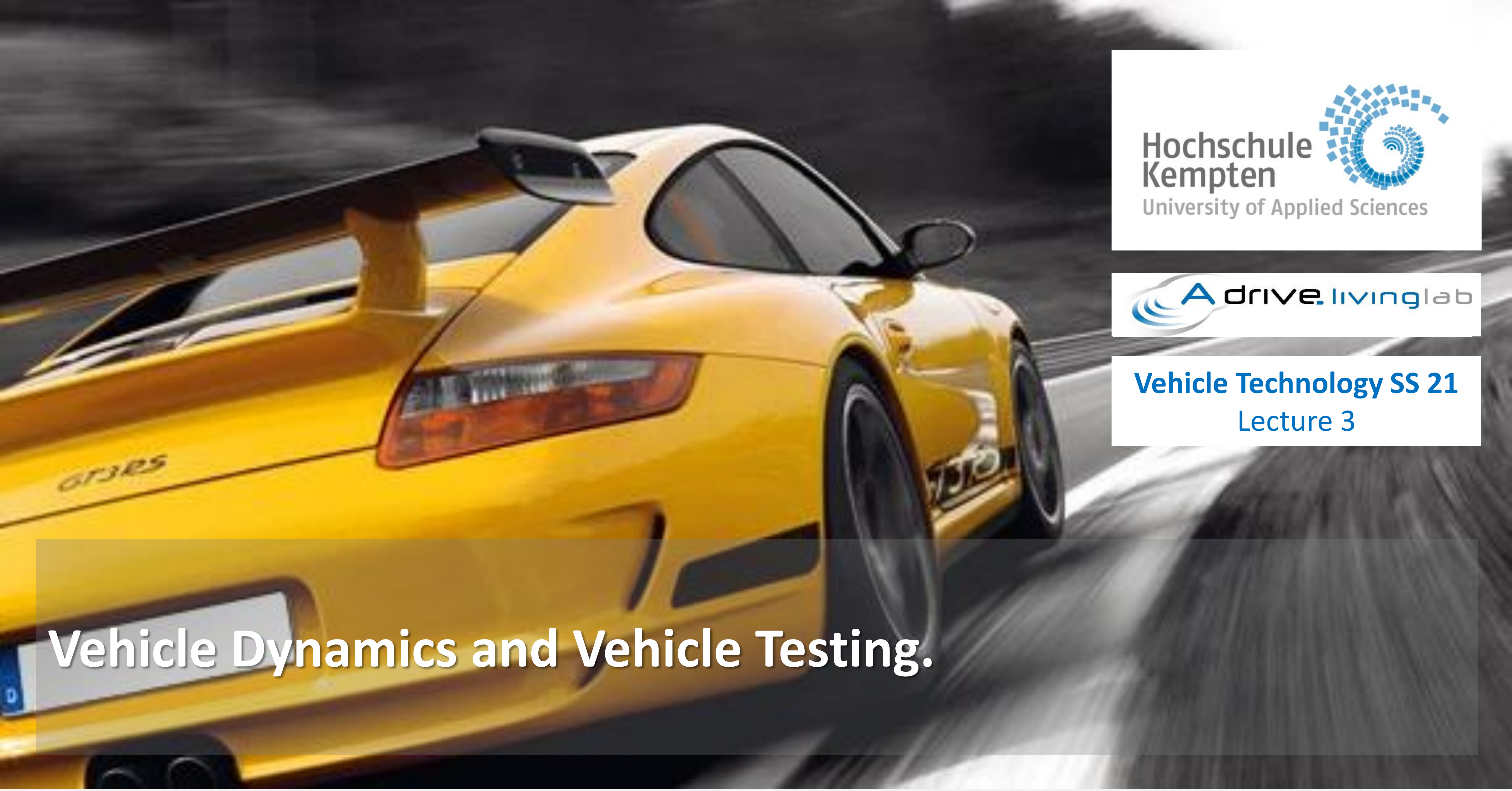


Hochschule Kempten
University of Applied Sciences

Adrive livinglab

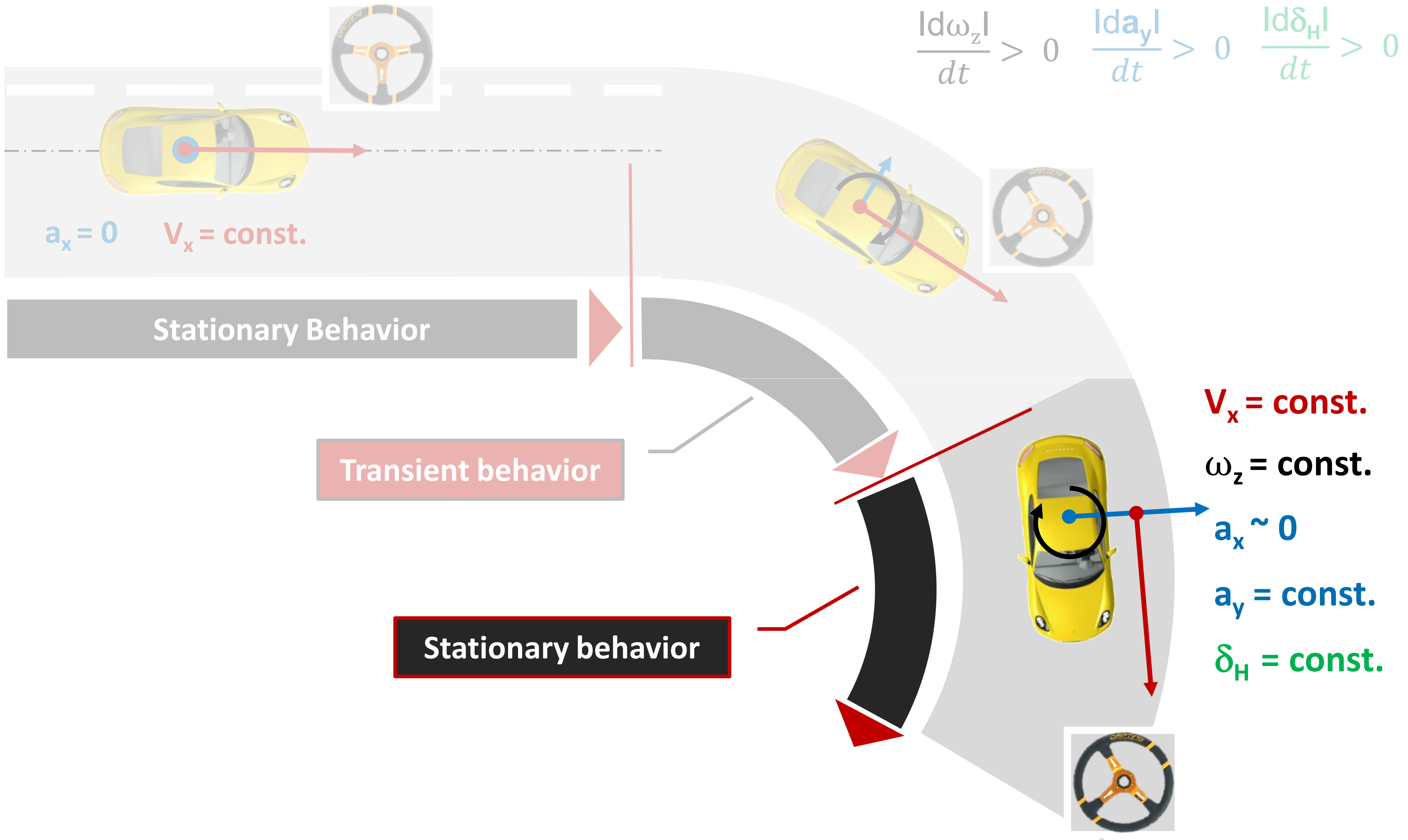
Vehicle Technology SS 21
Lecture 3

Vehicle Dynamics and Vehicle Testing.

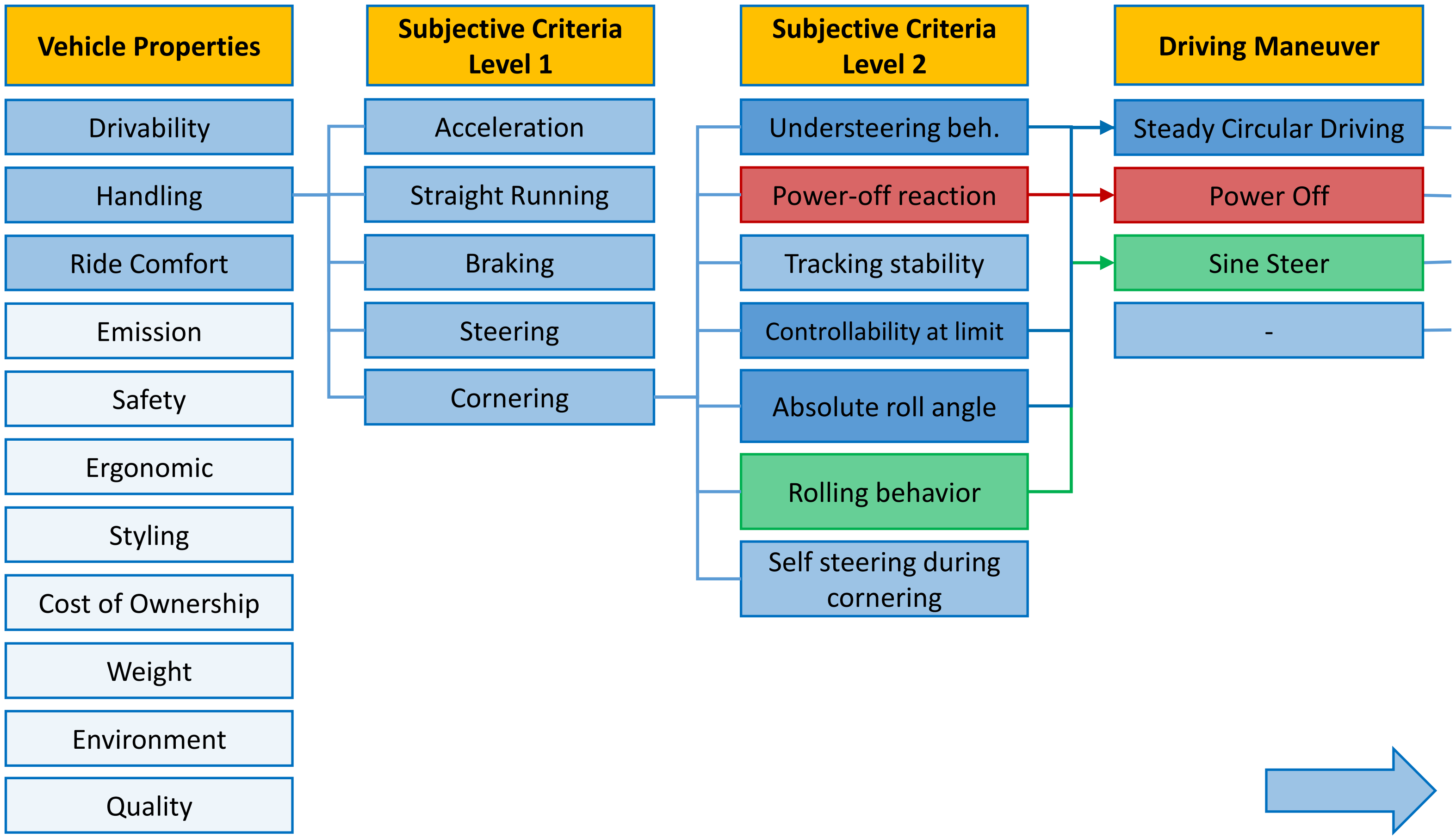
Agenda

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

Exercise 3: Lateral Dynamics: Stationary behavior

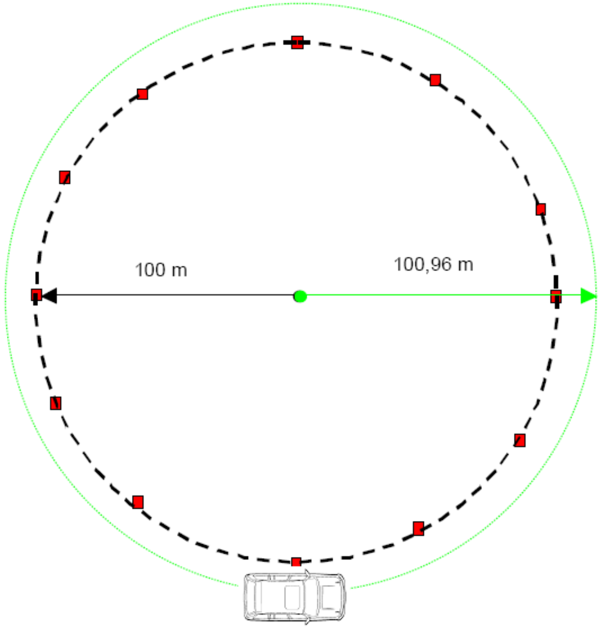


Evaluation structure and cause and effect chain



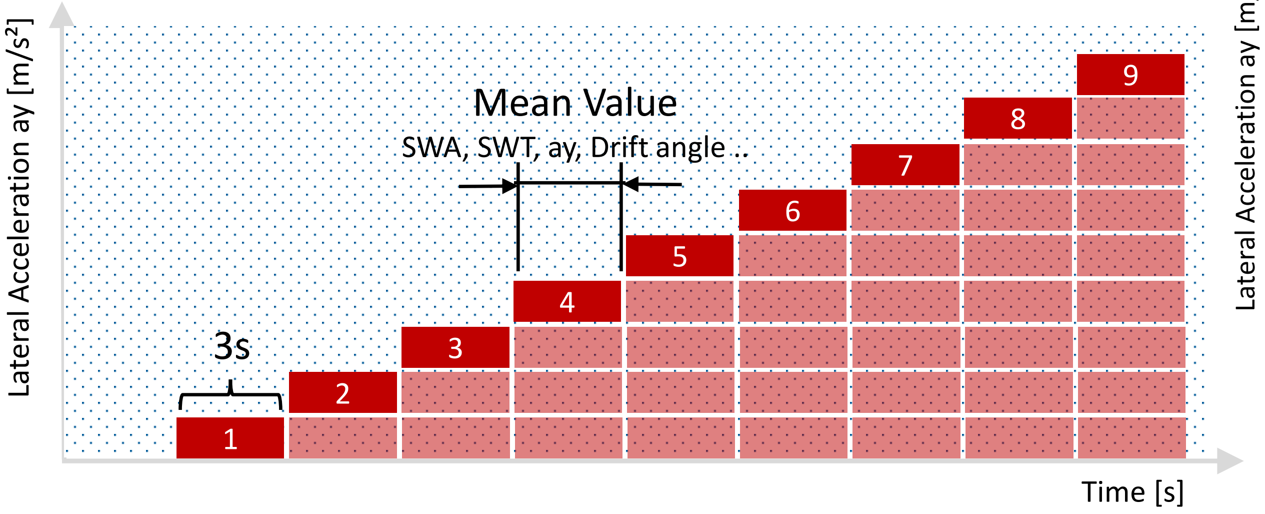
Most important maneuver: “ISO 4138 - Steady State Circular Driving”

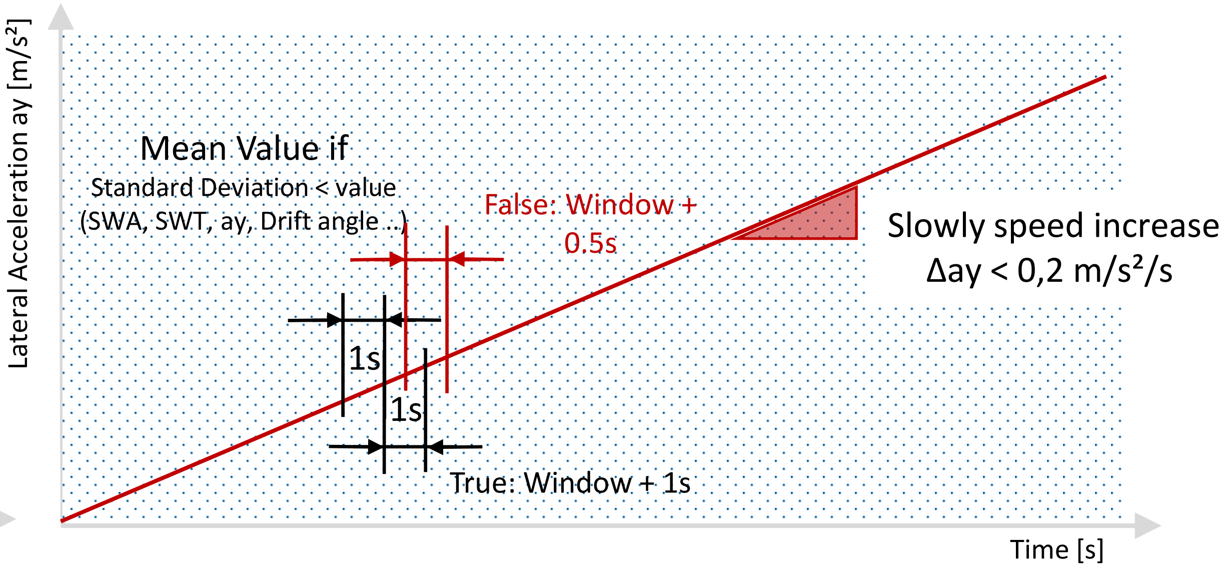
In the present experiment is right- and handed circle driving with the constant radius of 100 m. The tests are run in low gear two and three, with a step size **of 1.0 m/s²** lateral acceleration **of 1 m/s²** are set to the lateral limit. During the steady state test phase the steering wheel angle and 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 0.2 m/s²/s**.

Two ways to conduct "ISO 4138 - Steady State Circular Driving"





"Steady State Circular Driving"

"Quasi Steady State Circular Driving"

KPI and target matrix within a consistent development process

Driving Maneuver
Steady Circular Driving
Power Off
Sine Steer
...

