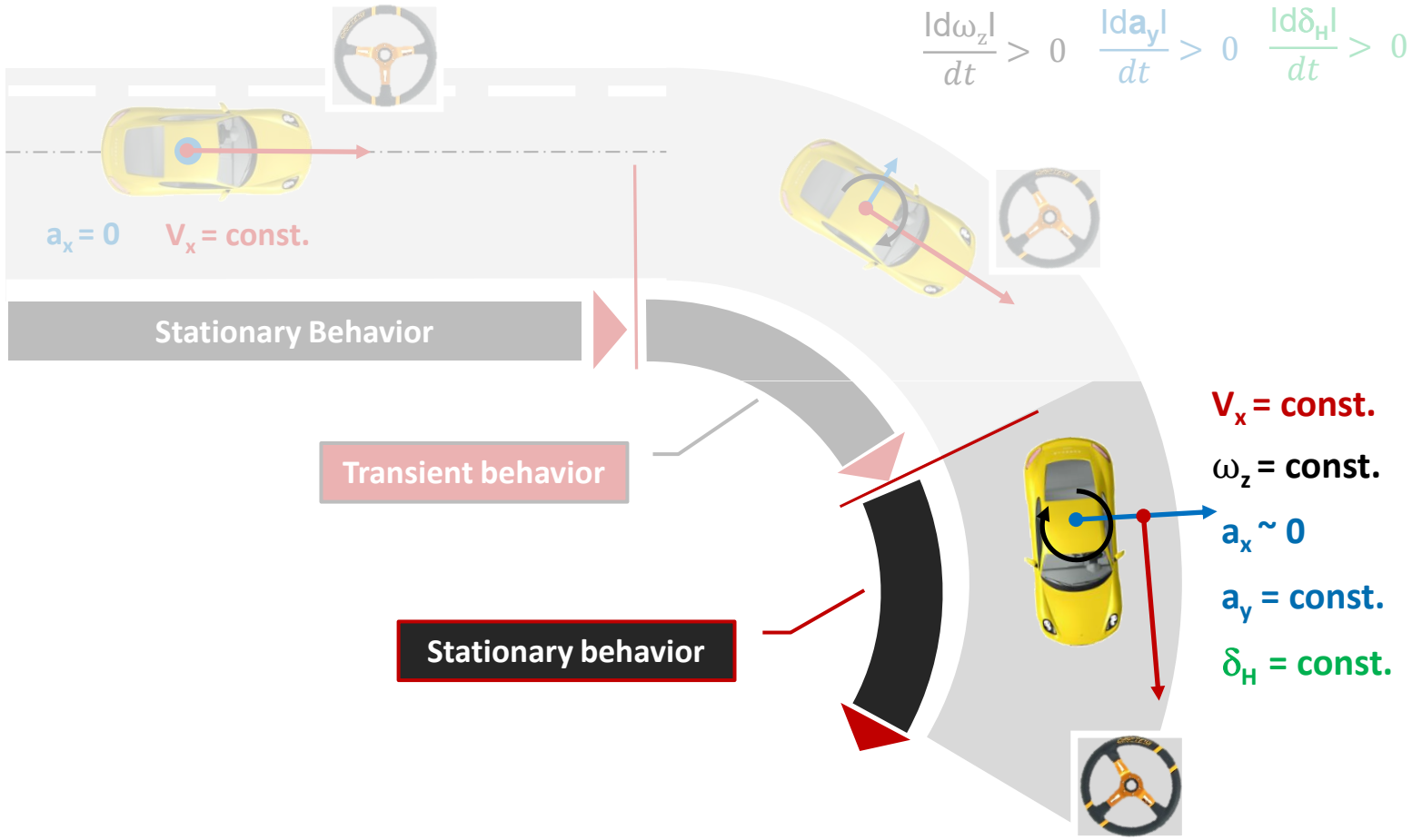


drive livinglab

Kempten University of Applied Sciences

Vehicle Dynamics Attribute Evaluation

Exercise 3: Lateral Dynamics: Stationary behavior



Exercise 3: Steady State Circular Driving

Test Condition

- Constant Radius: 100 m
- Speed: 0 – max kph
- da_y: 0,1 m/s²/s

SWA, a_y, Yaw, Radius: steady state condition

Analyze:

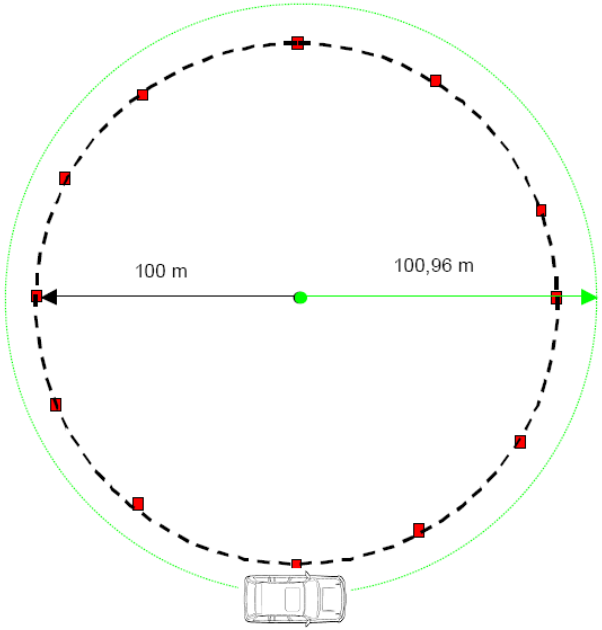
- Car.v
- Car.ay
- Car.Roll
- Car.SideSlipAngle