Objective Evaluation Criteria	Benchmark Result Veh 1	Veh 2	...	Target
Ackermann Angle(SWA)	28	25	..	25
Understeer Gradient	2,6	0.8	..	> 2 < 2,2
$a_{y,max}$	8,5	8,9	..	> 9
Yaw Gain Max	13,5	14,5	..	> 14,5
Roll Stiffness	4,2	4,6	..	> 3,6 > 4,0
SWT max	4,5	5,2	..	> 4,8 > 5,2
Ay rel at SWT	70	85	..	> 80 < 90
Side Slip Max	1,8	2,1	..	< 1,8
...	...	...	..	..

Brand specific

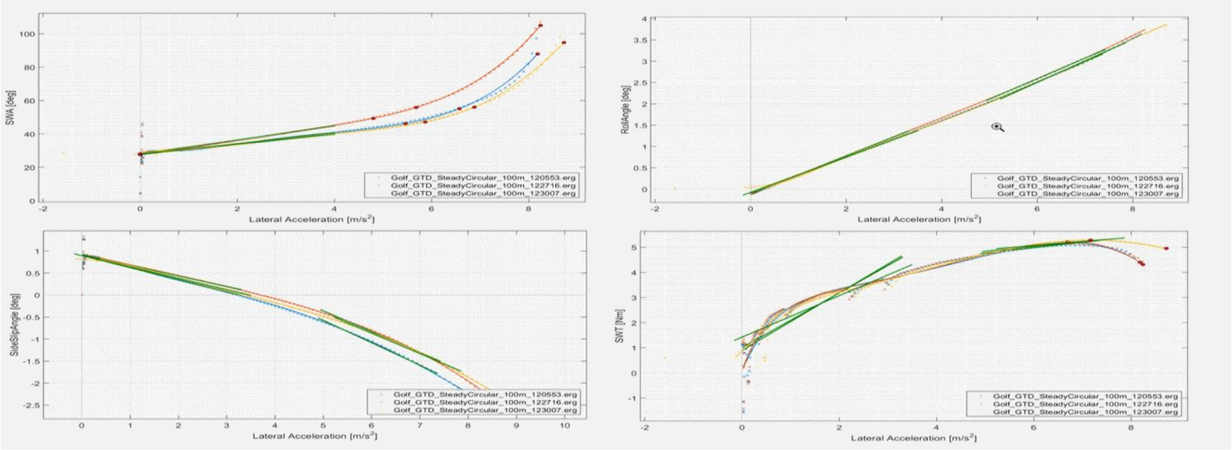
Test and evaluation methods for vehicle attributes

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

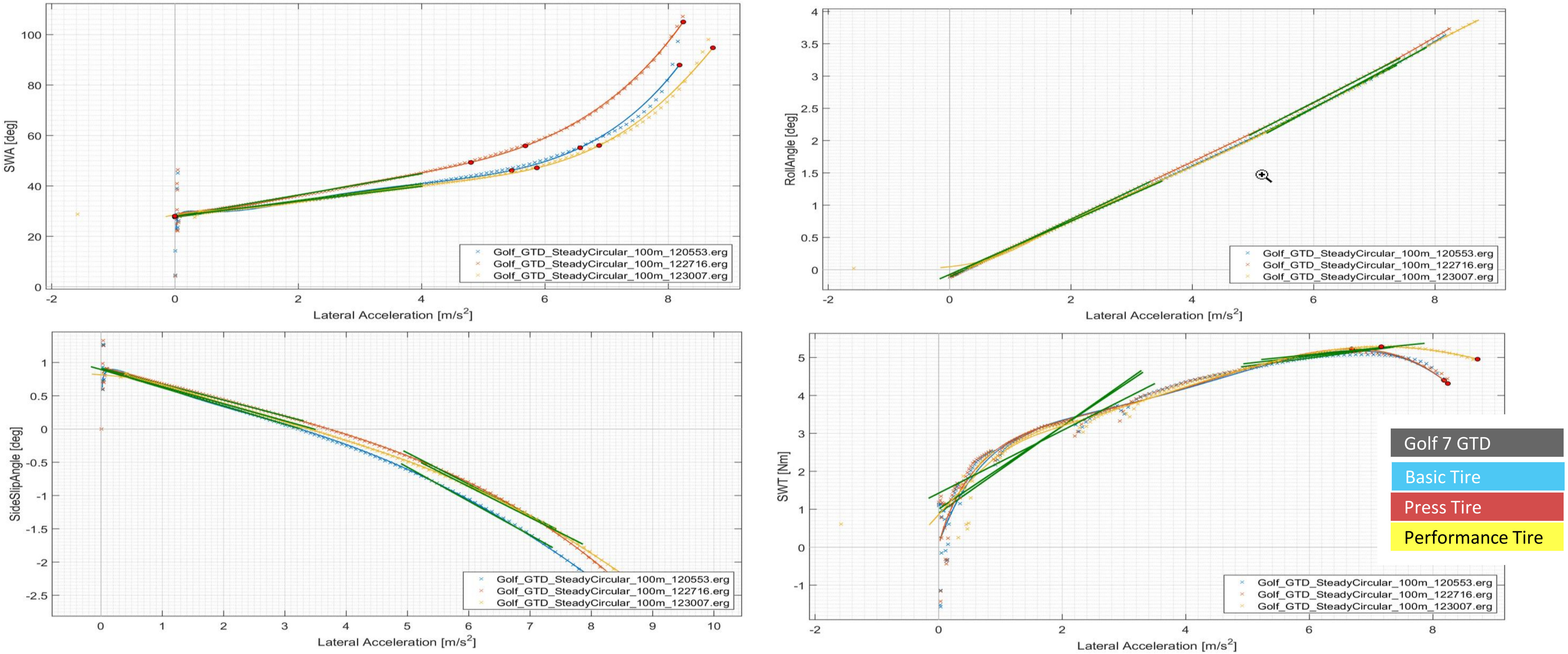
- **Its increase with increasing lateral acceleration is an indicative of** understeering behavior. For reasons of stability and safety feeling of the driver an understeering shall be aspired.
- Achieving the limit zone with correspondingly large lateral acceleration shall signaled by sharply increasing 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.

<u>Target quantities and characteristic values:</u>

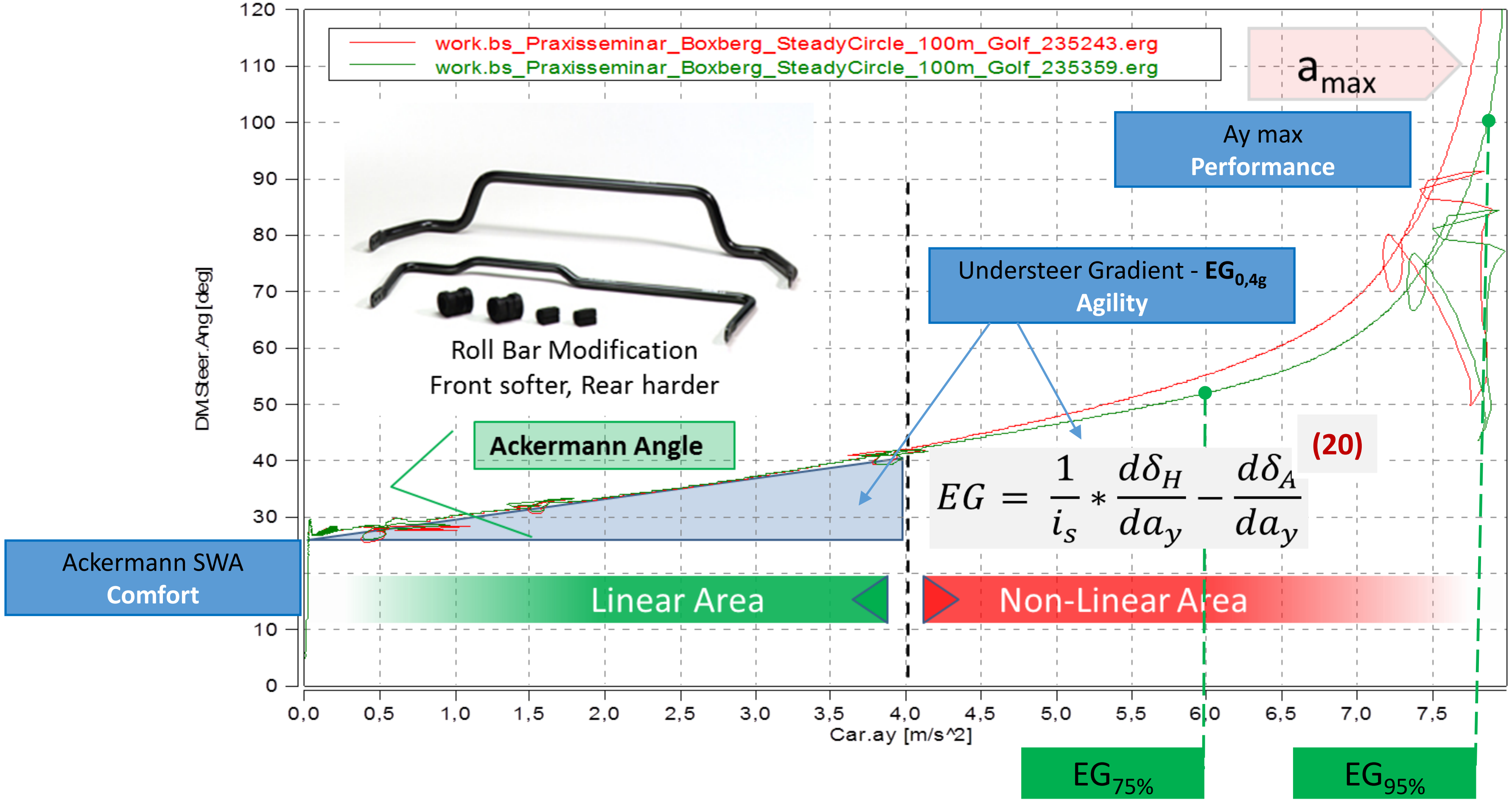
- Steer characteristics (Steer angle = f(Ay))
- Roll stiffness
- Maximum lateral acceleration
- Ackermann angle
- Maximum side slip angle on the front axle
- Understeer gradient in the linear range
- Steering torque/effort



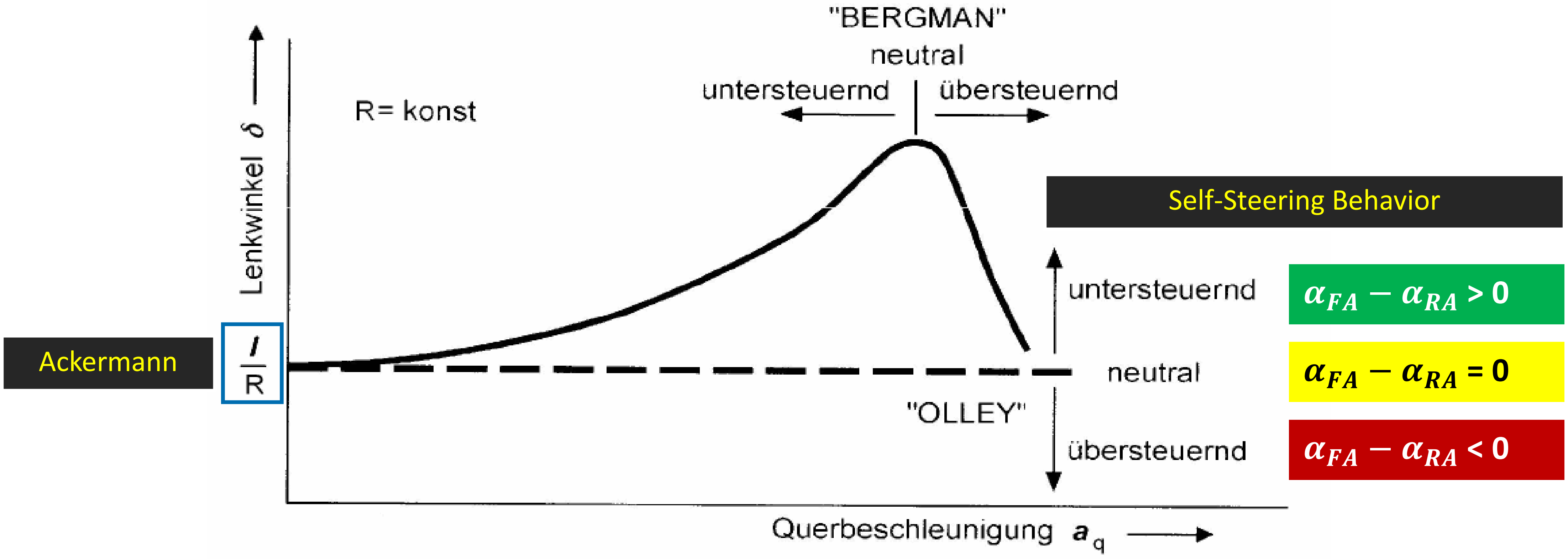
Exercise 3: Typical evaluation graph “Steady State Circular Driving”



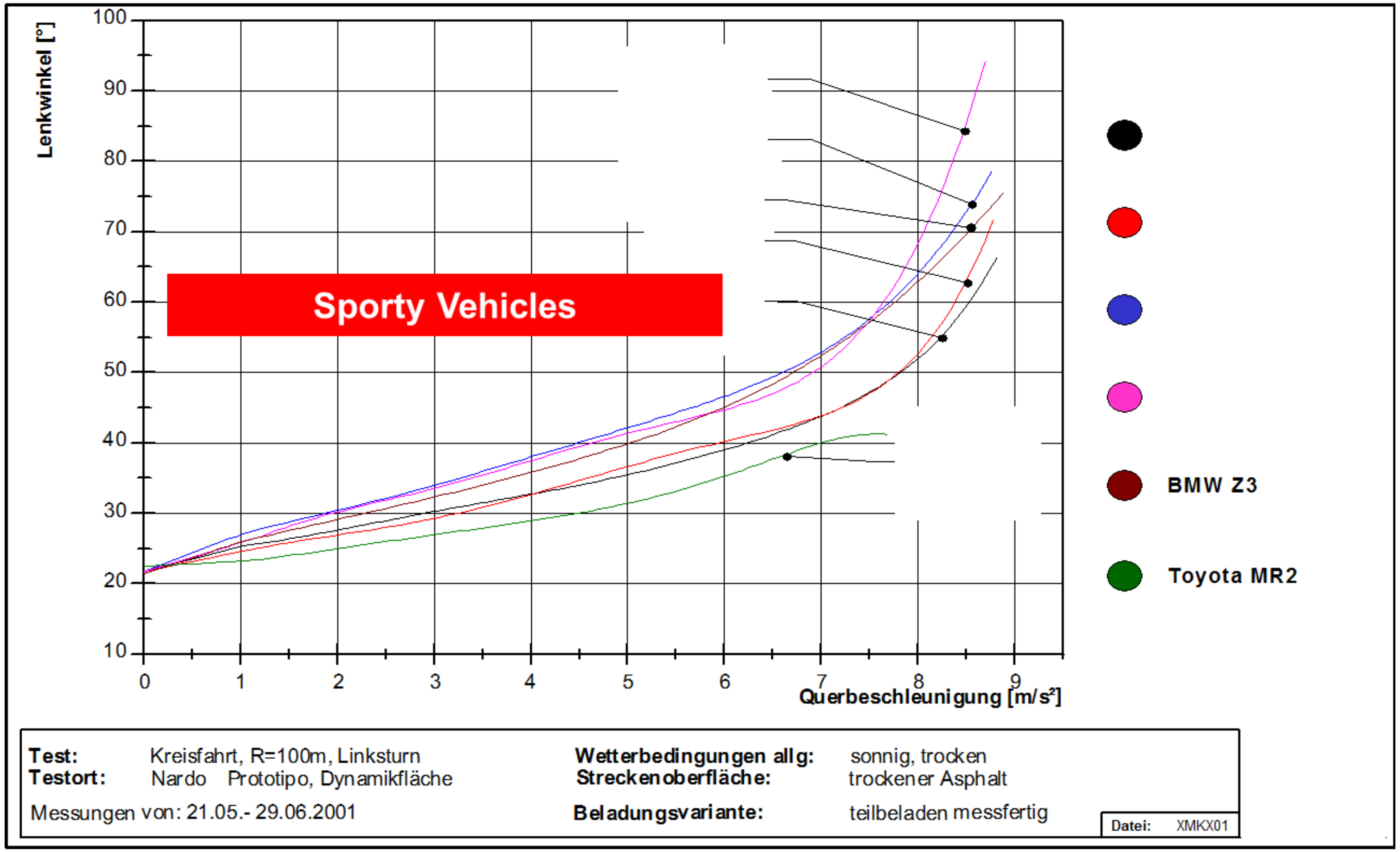
Typical evaluation criteria for steering angle demand behavior



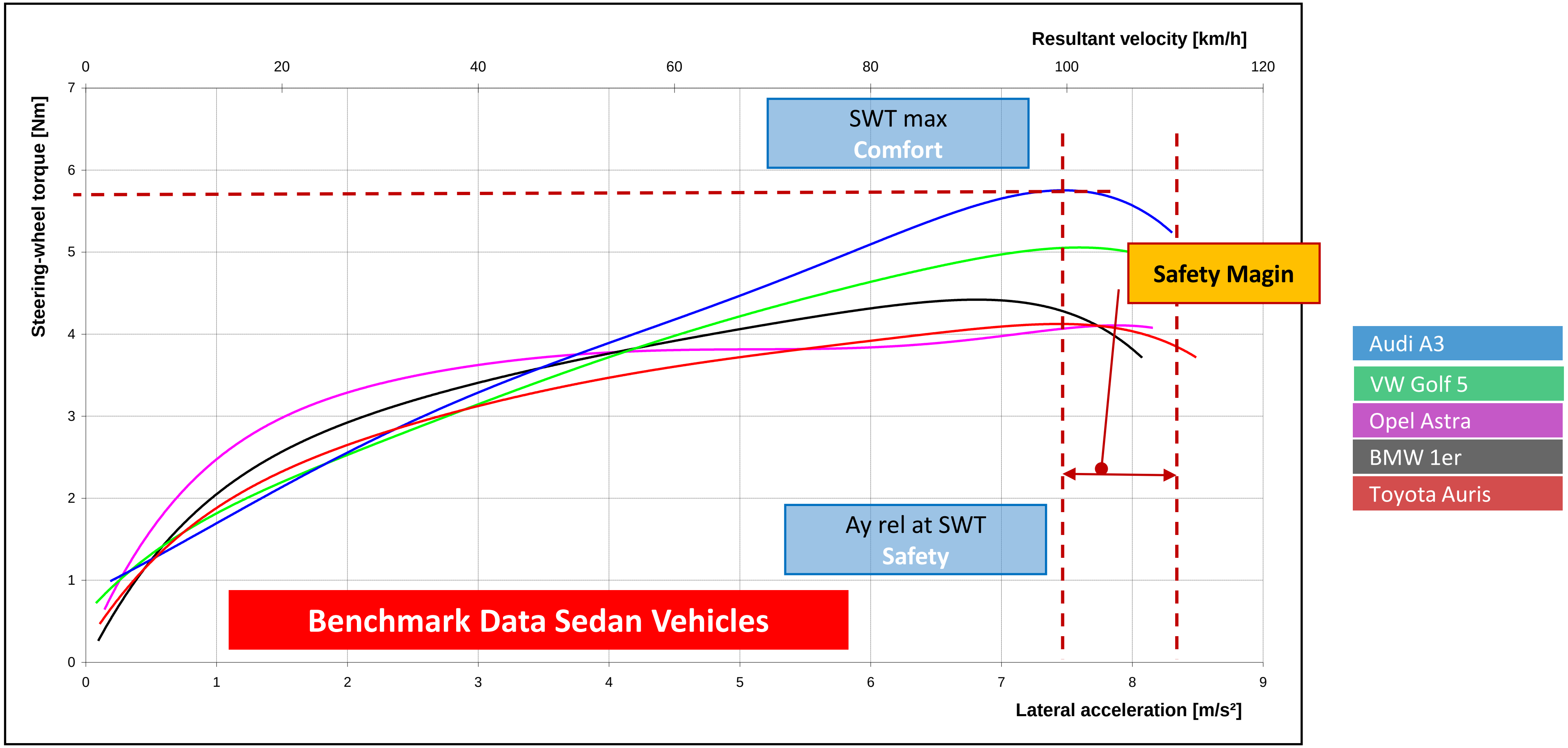
Understeer and oversteer definition



Understeer and oversteer behavior of sporty vehicle benchmarking



Typical evaluation criteria steering torque effort behavior based on sporty vehicle benchmarking

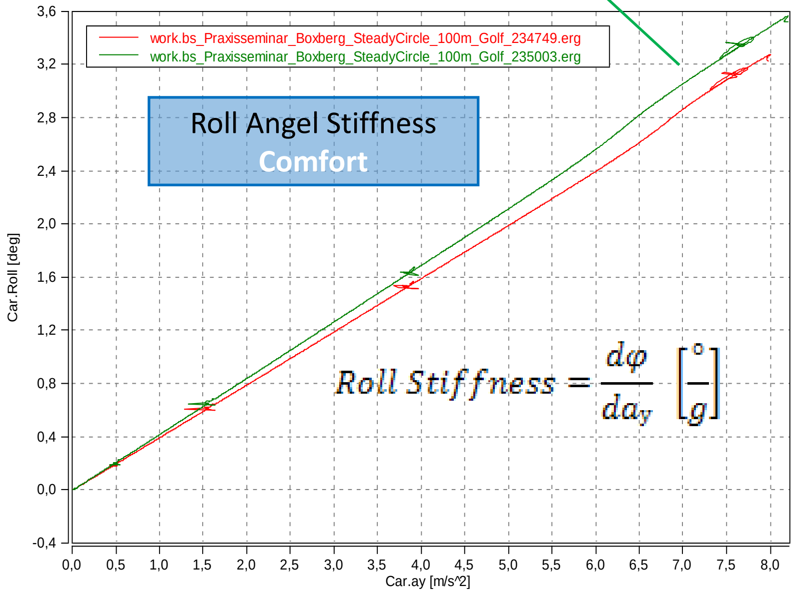


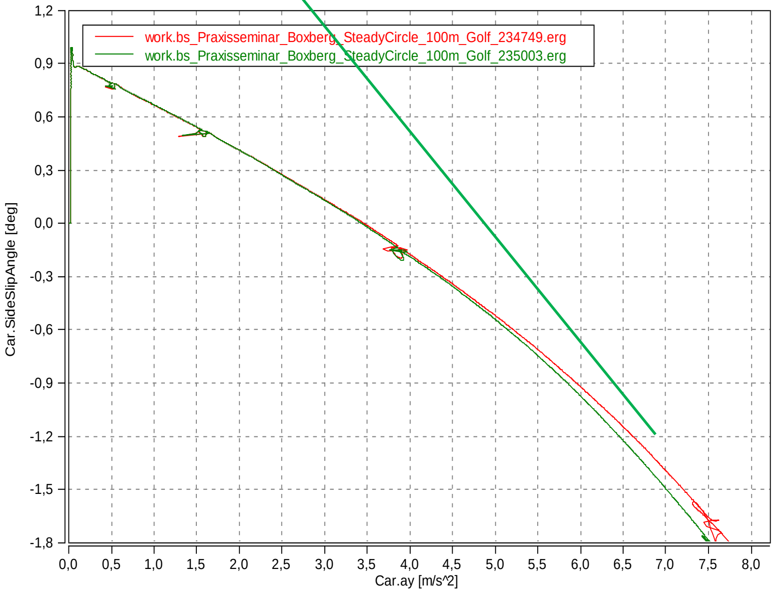
Typical evaluation criteria roll and drift behavior

Roll Bar Modification
Front softer, Rear harder

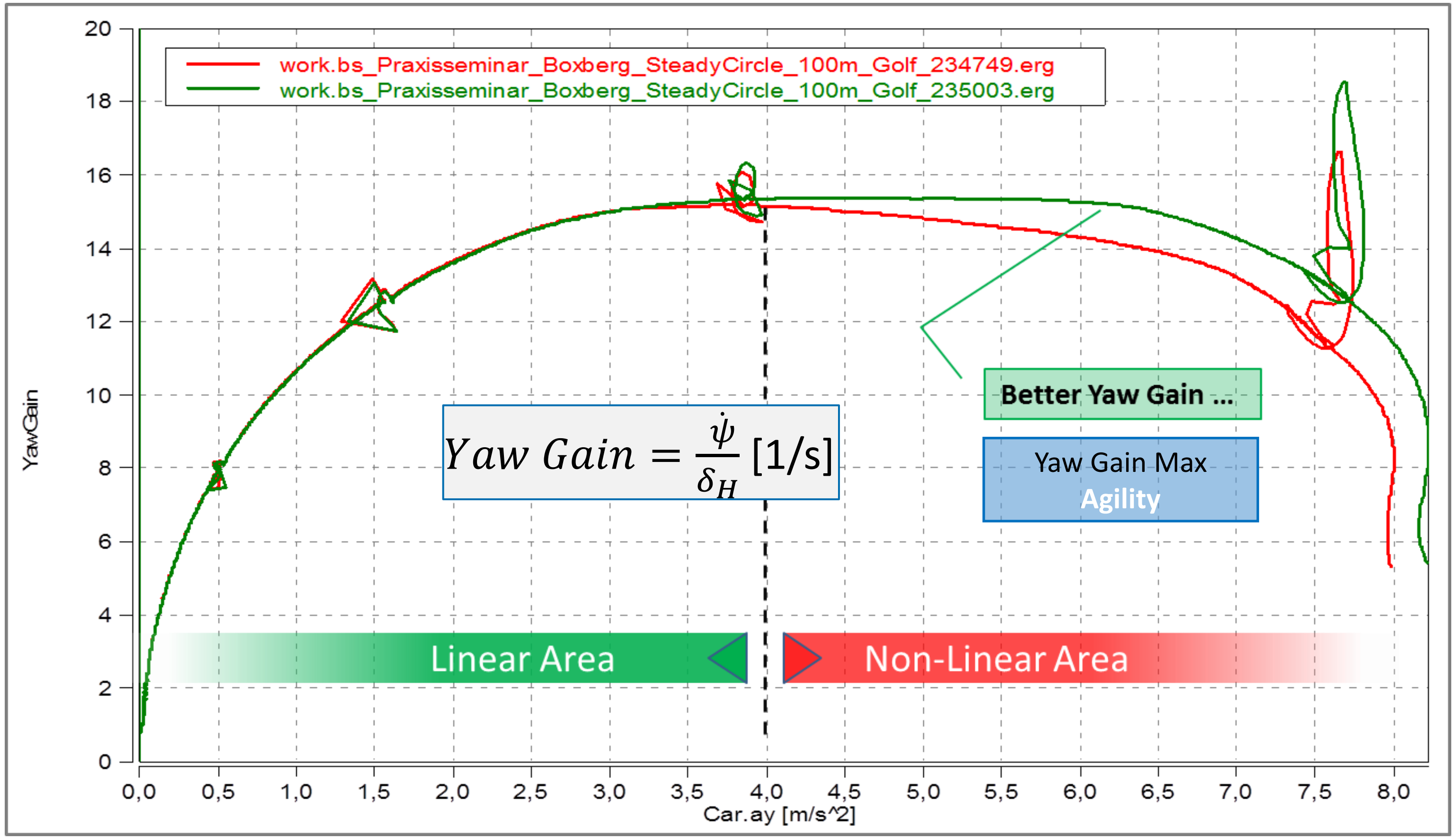
Bigger Roll Angle

... bigger Side Slip Angle





Typical evaluation criteria for yaw gain



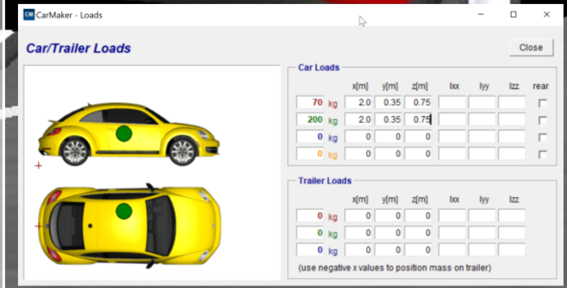
Exercise 6: Steady State Circular Driving

Test Condition
- Constant Radius: 100 m
- Speed: 0 – max kph
- da_y: 0,2 m/s²/s

SWA, a_y, Yaw, Radius: steady state condition

Visualize:
- Steer.WhlAng, Car.v, Car.ay, Car.Roll, Car.SideSlipAngle

1. Change & Analyze Load Sensitivity:
a. Base with 200 kg at CoG (basic tire)
b. 200 kg rear axle
c. 200 kg front axle
d. Vehicle roof mass 200 kg



2. Change & Analyze Tire Sensitivity:
1. Basic Tire
2. Press Tire
3. Performance Tire

3. Change & Analyze Stabi Sensitivity:
1. Base with Basic Tire
2. Stabi front 2,0, Rear 0,5
3. Stabi front 0,5, Rear 2,0

4. Change & Analyze Camber Sensitivity:
1. Base with Basic Tire
2. Camber front STD, rear +3
   Eval Car.CRL.rx_ext=0.0523, Eval Car.CRR.rx_ext=-0.0523
3. Camber front +3, rear STD
   Eval Car.CFL.rx_ext=0.0523, Eval Car.CFR.rx_ext=-0.0523

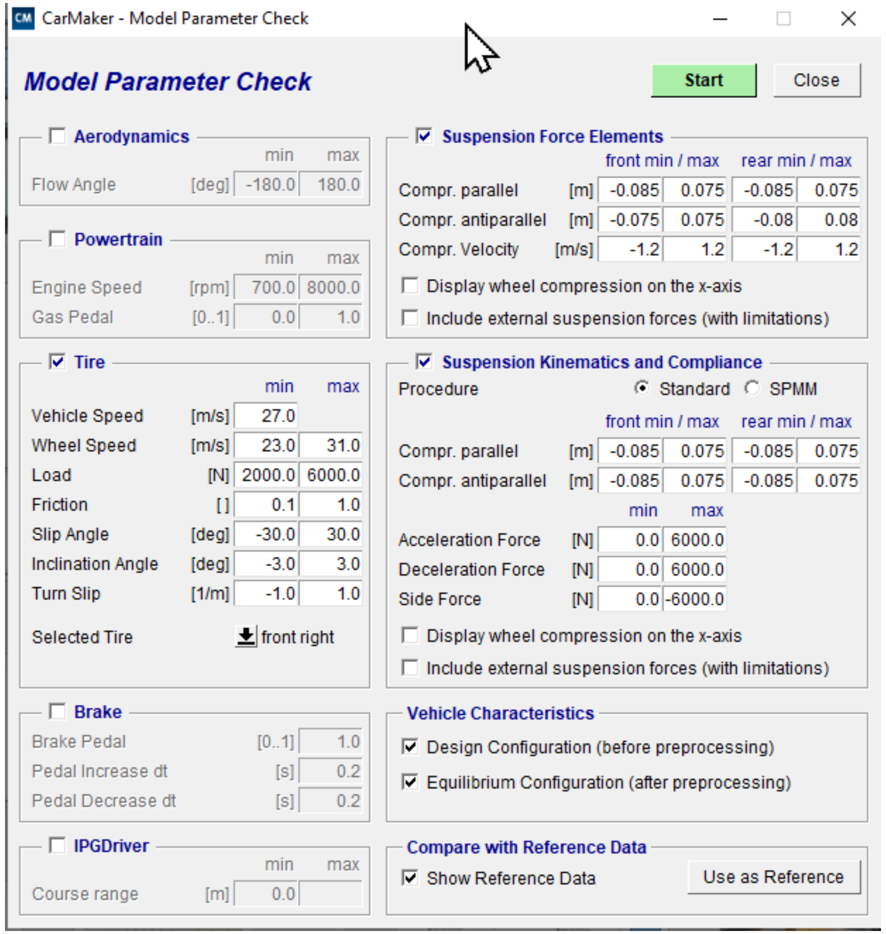
Exercise 6: KPI – Summery Steady State Circular Driving

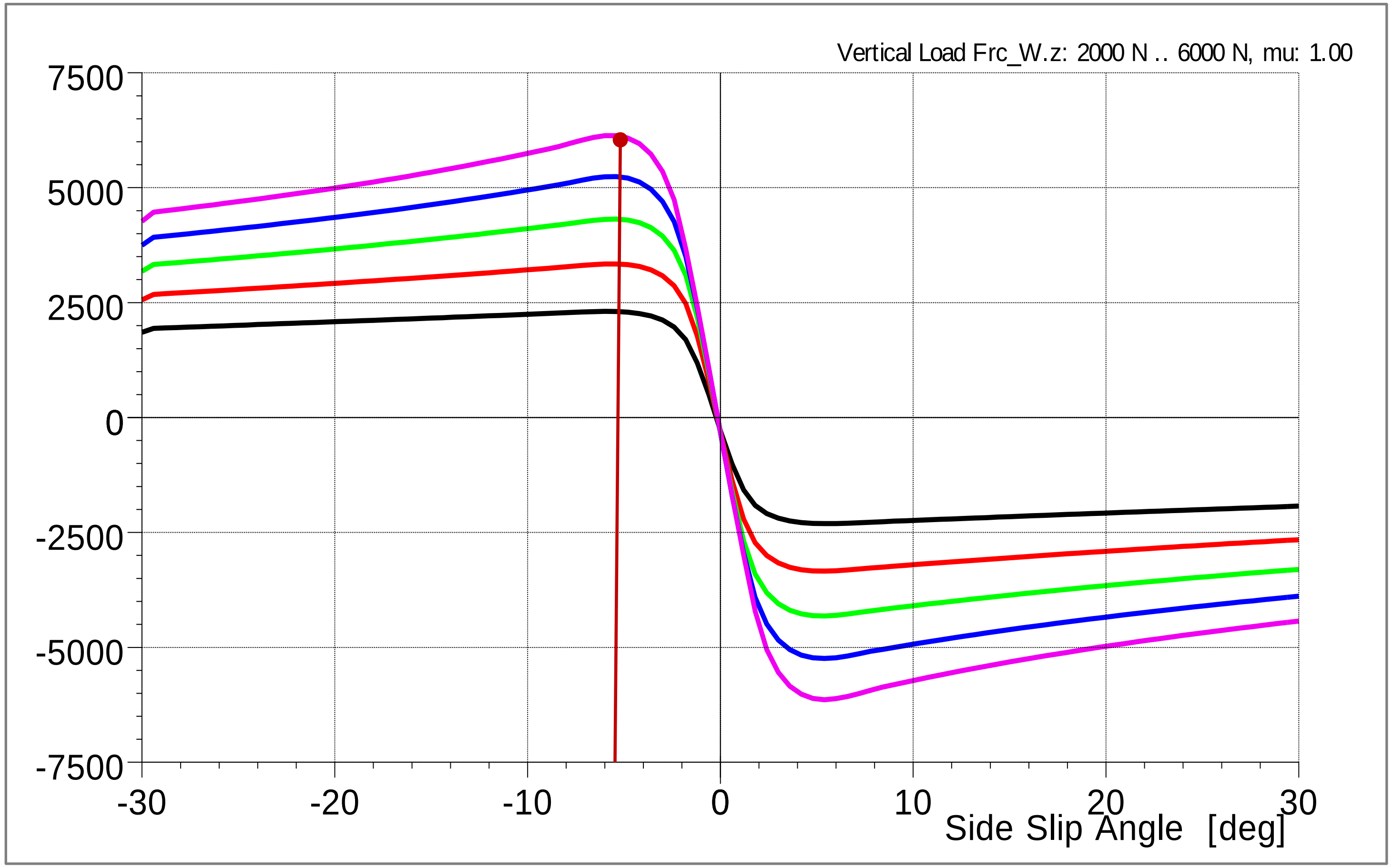
No.	Unit	KPI	Golf_GTD...	Golf_GTD...	Golf_GTD...
1	Nm	MaxSWT	5.18	5.22	5.28
2	deg	SWAatSWTmax	57	68	59.9
3	Nm/deg	SteeringStiffnessLowG	0.308	0.252	0.27
4	Nm/deg	SteeringsStiffnessHighG	0.0195	0.013	0.0132
6	m/s^2	AyatSWTmax	6.72	6.69	7.16
7	m/s^2	MaxAy	8.18	8.24	8.72
8	Nm	SWTatMaxAy	4.4	4.32	4.96
9	%	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