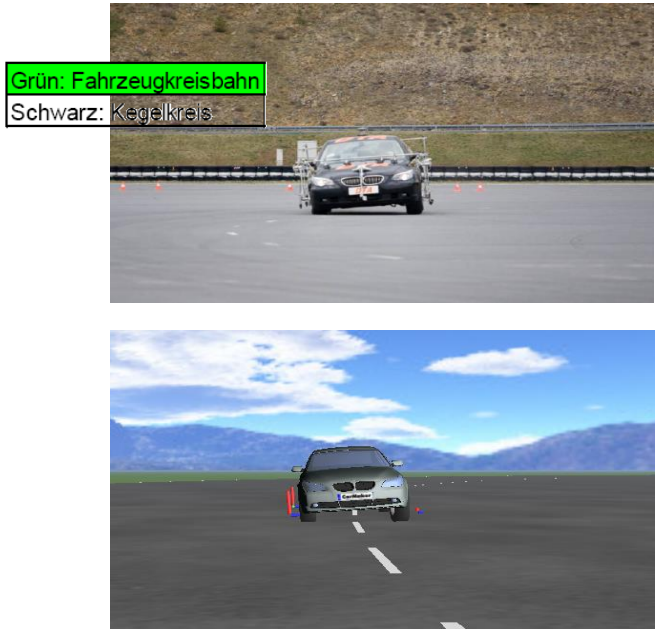
Change & Analyze:

- Vehicle load 200 kg rear axle / front axle
- Vehicle roof mass 200 kg

Exercise 3: Most important maneuver: “Steady State Circular Driving”

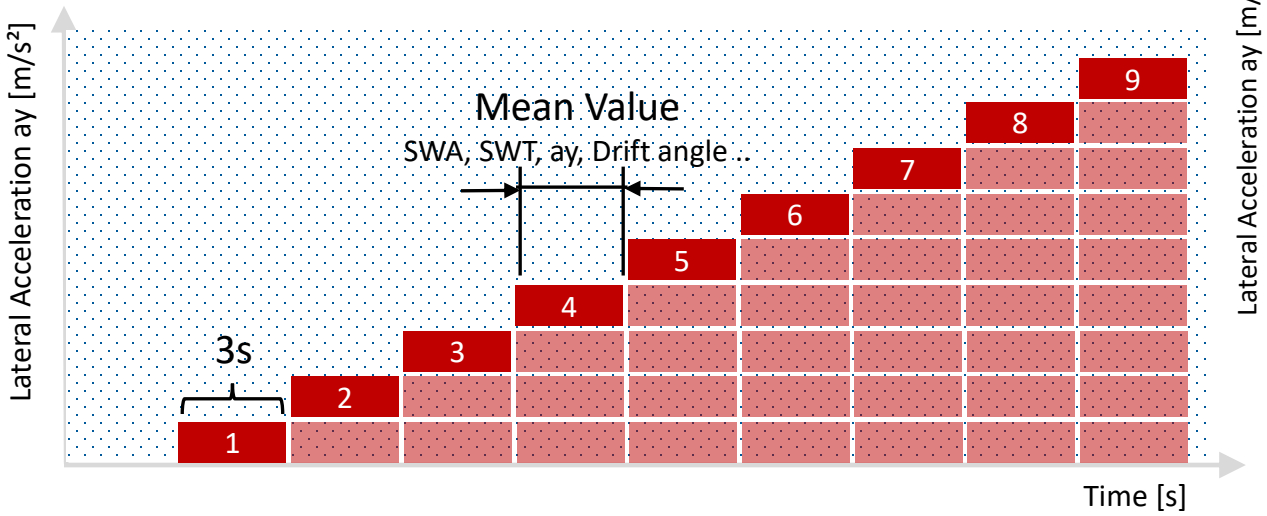
In the present experiment is right- and handed circle driving with the constant radius of 100 m. The tests are run in low gear two and three, with a step size **of 1.0 m/s²** lateral acceleration **of 1 m/s²** are set to the lateral limit. During the steady state test phase the steering wheel angle and gas pedal position shall keep constant. In each lateral acceleration stage, the stationary conditions must be maintained over the measurement period of **3 seconds**, three times are carried out to demonstrate the repeatability and determination of averages.