Model Parameter Check to check & compare component behavior





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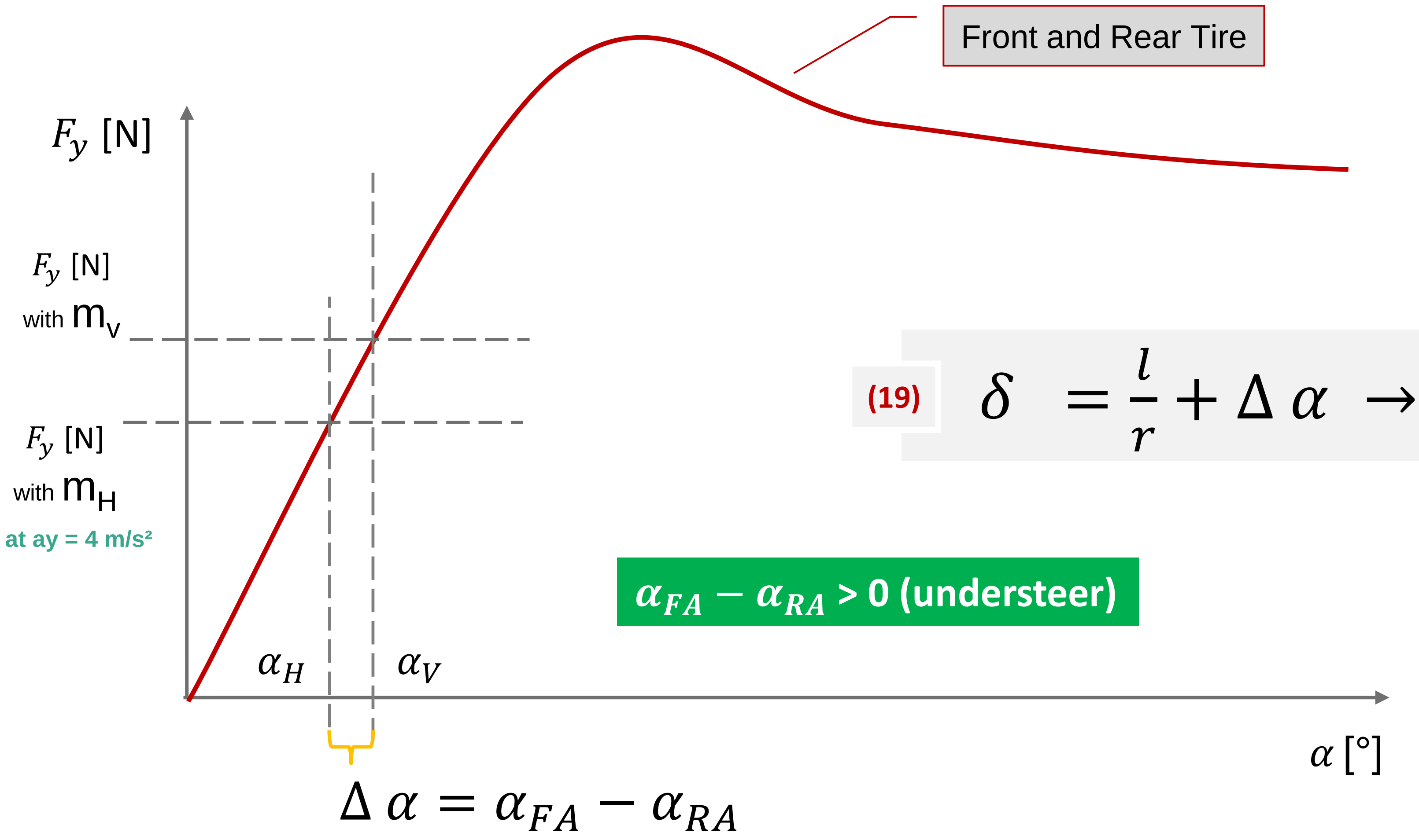
Case 1: Understeer behavior with wheel load distribution

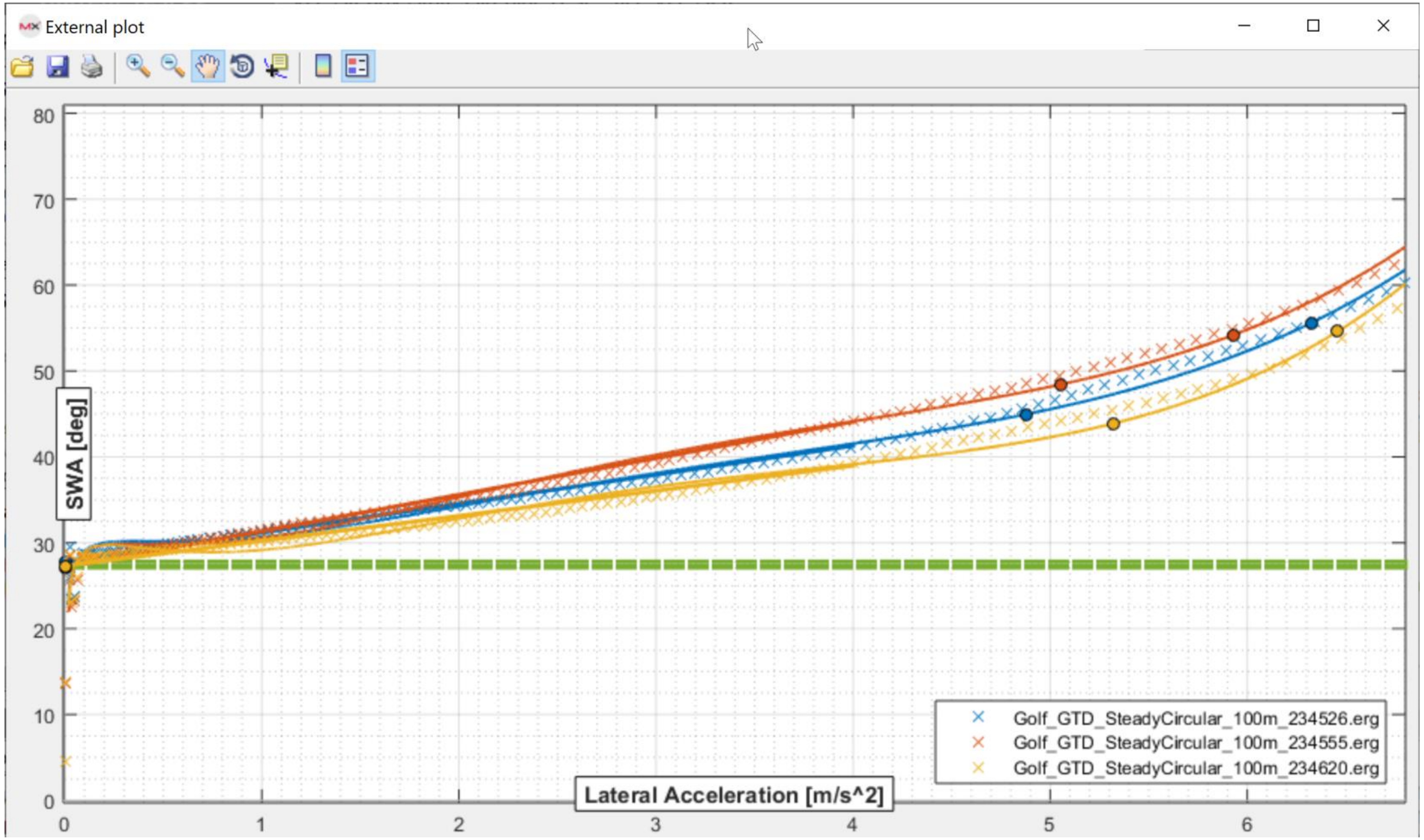


$$\delta \;= \frac{l}{r} + \Delta\,\alpha \;\rightarrow [\alpha_{FA} - \alpha_{RA}] \qquad (19)$$

$\alpha_{FA} - \alpha_{RA}$ > 0 (understeer)

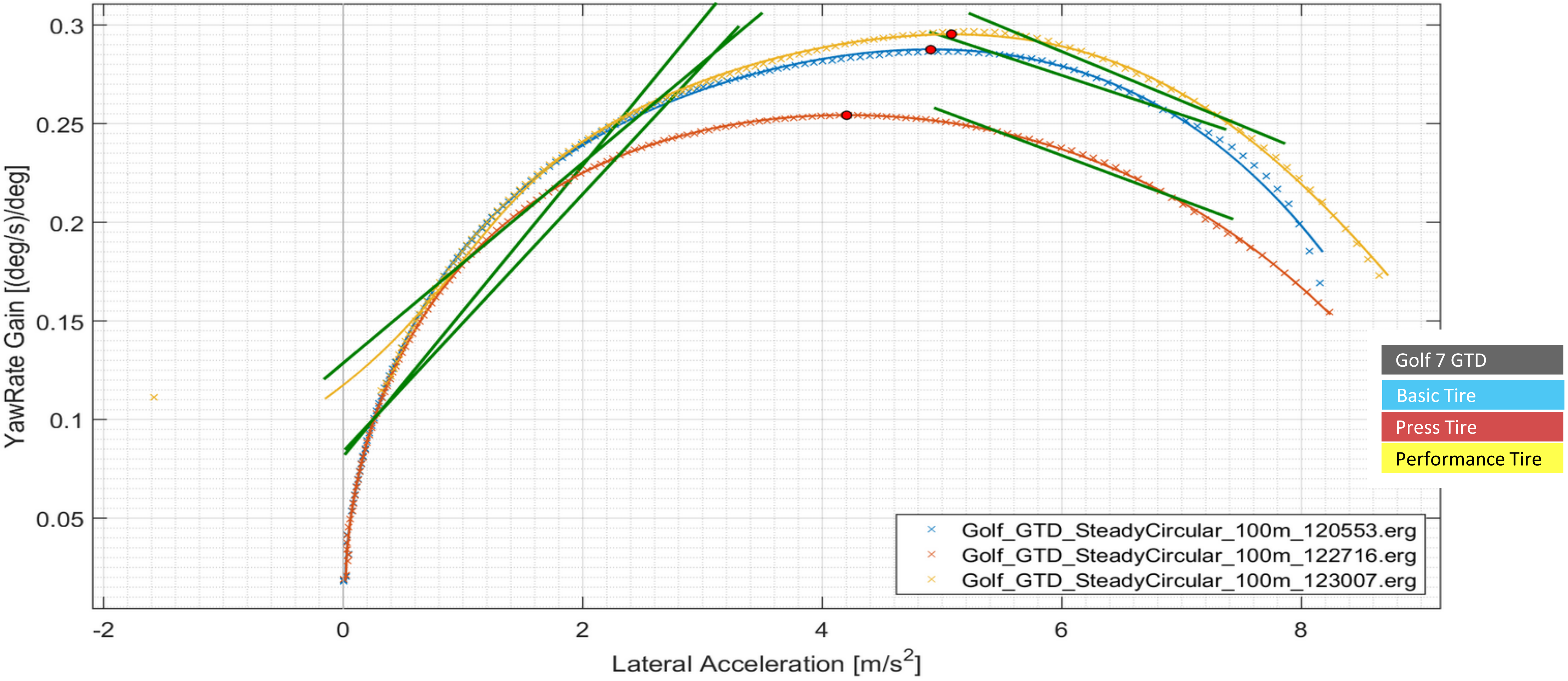
Note: Tire load are neglectable

Understeer behavior with wheel load distribution of 100 kg



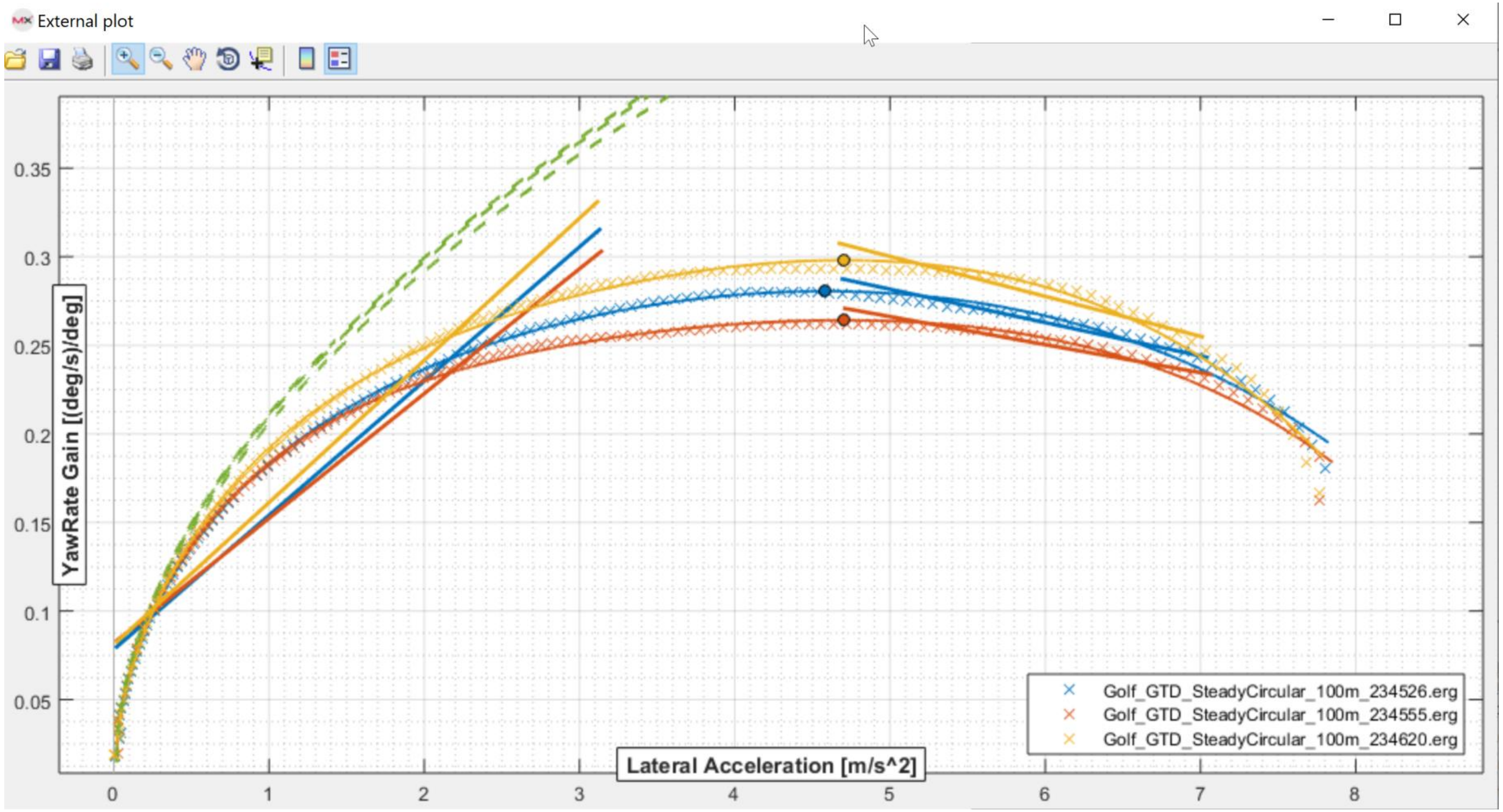
Golf 7 GTD
100 kg x=2000
100 kg x=4000
100 kg x=0