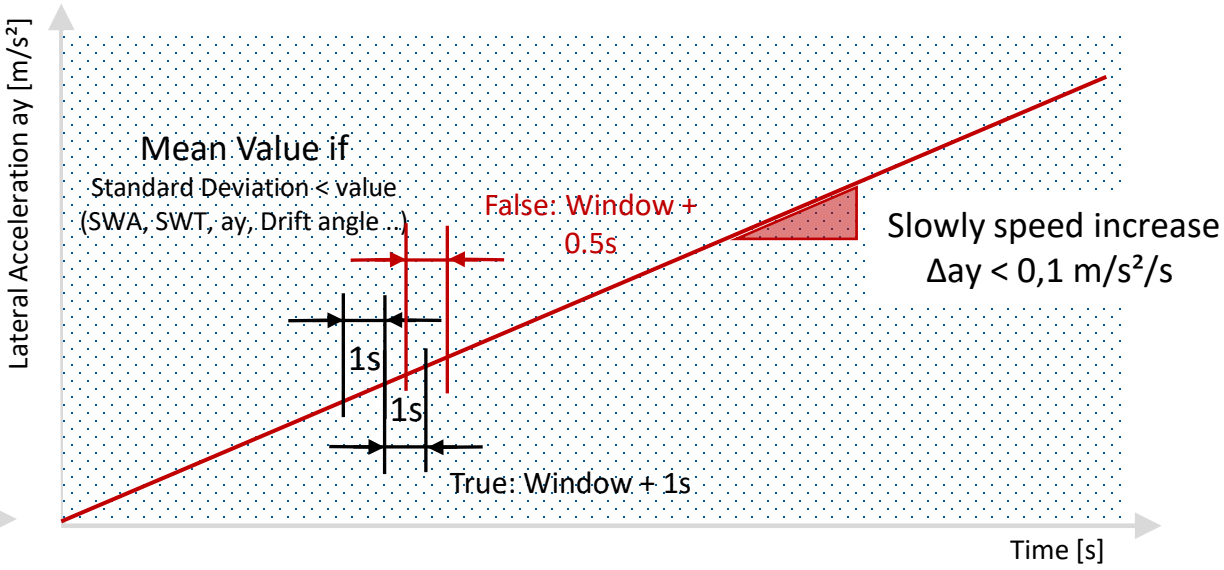


The measurement results (steering angle, sideslip angle, roll angle, toe angle, camber angle, ect.) are usually applied versus the lateral acceleration. The tire temperature should be recorded for tire stress indication, particularly when at high lateral accelerations should be applied over longer times. Otherwise, the tire must be cooled between test runs to ensure comparable conditions. Alternatively, the test can be driven in quasi-stationary circle driving, there the lateral acceleration will smoothly increased. The lateral acceleration change shall **not exceed 0.1 m/s²/s**.

Exercise 3: Two ways to conduct “Steady State Circular Driving”



“Steady State Circular Driving”



“Quasi Steady State Circular Driving”

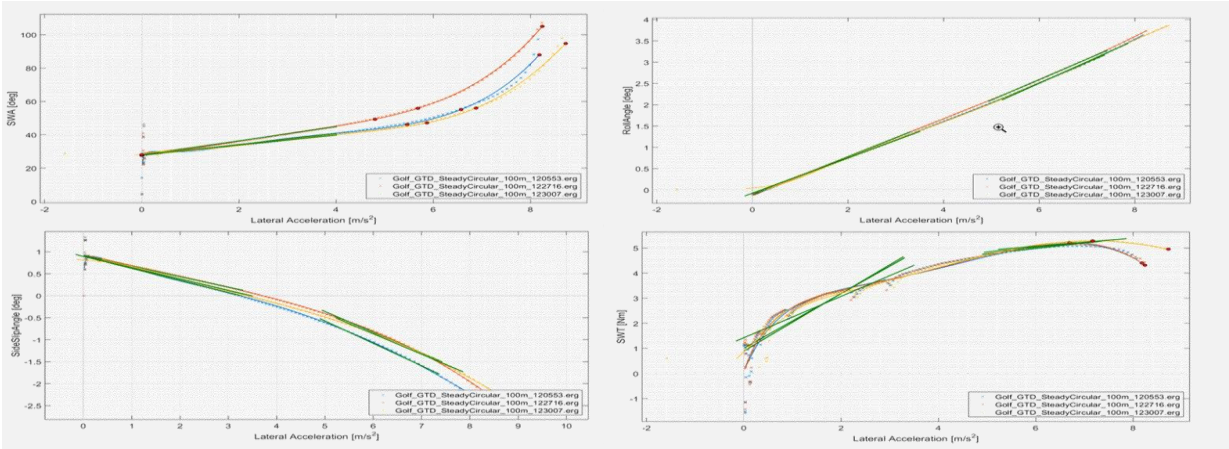
Vehicle Dynamics Attribute Evaluation

The progress of the steering wheel angle is an important criterion for the self-steering behavior of the vehicle.

- **Its increase with increasing lateral acceleration is an indicative of** understeering behavior. For reasons of stability and safety feeling of the driver an understeering shall be aspired.
- Achieving the limit zone with correspondingly large lateral acceleration shall signaled by sharply increasing steering angle.
- Thus, also a large decrease in the steering wheel torque is usually associated.
- The signals of drift and roll angle are parameters for comfort and safety.
- Oversteer behavior is no longer practical for modern vehicles.
- Important is the tuning philosophy: How far the gradients of yaw rate and steering angle approaches the critical speed. This is the condition there the vehicle is most sensitive to steering inputs – from slow to agile.

Target quantities and characteristic values:

- Steer characteristics (Steer angle = f(Ay))
- Roll stiffness
- Maximum lateral acceleration
- Ackermann angle
- Maximum side slip angle on the front axle
- Understeer gradient in the linear range
- Steering torque/effort