Typical evaluation criteria for yaw gain



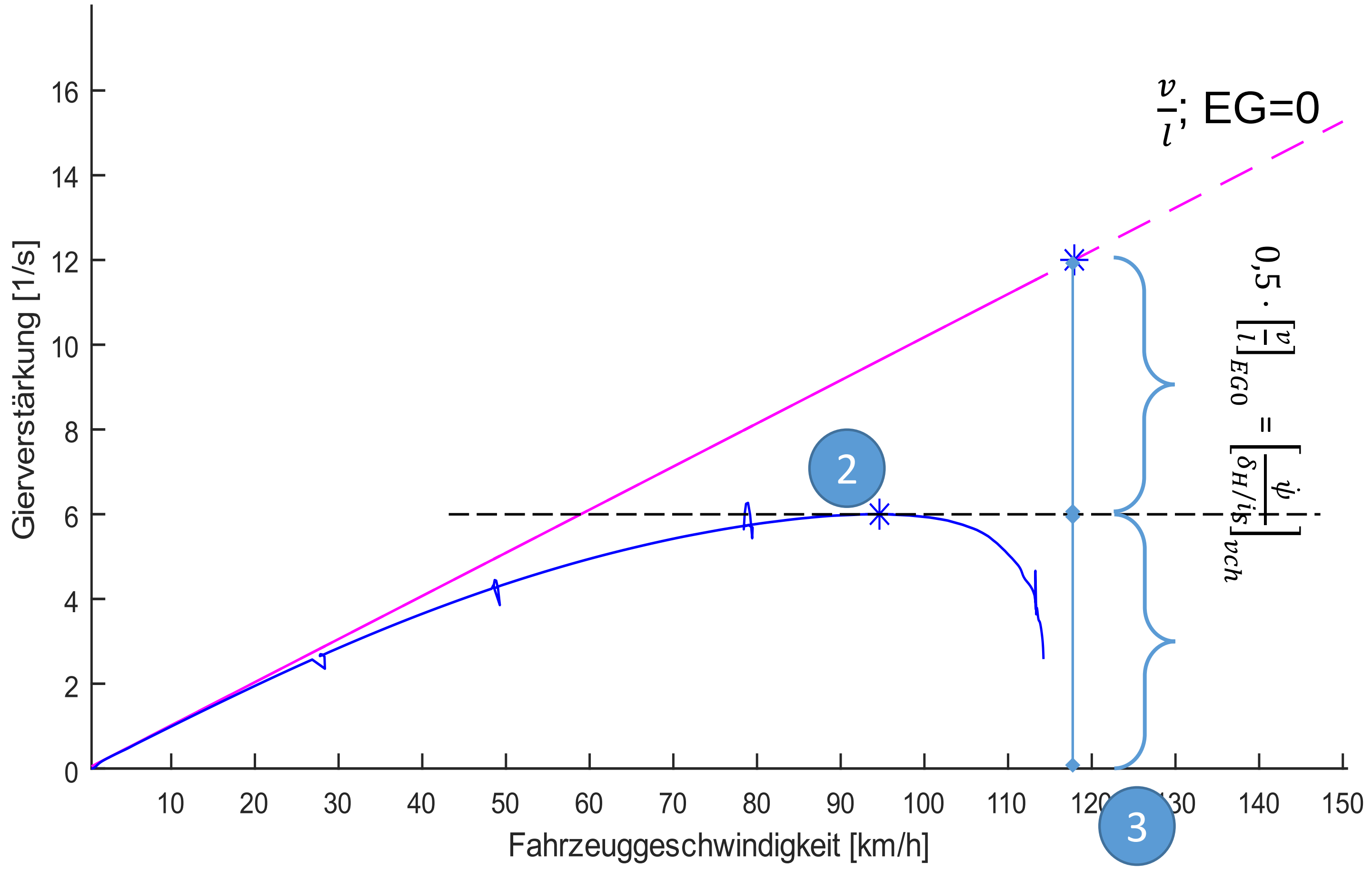
Vehicle Dynamics Attribute Evaluation

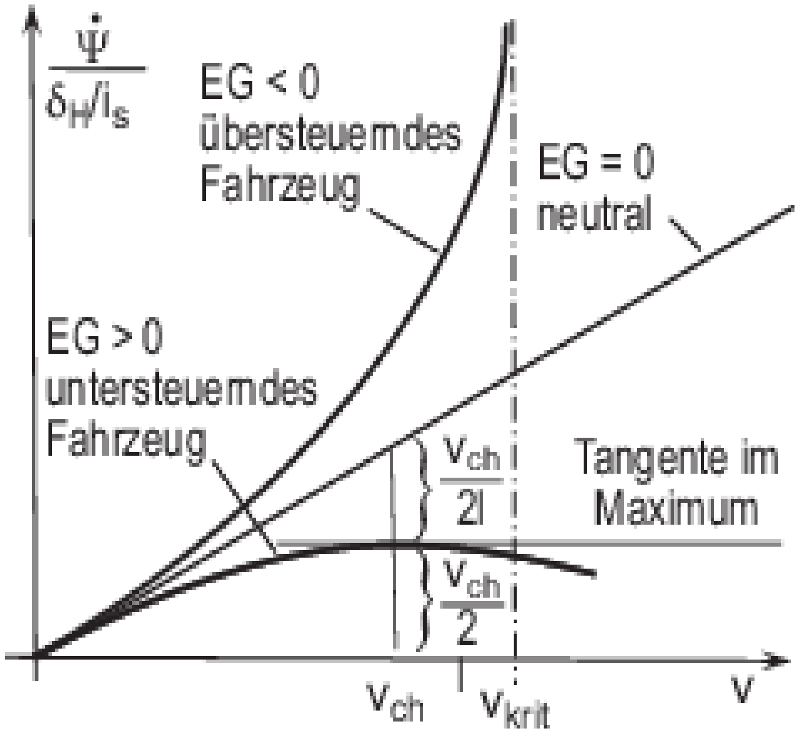
Typical evaluation criteria for yaw gain



Golf 7 GTD
100 kg x=2000
100 kg x=4000
100 kg x=0

Identification of Characteristic Speed



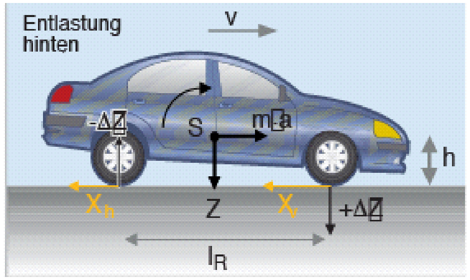


Combined tire characteristics: dynamic load distribution

GEWICHTSVERLAGERUNG IN LÄNGSRICHTUNG

Nehmen wir an, die Schwerpunkthöhe eines Fahrzeugs ist bekannt und die Reibungskraft X greift beim Bremsen an der Schnittstelle Reifen/Straße an.
Das entstehende Bremsmoment verursacht eine hohe **dynamische Achslastverschiebung** von hinten nach vorn, so dass kurzfristig vorne eine Überlast (+ΔZ), hinten eine Unterlast (-ΔZ) entsteht. So scheint die Vorderachse schwerer, die Hinterachse leichter als im ungebremsten Fall. Ohne ABS kann dies dazu führen, dass die entlasteten Hinterräder vor den Vorderrädern blockieren, was sich in punkto Fahrstabilität sehr ungünstig auswirken und zum Schleudern führen kann.

Bremskraftregler verhindern dieses instabile Überbremsen der Hinterräder und erfüllen so das Fahrstabilitätskriterium.

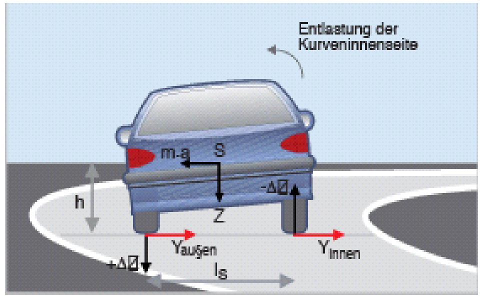


X = Längsreibungskraft vorne (X_v) und hinten (X_h), in N
S = Schwerpunkt des Fahrzeugs,
m = Masse des Fahrzeugs, in kg
a = Beschleunigung in Längsrichtung, in m/s²
Z = Gewichtskraft (= Summe der 4 Radlasten), in N
h = Schwerpunkthöhe über der Straße, in m
l_R = Radstand des Fahrzeugs, in m

GEWICHTSVERLAGERUNG ZUR SEITE

Nehmen wir an, die Schwerpunkthöhe eines Fahrzeugs ist bekannt und die seitliche Reibungskraft Y greift in der Kurve an den Schnittstellen Reifen/Straße an. Das entstehende **Rollmoment** verursacht eine **dynamische Achslastverschiebung** von der Kurvenaußen- auf die -innenseite, so dass fliehkraftbedingt innenseitig eine Überlast (+ΔZ), an der Außenseite eine Unterlast (-ΔZ) entsteht. Die Summe der unterschiedlichen vier Seitenkräfte fällt geringer aus als für den hypothetischen Fall gleichmäßiger Kraftverteilung.
Seitliche Gewichtsverlagerung führt somit zur Abnahme des Querhaftungspotenzials.

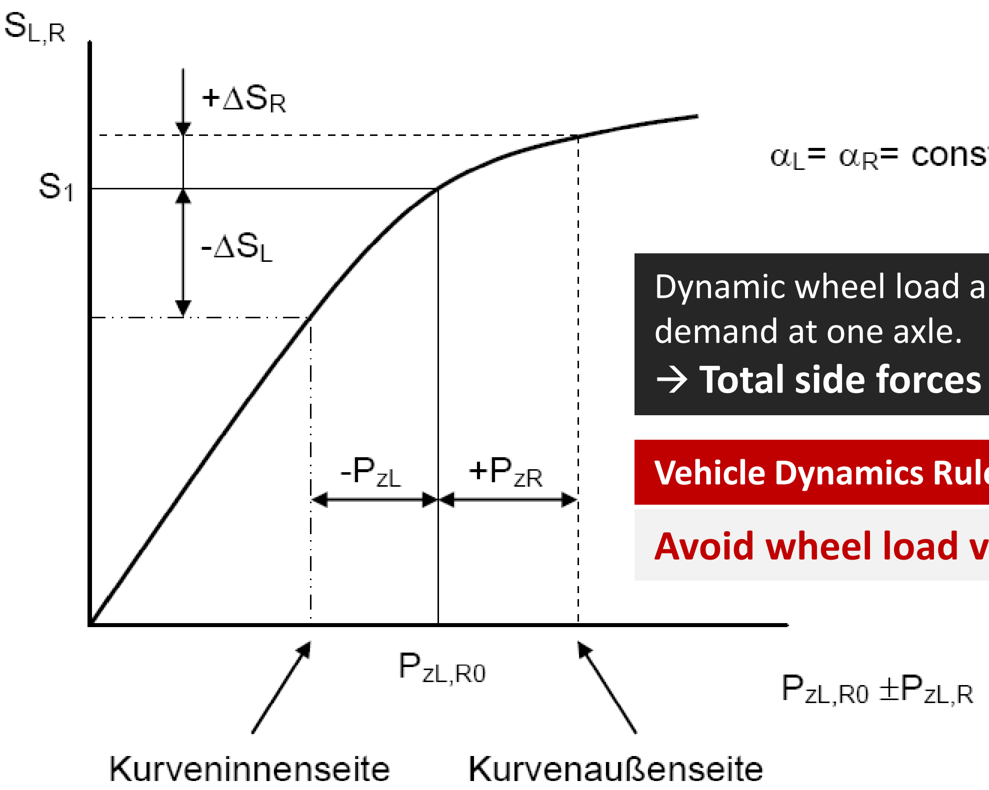
Um diesen unerwünschten Effekt zu reduzieren, kann der Konstrukteur z.B. die Spur verbreitern oder die Schwerpunkthöhe verringern.



Y = Quer-Reibungskraft vorne (Y_v) und hinten (Y_h), in N
S = Schwerpunkt des Fahrzeugs,
m = Masse des Fahrzeugs, in kg
a = Beschleunigung in Querrichtung, in m/s²
Z = Gewichtskraft (= Summe der 4 Radlasten), in N
h = Schwerpunkthöhe über der Straße, in m
l_S = Spurweite des Fahrzeugs, in m.

$$F_R \leq \mu * F_N$$

Coulombsche Friction Rule, **but μ for tire & road are strongly non-linear**



Dynamic wheel load and side force demand at one axle.
→ **Total side forces are reduced**

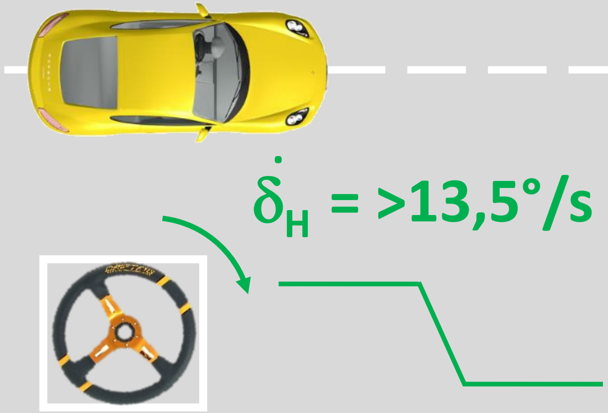
Vehicle Dynamics Rule No. 1:

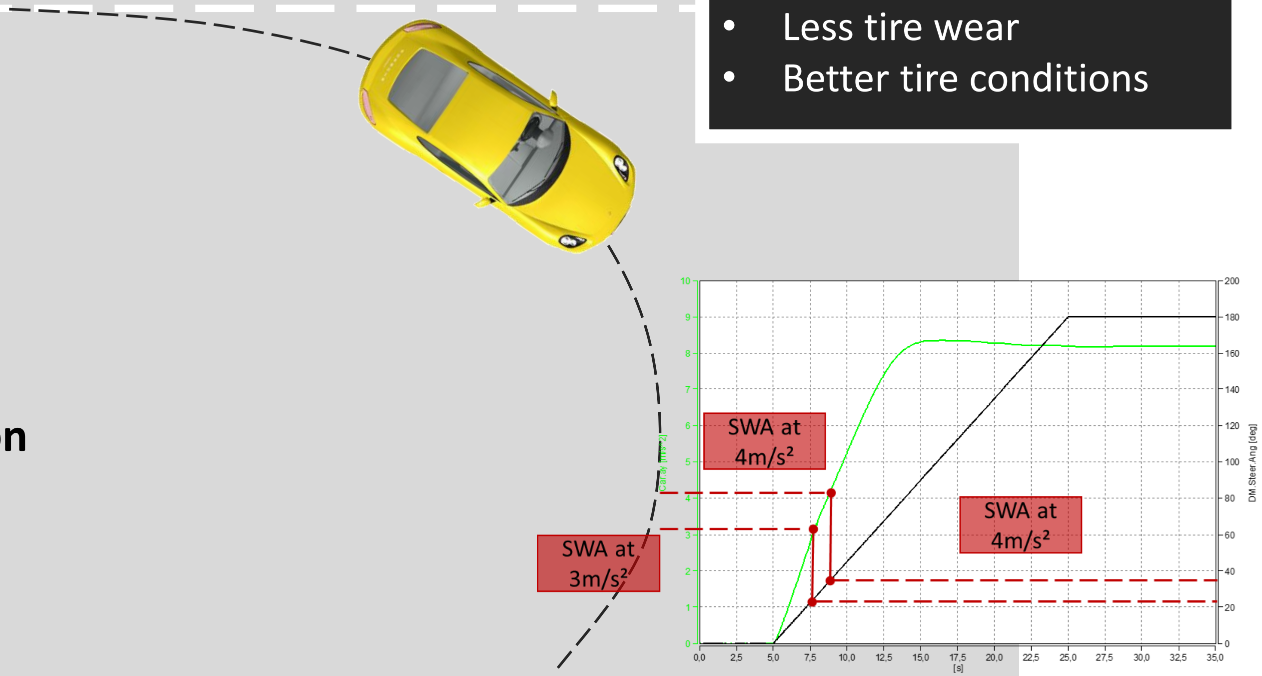
Avoid wheel load variation

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

V = 100 km/h

$\dot{\delta}_H$ = >13,5°/s



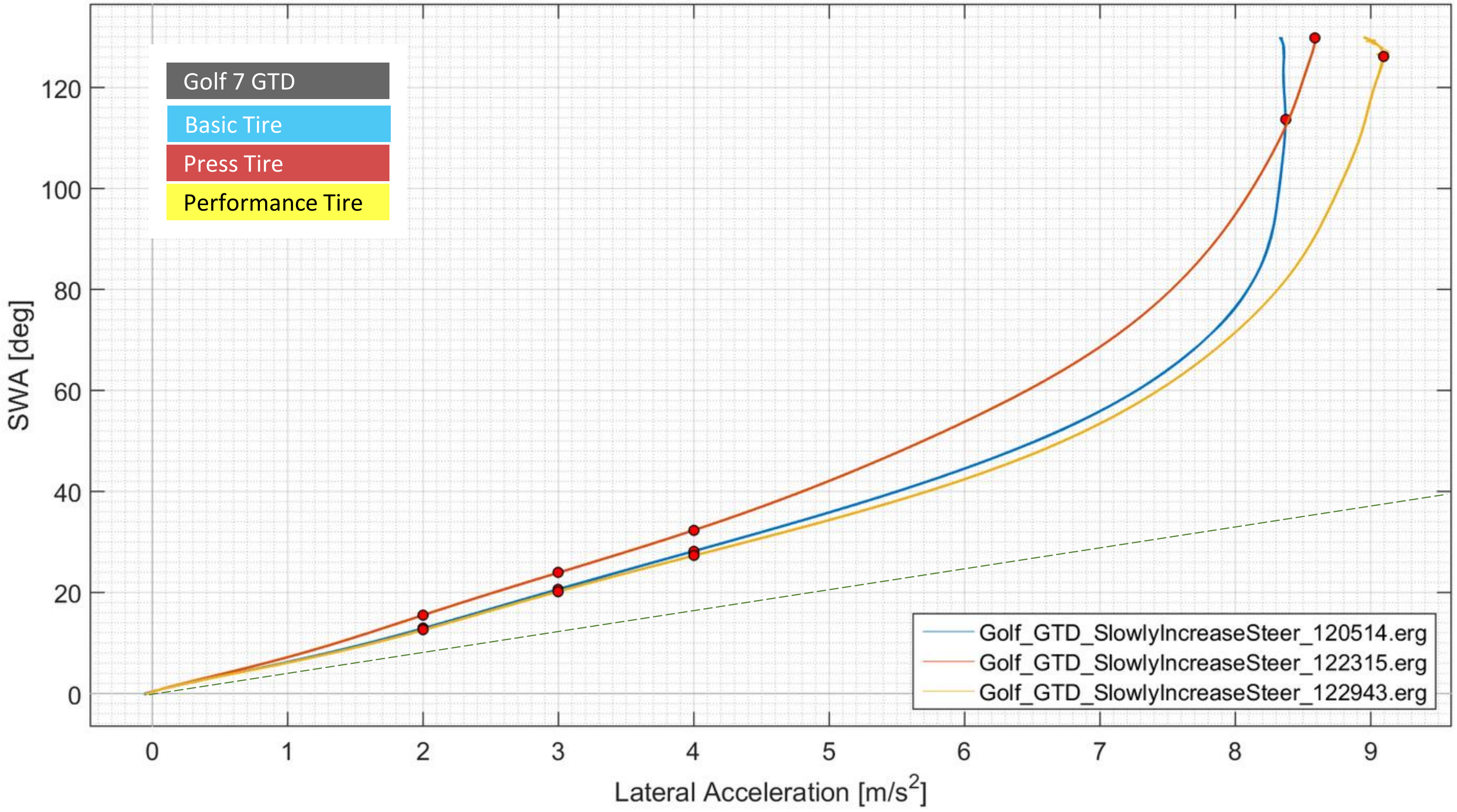


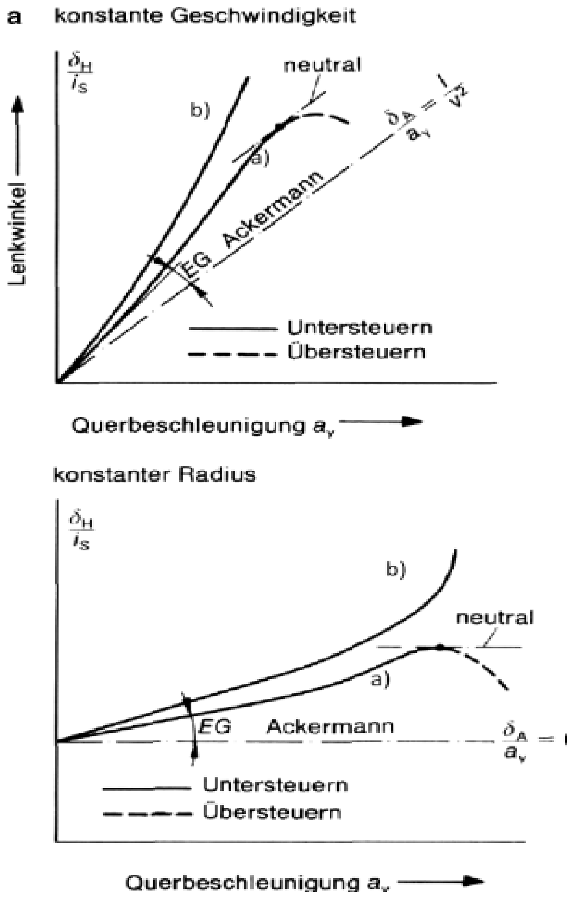
Advantages:
- Smaller test track size
- Less time consumption
- Less tire wear
- Better tire conditions