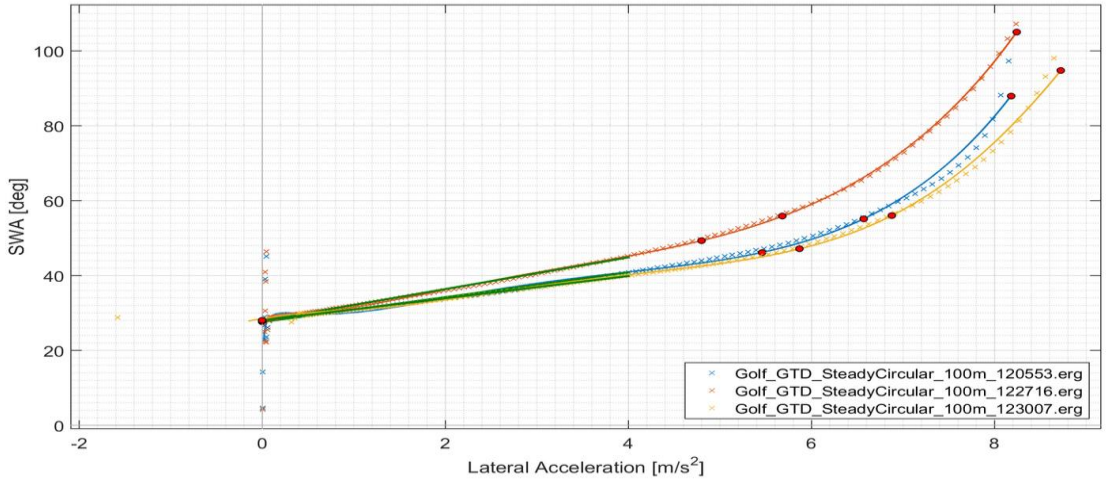


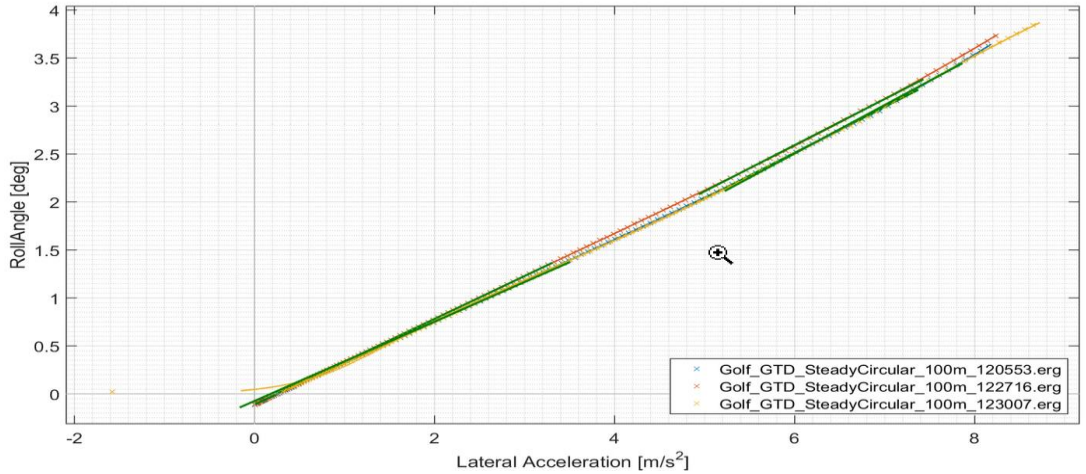
Vehicle Dynamics Attribute Evaluation

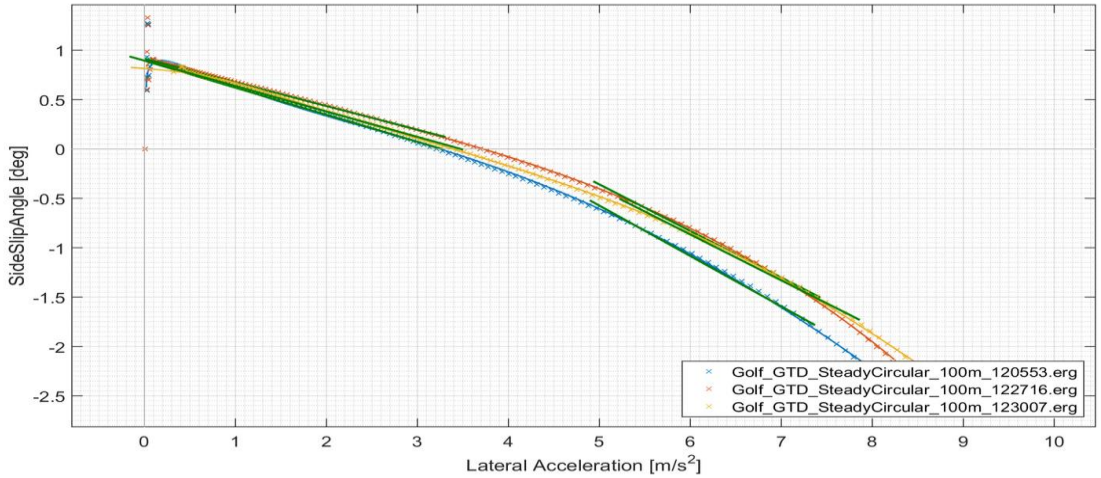
KPI and target matrix within a consistent development process

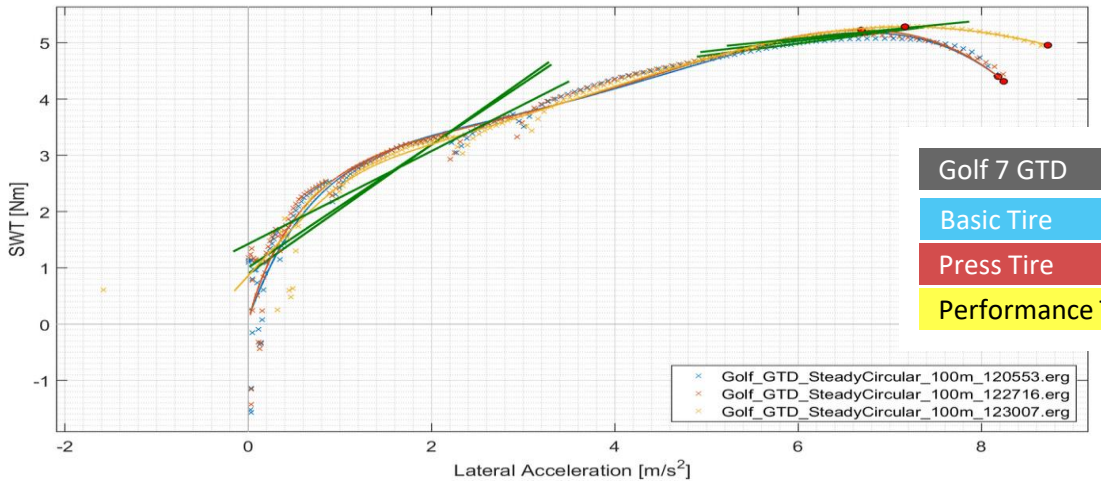
Vehicle Dynamics Attribute Evaluation

Exercise 3: Typical evaluation graph “Steady State Circular Driving”









Golf 7 GTD
Basic Tire
Press Tire
Performance Tire

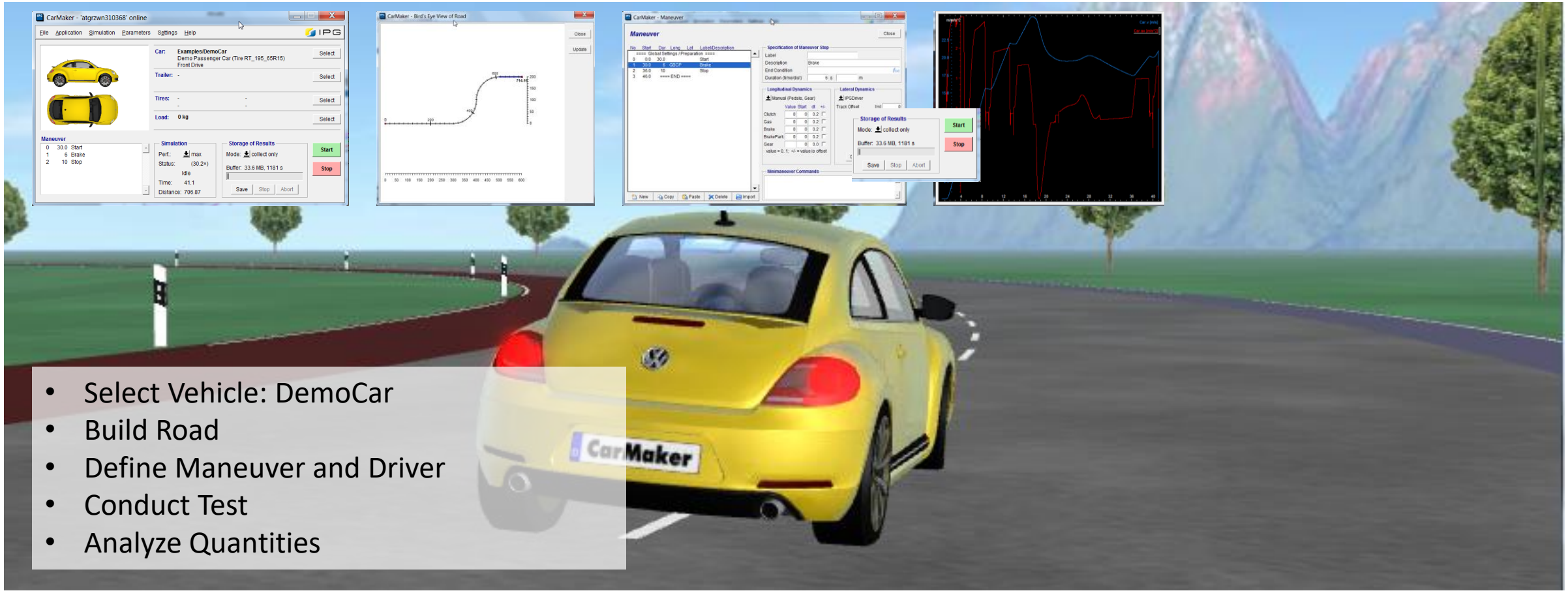
drive livinglab

Exercise 3: KPI – Summery Steady State Circular Driving

No.	Unit	KPI	Golf_GTD...	Golf_GTD...	Golf_GTD...
1	Nm	MaxSWT	5.18	5.22	5.28
2	deg	SWAatSWTmax	57	68	59.9
3	Nm/deg	SteeringStiffnessLowG	0.308	0.252	0.27
4	Nm/deg	SteeringsStiffnessHighG	0.0195	0.013	0.0132
6	m/s^2	AyatSWTmax	6.72	6.69	7.16
7	m/s^2	MaxAy	8.18	8.24	8.72
8	Nm	SWTatMaxAy	4.4	4.32	4.96
9	%	AySafetyMargin	17.8	18.9	17.9
10	Nm/(m/s^2)	SWTgradientLowG	1.15	1.09	0.826
11	Nm/(m/s^2)	SWTgradientHighG	0.211	0.186	0.162
13	deg/(m/s^2)	UndersteerGradient	3.32	4.23	2.96
14	deg	AckermannAngle	27.6	27.9	28
15	deg/(m/s^2)	LinearIncreasingSWAGradient	3.32	4.31	3.09
16	m/s^2	EndOfLinearIncreasingGradient	5.46	4.8	5.87
17	km/h	CharacteristicSpeed	92.4	85.9	94.7
19	deg	SWAatMaxAy	88	105	94.8
20	deg	MaxSWA	88	105	94.8

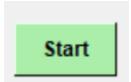
			Basic Tire	Press Tire	Performance Tire
21	m/s^2	AyAtSWAmax	8.18	8.24	8.72
22	(deg/s)/deg	MaxYawGain	0.288	0.254	0.295
23	m/s^2	AyAtYawGainMax	4.91	4.2	5.08
24	[(deg/s)/deg]/(m/s^2)	YawGainGradientLowG	0.0738	0.0653	0.0508
25	[(deg/s)/deg]/(m/s^2)	YawGainGradientHighG	-0.02	-0.0226	-0.025
27	(m/s^2)/deg	MaxAyGain	0.119	0.101	0.124
28	m/s^2	AyAtAyGainMax	6.22	5.95	6.29
29	[(m/s^2)/deg]/(m/s^2)	AyGainGradientLowG	0.0271	0.0249	0.0261
30	[(m/s^2)/deg]/(m/s^2)	AyGainGradientHighG	0.00047	-0.00199	-0.00294
32	(deg/s)/(m/s^2)	YawRateGradientLowG	2.89	2.85	2.26
33	(deg/s)/(m/s^2)	YawRatGradientHighG	1.18	1.18	1.18
35	deg/(m/s^2)	RollAngleGradientLowG	0.431	0.447	0.413
36	deg/(m/s^2)	RollAngleGradientHighG	0.478	0.481	0.505
38	deg/(m/s^2)	SideSlipAngleGradientLowG	-0.274	-0.24	-0.257
39	deg/(m/s^2)	SideSlipAngleGradientHighG	-0.51	-0.472	-0.465
41	m	MeanRadius	100	99.6	99.9