SWA at 4m/s² used for steering angle identification
- Step steer (4m/s²)
- Sine steer (4m/s²)
- Sine with Dwell (3m/s²)
- …

Vehicle Dynamics Attribute Evaluation

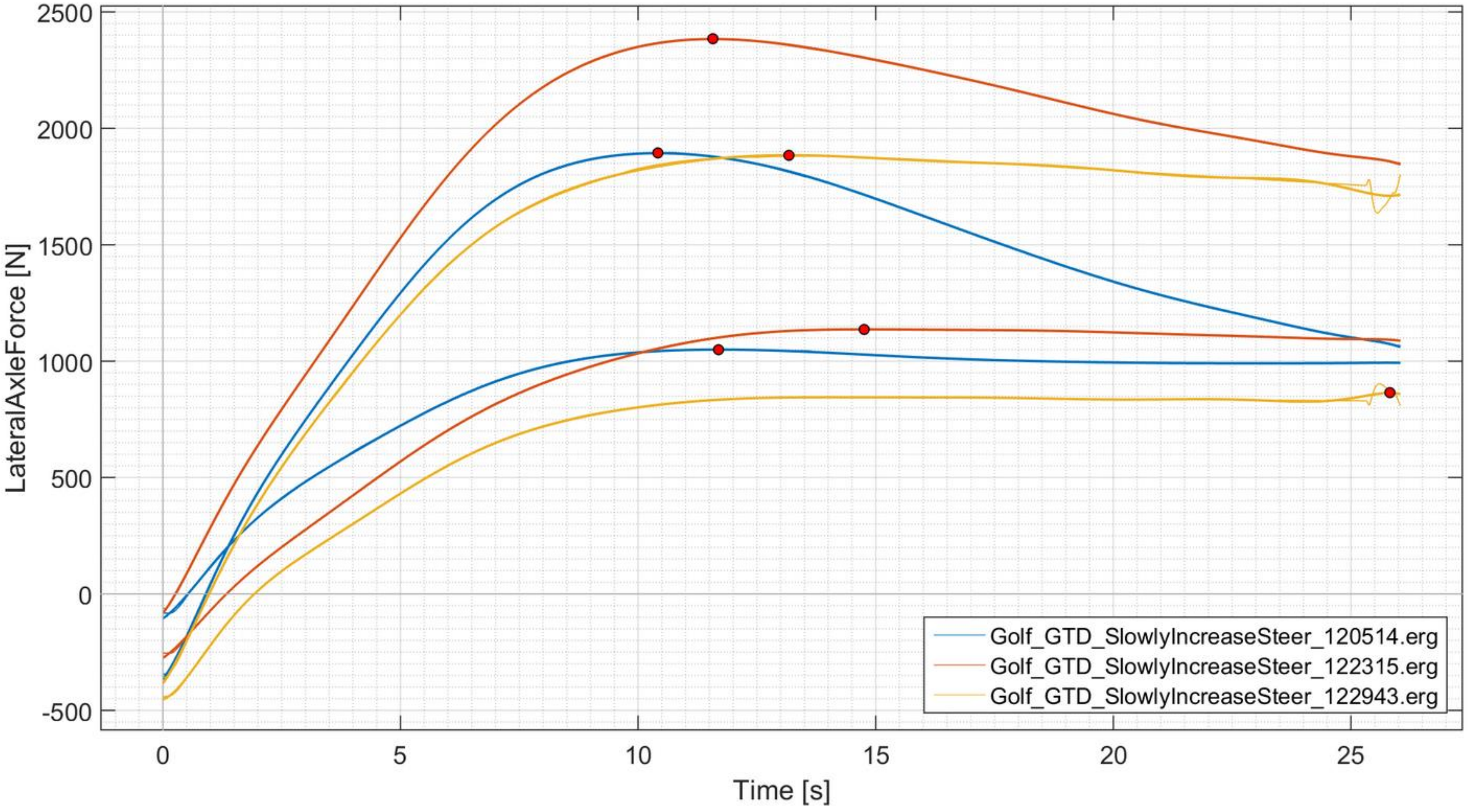
Option: Slowly increase steer test (SIS) and an identifying maneuver





Vehicle Dynamics Attribute Evaluation

Lateral forces front left & right and rear left & right



Golf 7 GTD

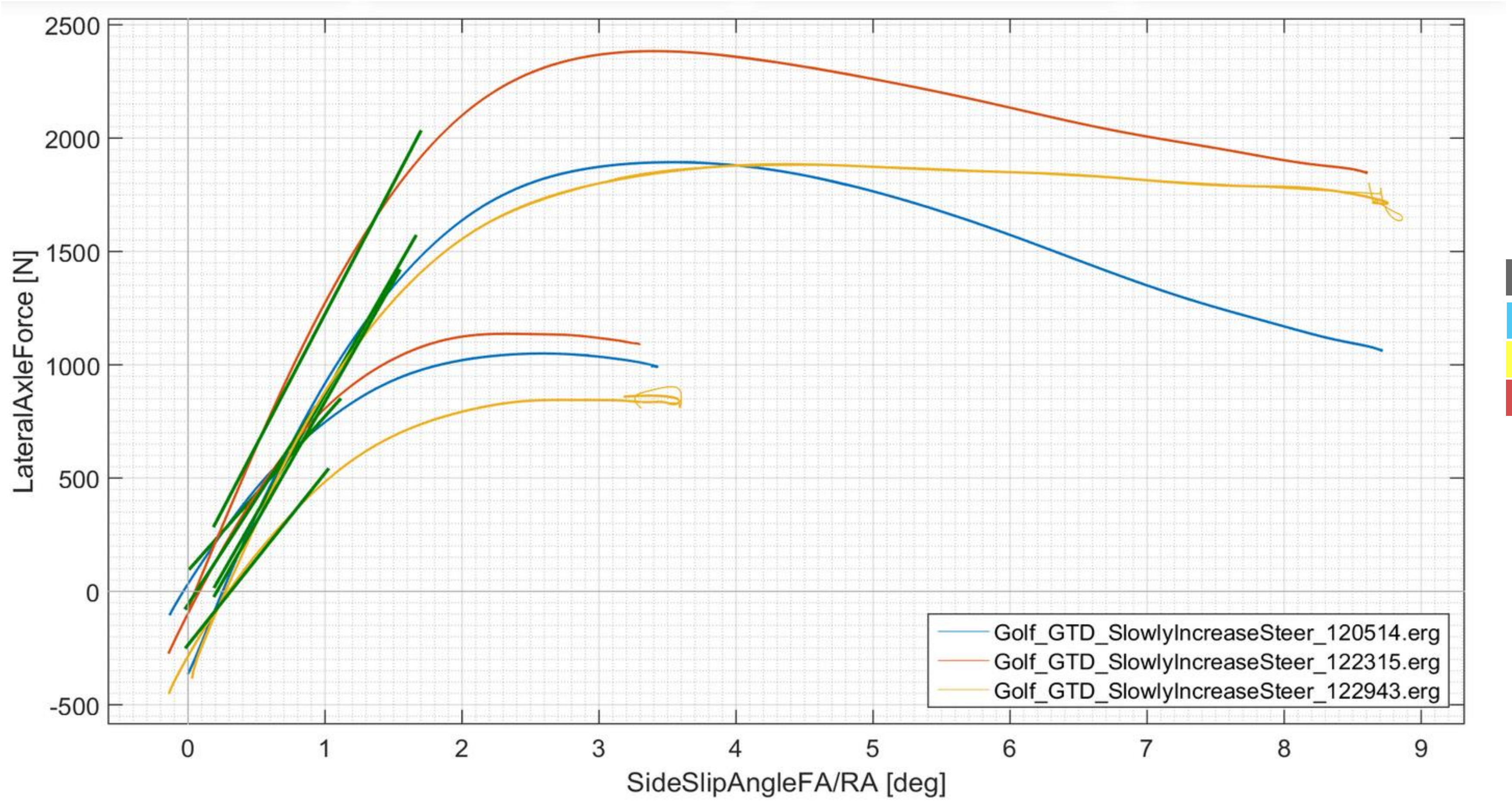
Basic Tire

Press Tire

Performance Tire

Vehicle Dynamics Attribute Evaluation

Lateral axle forces front & rear with side slip stiffness



Golf 7 GTD
Basic Tire
Press Tire
Performance Tire

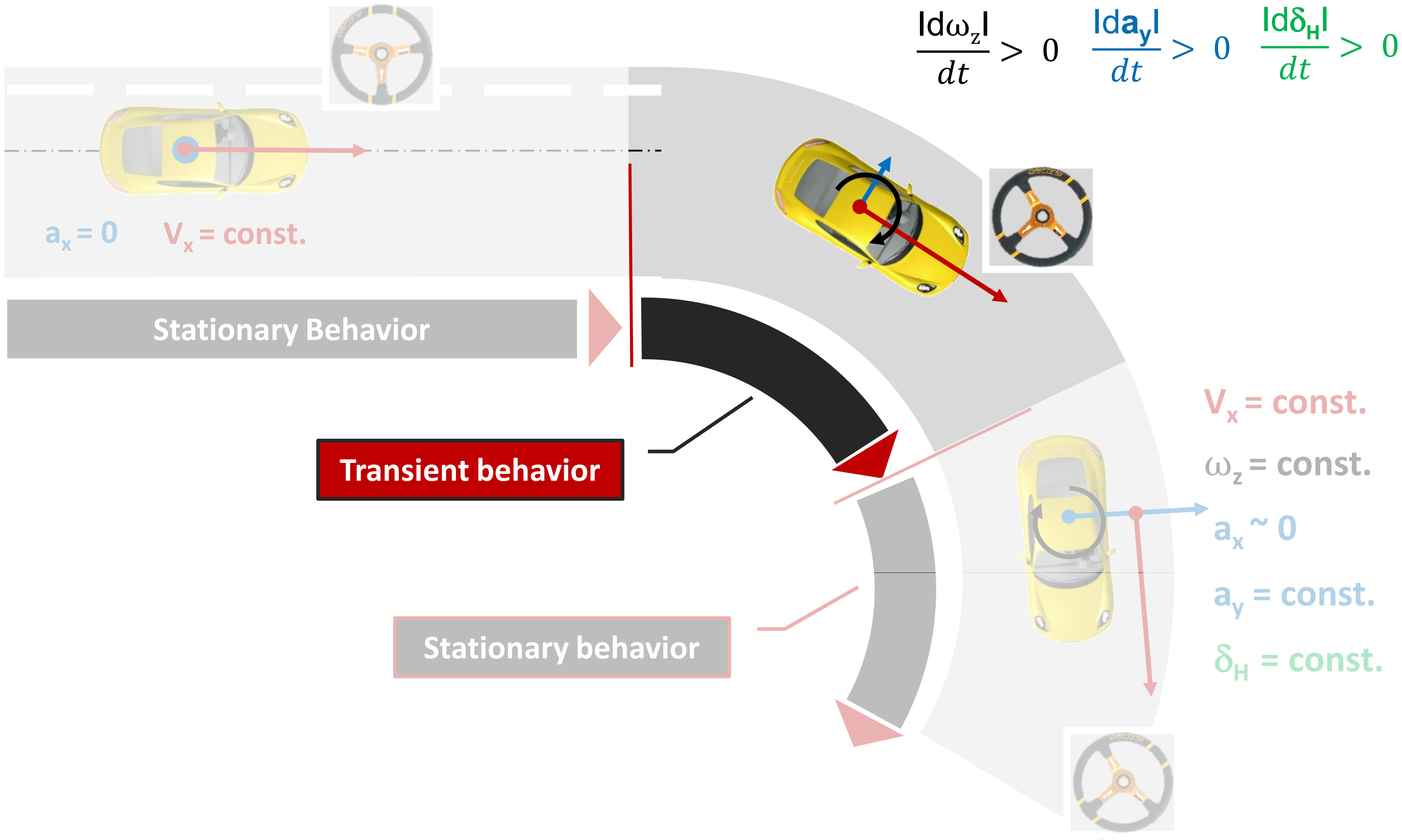
Vehicle Dynamics Attribute Evaluation

KPI – Summery Slowly increase steer test

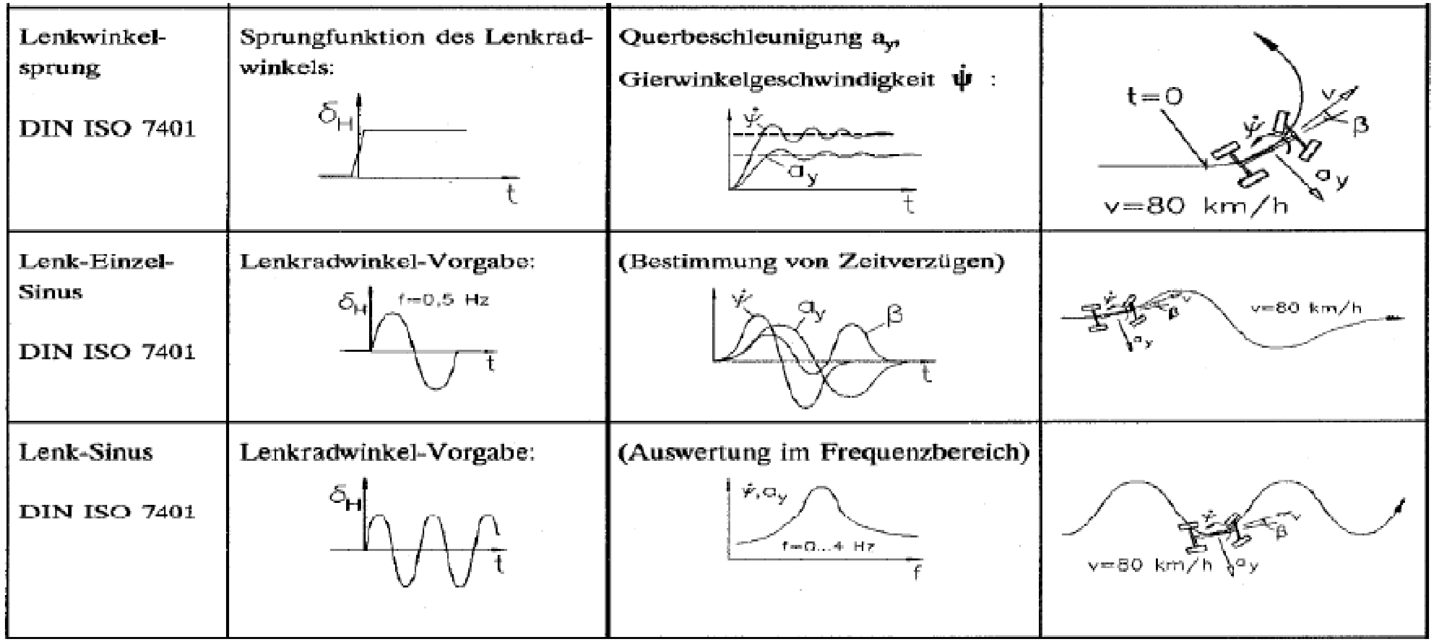
Basic Tire | Press Tire | Performance Tire

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
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