Exercise 4: New TestRun from the scratch



- Select Vehicle: DemoCar
- Build Road
- Define Maneuver and Driver
- Conduct Test
- Analyze Quantities

Exercise 4: New TestRun from the scratch

1. Select vehicle DemoCar
2. Build Road
    1. 500m straight, 90° left corner, 90° right corner, 500m straight
3. Build maneuver
    1. Accelerate until Car.v>80/3.6
    2. Drive constant 80 kph for 1s
    3. Brake with 6 m/s²
4. Save Test Run and simulating 

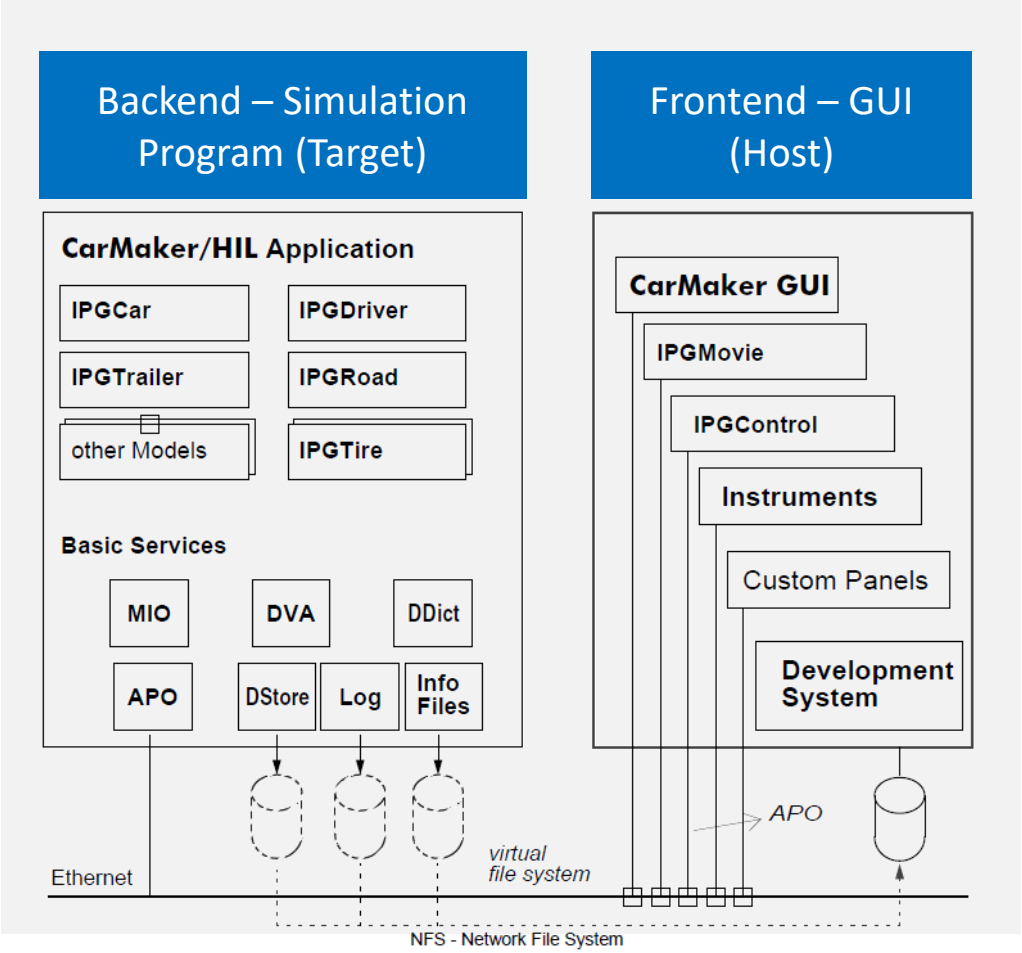
5. Change left hand and right hand driving (road) and driver parameter curve cutting
6. **Extend the road as you want**

Exercise 5: Creating µ-Split braking test

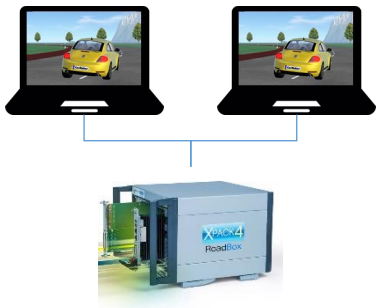
Chapter 5 Quick Start Guide

1. Building a Road Network Using the Scenario Editor
2. Defining the Maneuver
3. Saving Your TestRun
4. Selecting a Vehicle and Simulating
5. Analyze Car.ax, Steer.WhlAng, Car.YawRate in IPGControl

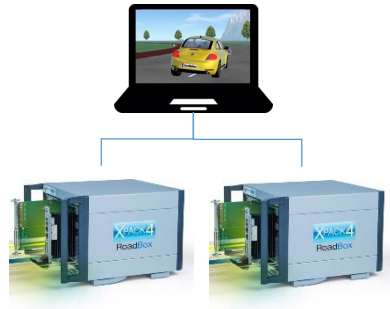
Front End & Back End Architecture - Interaction with Simulation Program



CarMaker Office
Frontend + Backend



Muli-Host



Muli-Target

CarMaker HIL
Frontend

Digital (z.B. CAN) Analog

LAN

CarMaker HIL
Backend

CarMaker flow process charts - The main cycle explained

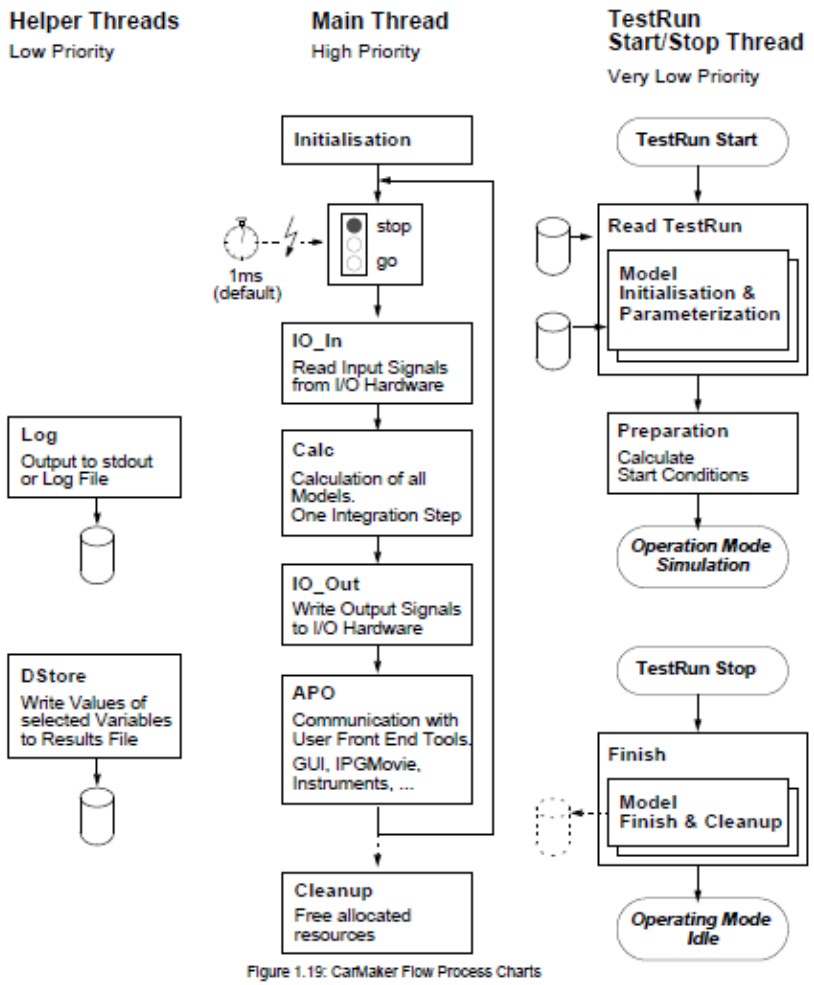


Figure 1.19: CarMaker Flow Process Charts