Lateral Dynamics: Transient behavior



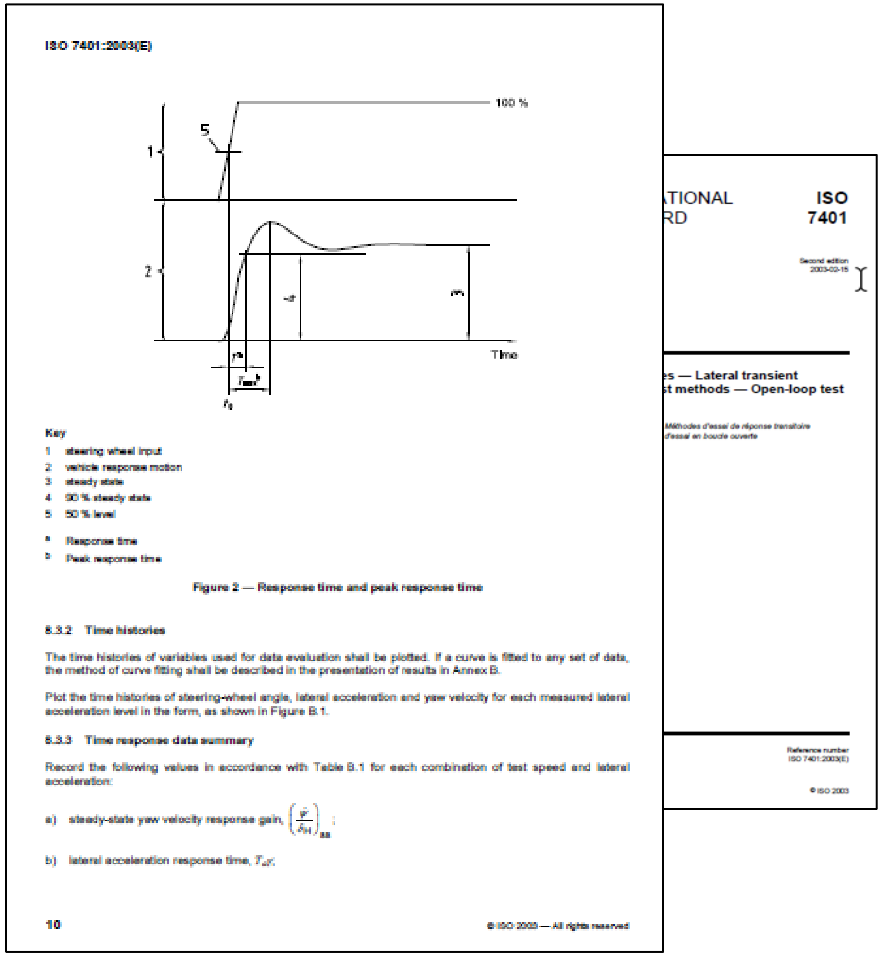
Lateral response tests to evaluate transient behavior



Lenkwinkel-sprung DIN ISO 7401	Sprungfunktion des Lenkrad-winkels:	Querbeschleunigung a_y, Gierwinkelgeschwindigkeit $\dot{\psi}$:	t=0 v=80 km/h
Lenk-Einzel-Sinus DIN ISO 7401	Lenkradwinkel-Vorgabe:	(Bestimmung von Zeitverzügen)	v=80 km/h
Lenk-Sinus DIN ISO 7401	Lenkradwinkel-Vorgabe:	(Auswertung im Frequenzbereich)	v=80 km/h

Time Domain:
- Step Steer
- Sinus Steer (one cycle)

Frequency Domain:
- Step Steer
- Stochastic Steer Input
- Triangle Impulse
- Sine Steer (continuous cycles, sweep)



ISO 7401:2003(E)

Key
1 steering wheel input
2 vehicle response motion
3 steady state
4 90 % steady state
5 50 % level

a Response time
b Peak response time

Figure 2 — Response time and peak response time

8.3.2 Time histories

The time histories of variables used for data evaluation shall be plotted. If a curve is fitted to any set of data, the method of curve fitting shall be described in the presentation of results in Annex B.

Plot the time histories of steering-wheel angle, lateral acceleration and yaw velocity for each measured lateral acceleration level in the form, as shown in Figure B.1.

8.3.3 Time response data summary

Record the following values in accordance with Table B.1 for each combination of test speed and lateral acceleration:

a) steady-state yaw velocity response gain, $\left(\frac{\dot{\psi}}{\delta_H}\right)_{ss}$;

b) lateral acceleration response time, T_{aY};

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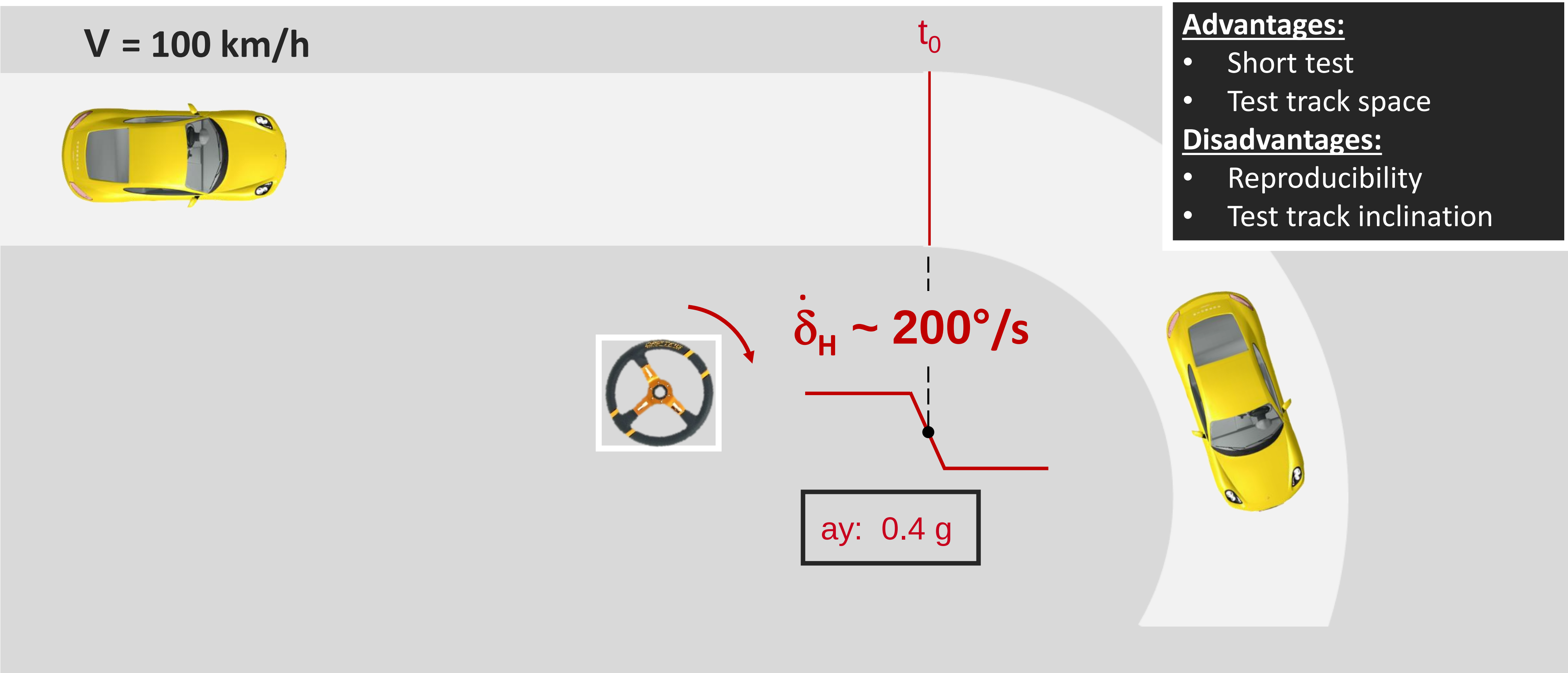
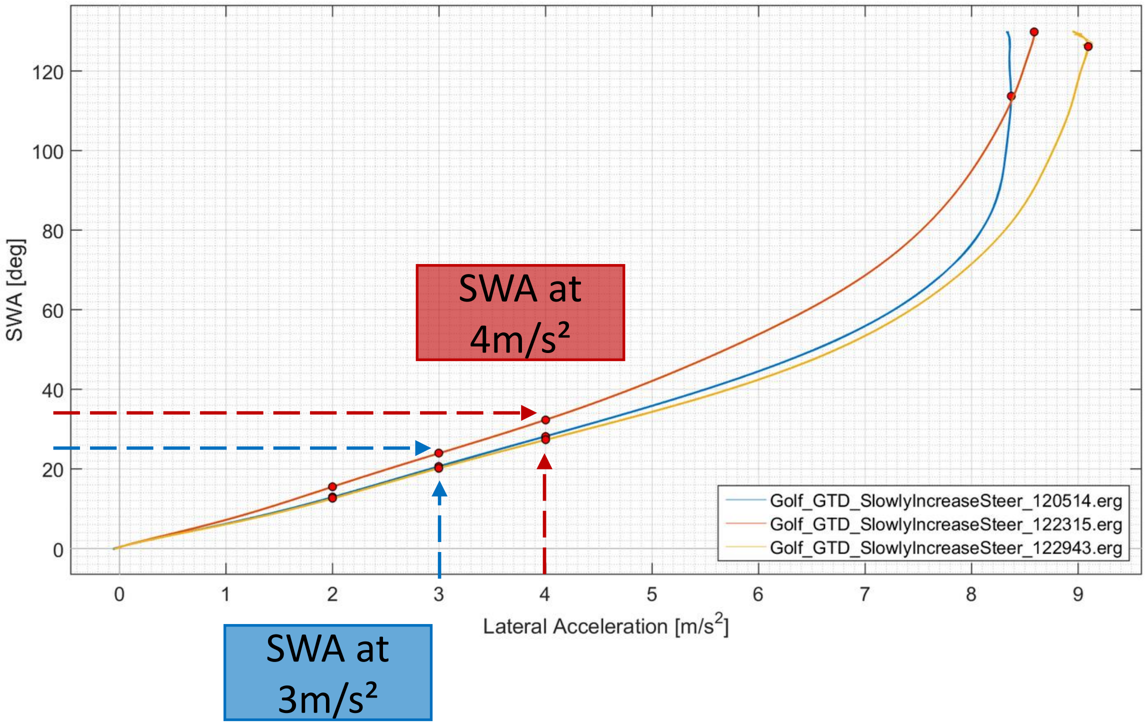
Lateral response tests to evaluate transient behavior with “Step Steer”



Advantages:
- Short test
- Test track space

Disadvantages:
- Reproducibility
- Test track inclination

Slowly increase steer test (SIS) an option for steady state circular driving and identify maneuver parameter



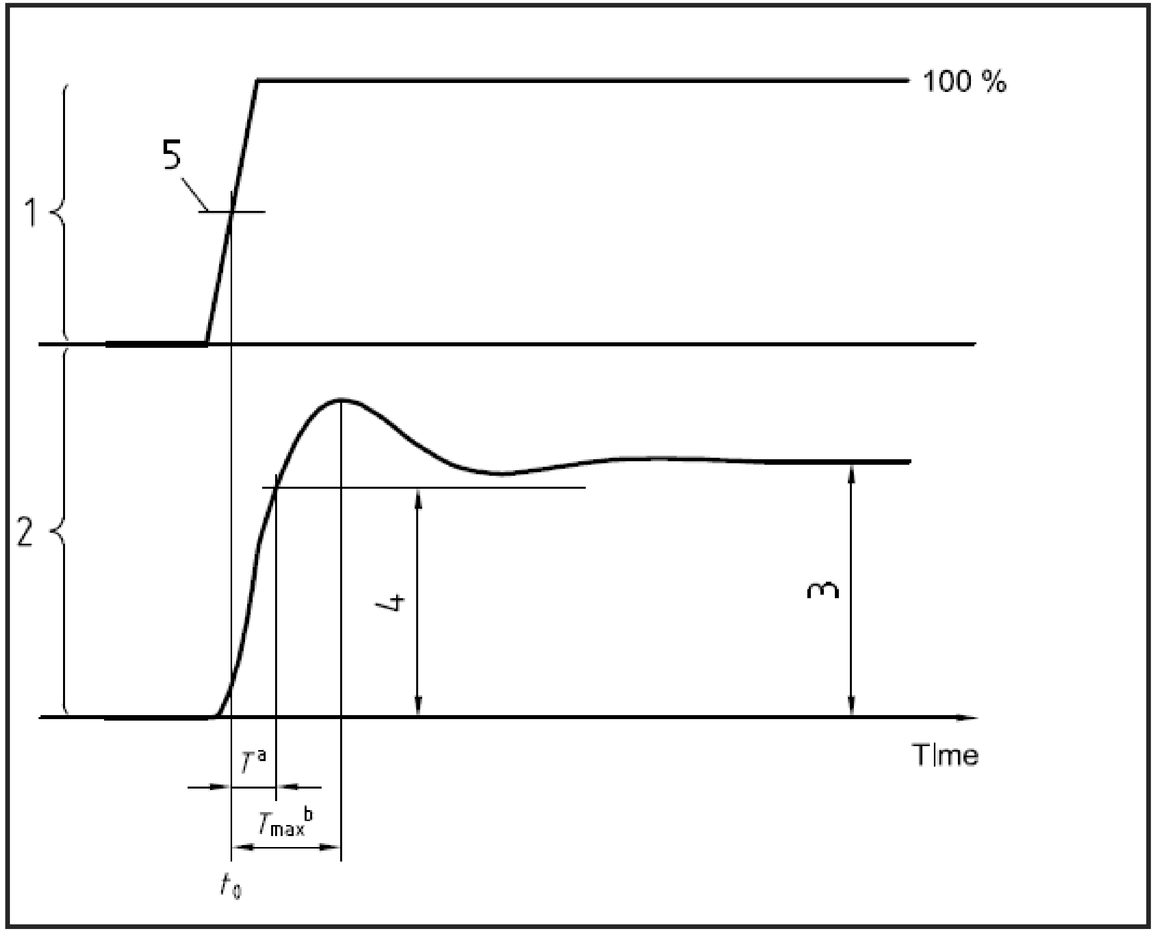
V= 80/100 kph constant SWA Gradient < 13,5°/s

SWA at 4m/s² used for steering angle identification

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

Vehicle Dynamics Attribute Evaluation

Lateral response tests to evaluate transient behavior – ISO 7401



Parameter	Symbol	Unit	Left turn	Right turn	Average
Steady-state yaw velocity response gain	$\left(\frac{\dot{\psi}}{\delta_H}\right)_{ss}$	s^{-1}			
Lateral acceleration response time	T_{aY}	s			
Yaw velocity response time	$T_{\dot{\psi}}$	s			
Lateral acceleration peak response time	$T_{aY,max}$	s			
Yaw velocity peak response time	$T_{\dot{\psi},max}$	s			
Overshoot value of lateral acceleration	U_{aY}	—			
Overshoot value of yaw velocity	$U_{\dot{\psi}}$	—			

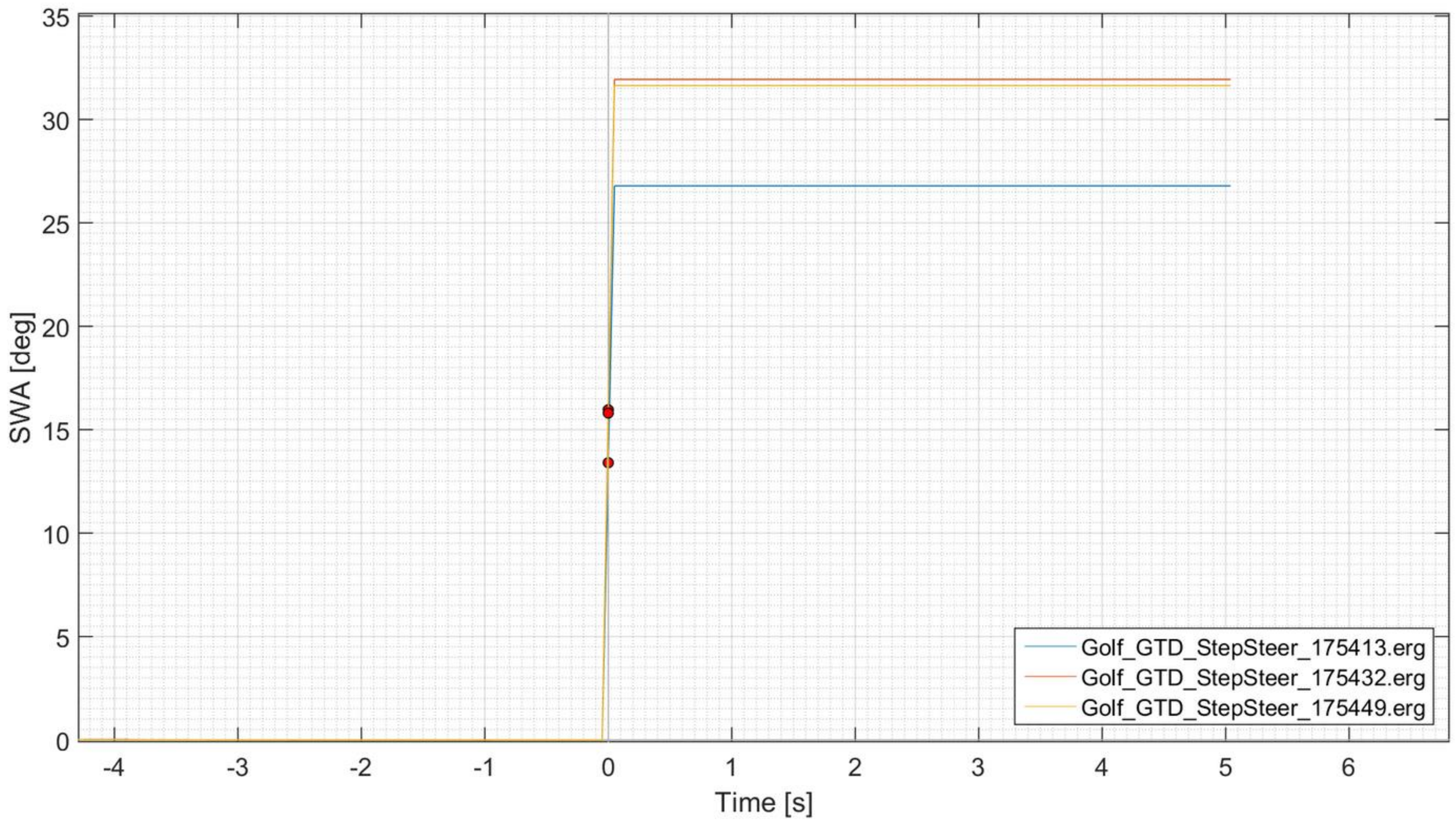
Key

1. steering wheel input
2. vehicle response motion
3. steady state
4. 90 % steady state
5. 50 % level