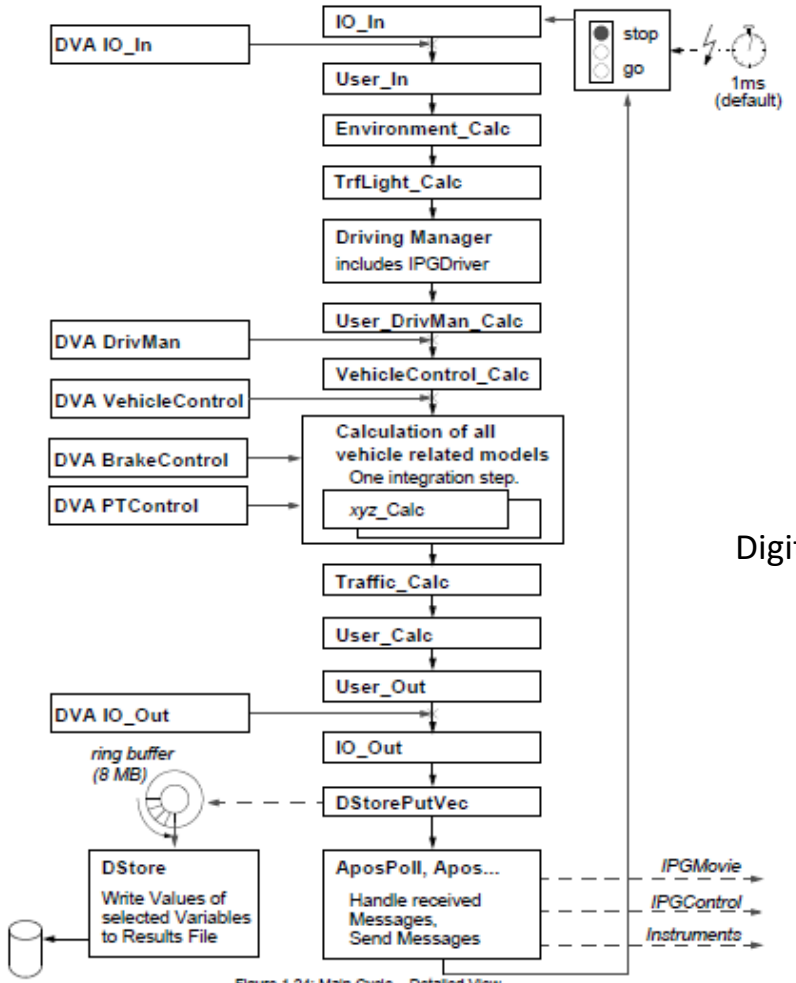
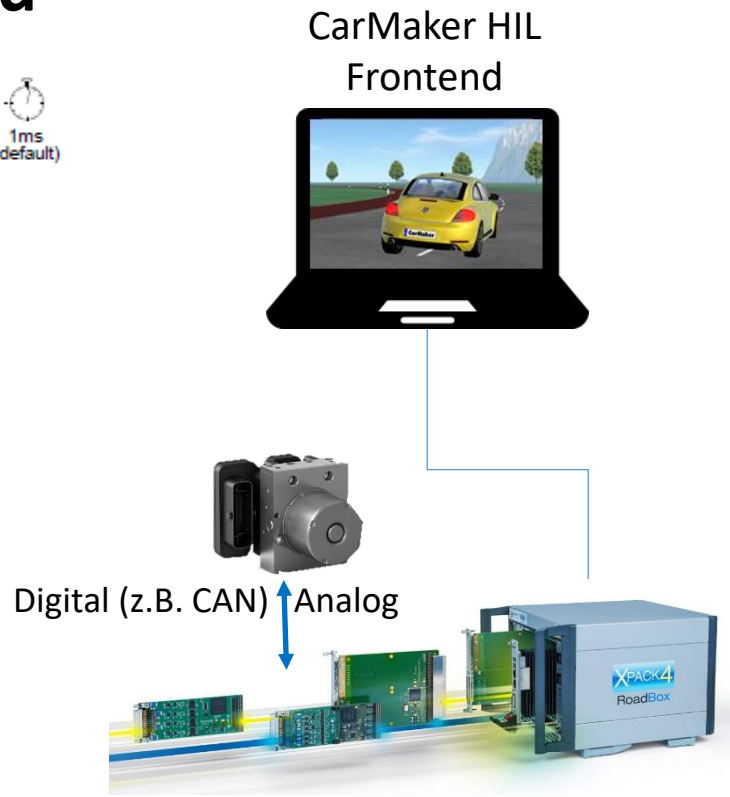
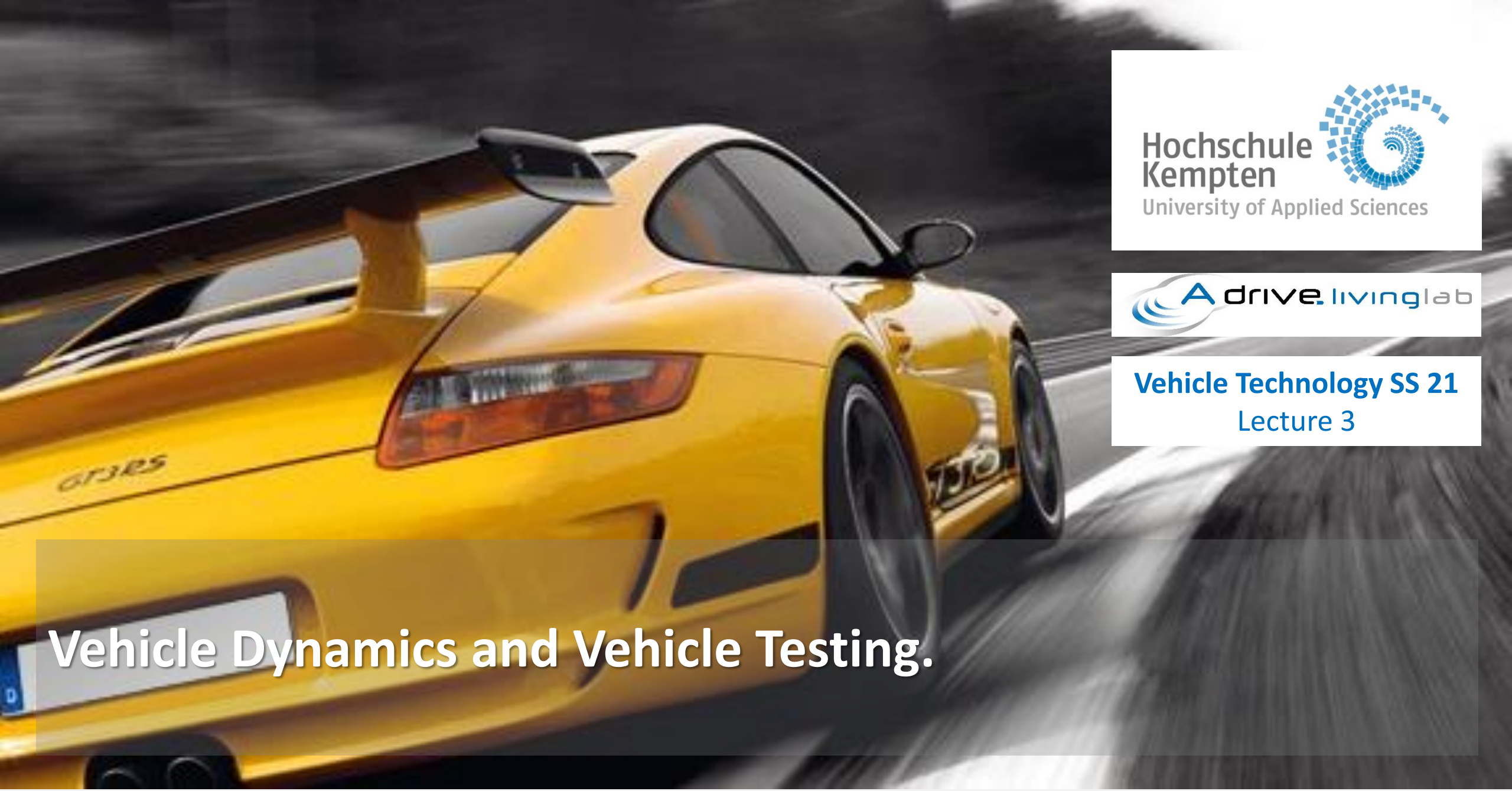


Figure 1.24: Main Cycle – Detailed View





Hochschule Kempten
University of Applied Sciences

drive livinglab

Vehicle Technology SS 21
Lecture 3

Vehicle Dynamics and Vehicle Testing.