A. Response time
B. Peak response time

Vehicle Dynamics Attribute Evaluation

Lateral response tests to evaluate transient behavior



Golf 7 GTD

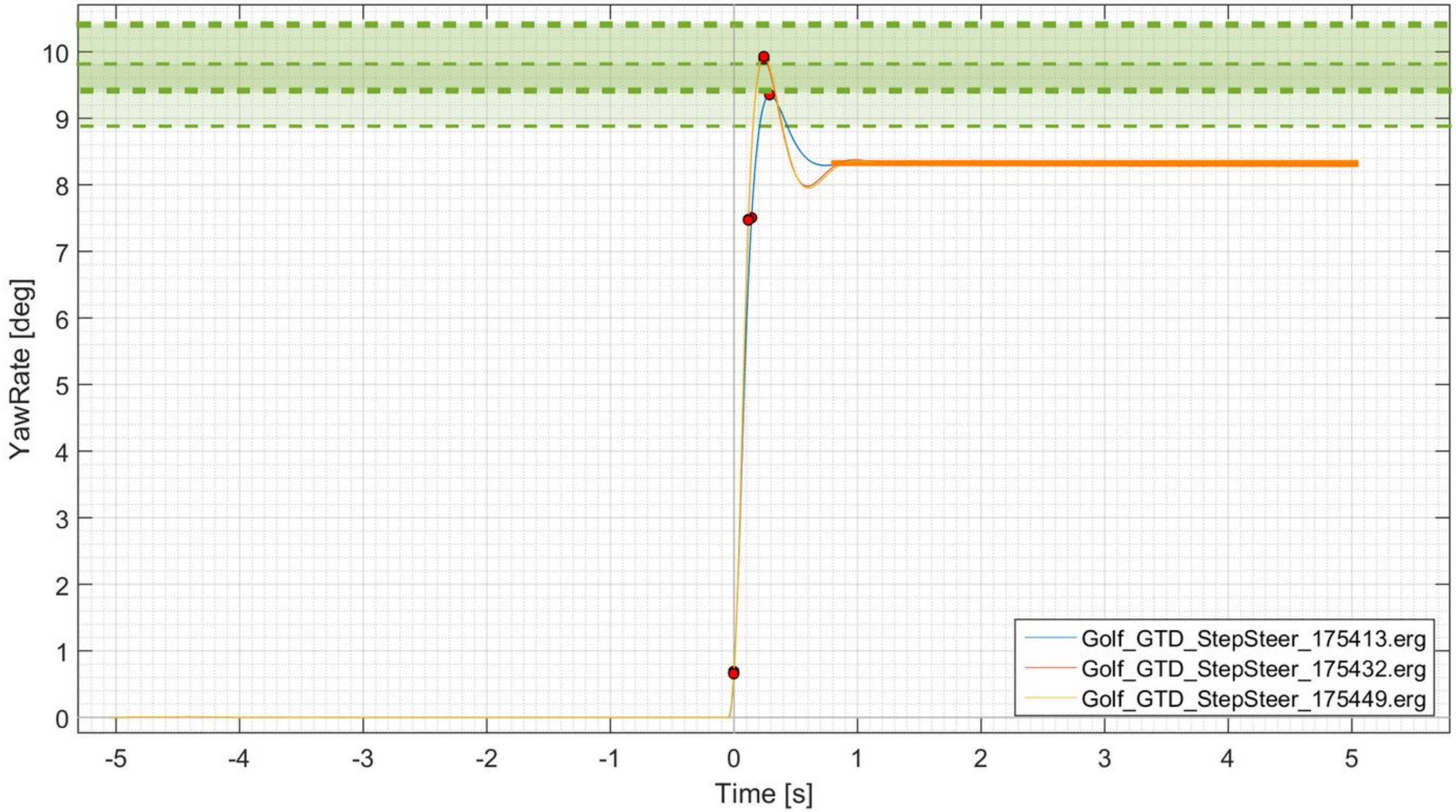
Basic Tire

Press Tire

Performance Tire

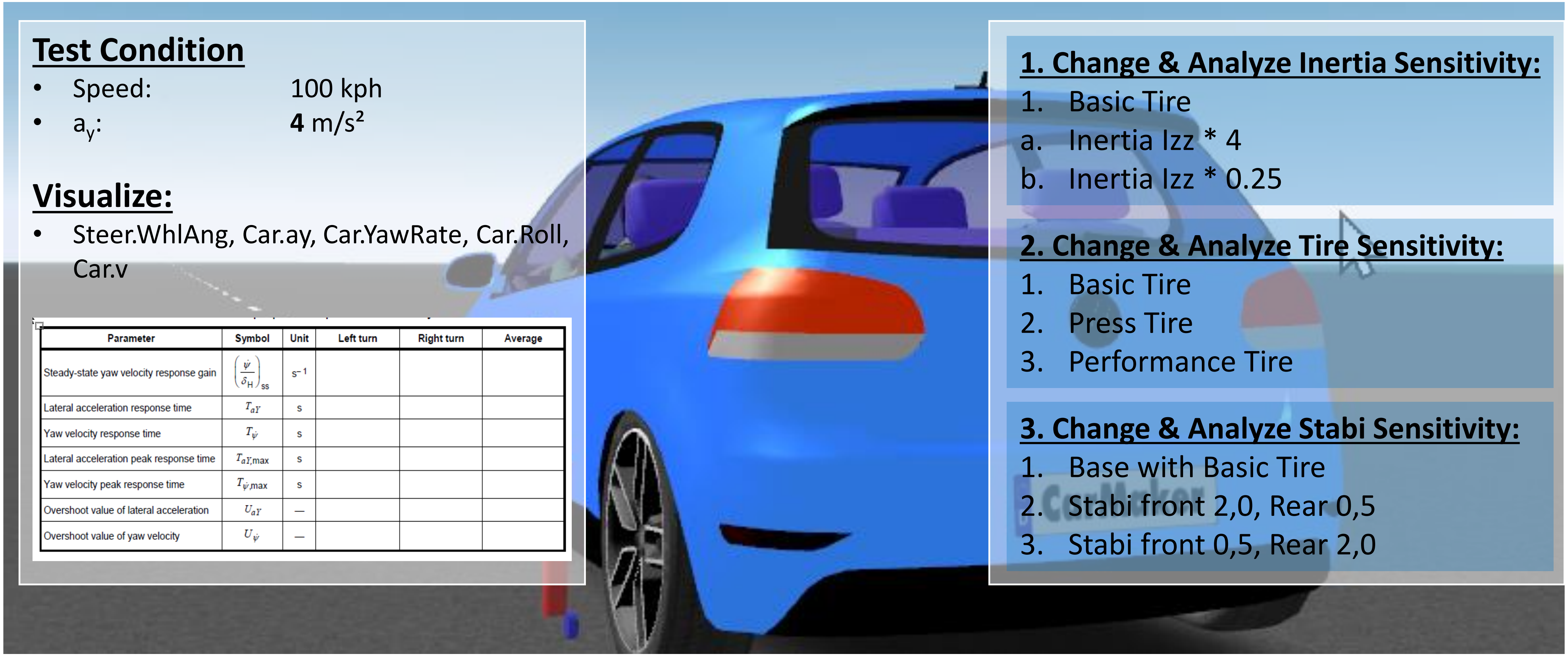
Vehicle Dynamics Attribute Evaluation

Lateral response tests to evaluate transient behavior



Golf 7 GTD
Basic Tire
Press Tire
Performance Tire

Exercise 7: Lateral response behavior



Test Condition

- Speed: 100 kph
- a_y: **4** m/s²

Visualize:

- Steer.WhlAng, Car.ay, Car.YawRate, Car.Roll, Car.v

Parameter	Symbol	Unit	Left turn	Right turn	Average
Steady-state yaw velocity response gain	$\left(\frac{\dot{\psi}}{\delta_H}\right)_{ss}$	s^{-1}			
Lateral acceleration response time	T_{aY}	s			
Yaw velocity response time	$T_{\dot{\psi}}$	s			
Lateral acceleration peak response time	$T_{aY,max}$	s			
Yaw velocity peak response time	$T_{\dot{\psi},max}$	s			
Overshoot value of lateral acceleration	U_{aY}	—			
Overshoot value of yaw velocity	$U_{\dot{\psi}}$	—			

1. Change & Analyze Inertia Sensitivity:

1. Basic Tire

a. Inertia Izz * 4

b. Inertia Izz * 0.25

2. Change & Analyze Tire Sensitivity:

1. Basic Tire
2. Press Tire
3. Performance Tire

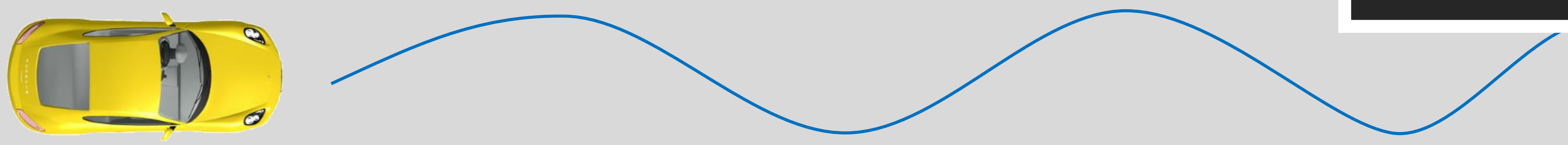
3. Change & Analyze Stabi Sensitivity:

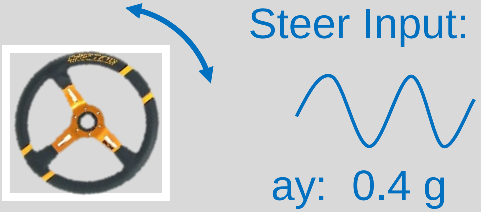
1. Base with Basic Tire
2. Stabi front 2,0, Rear 0,5
3. Stabi front 0,5, Rear 2,0

Frequency response test (Sine Sweep) to evaluate transient behavior

V = 100 km/h

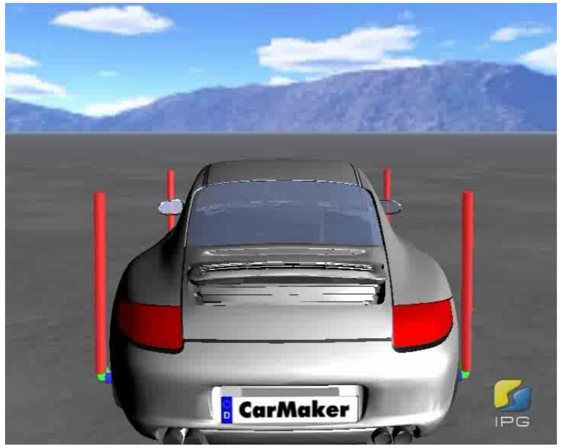
Issues:
- Test track space
- Vehicle Drift
- Test track inclination





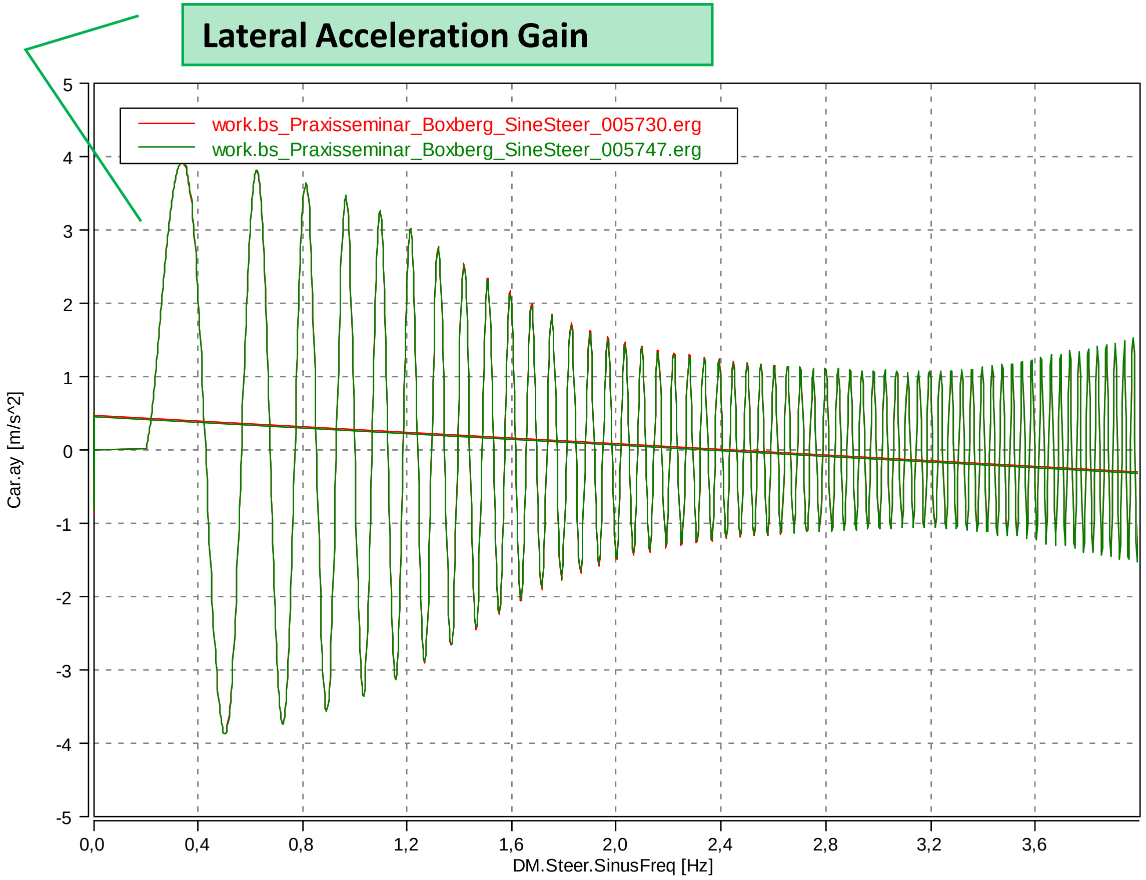
Steer Input: Sine 0.2 – 4 Hz

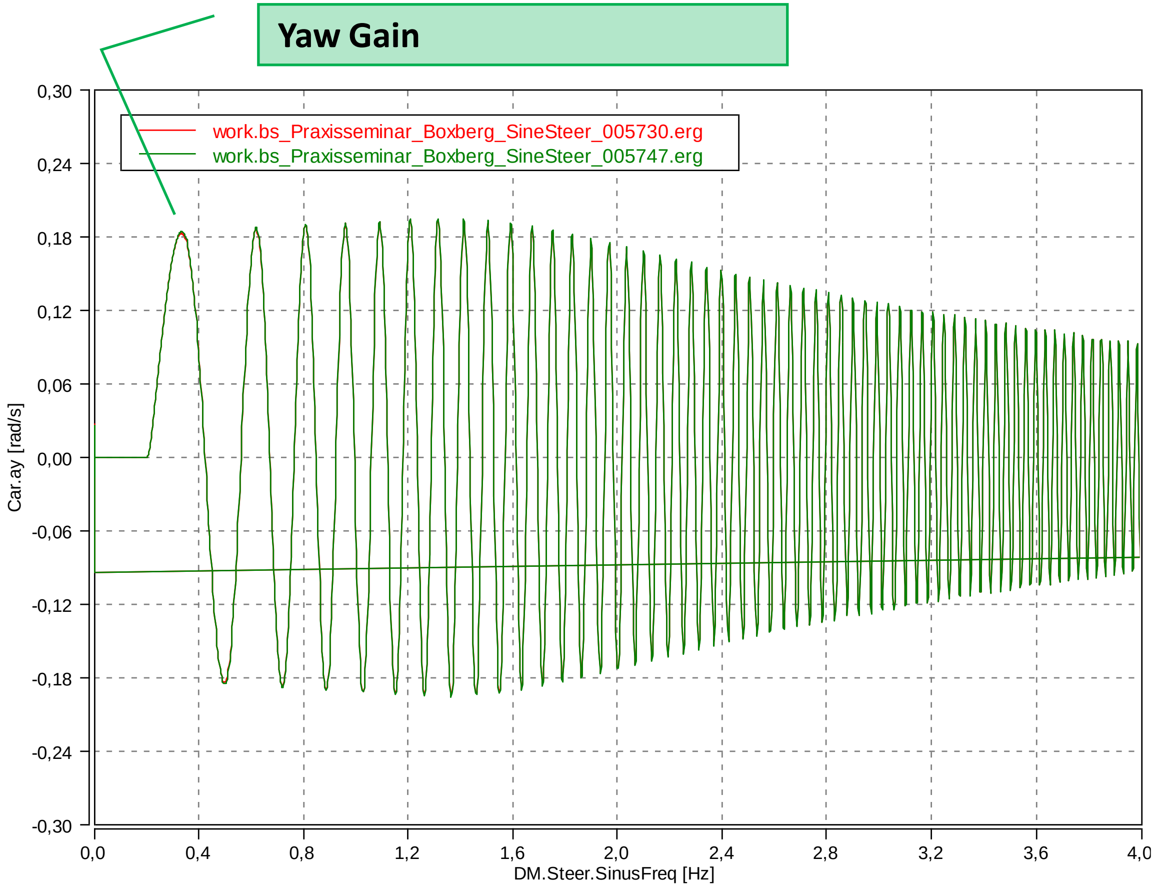
ay: 0.4 g



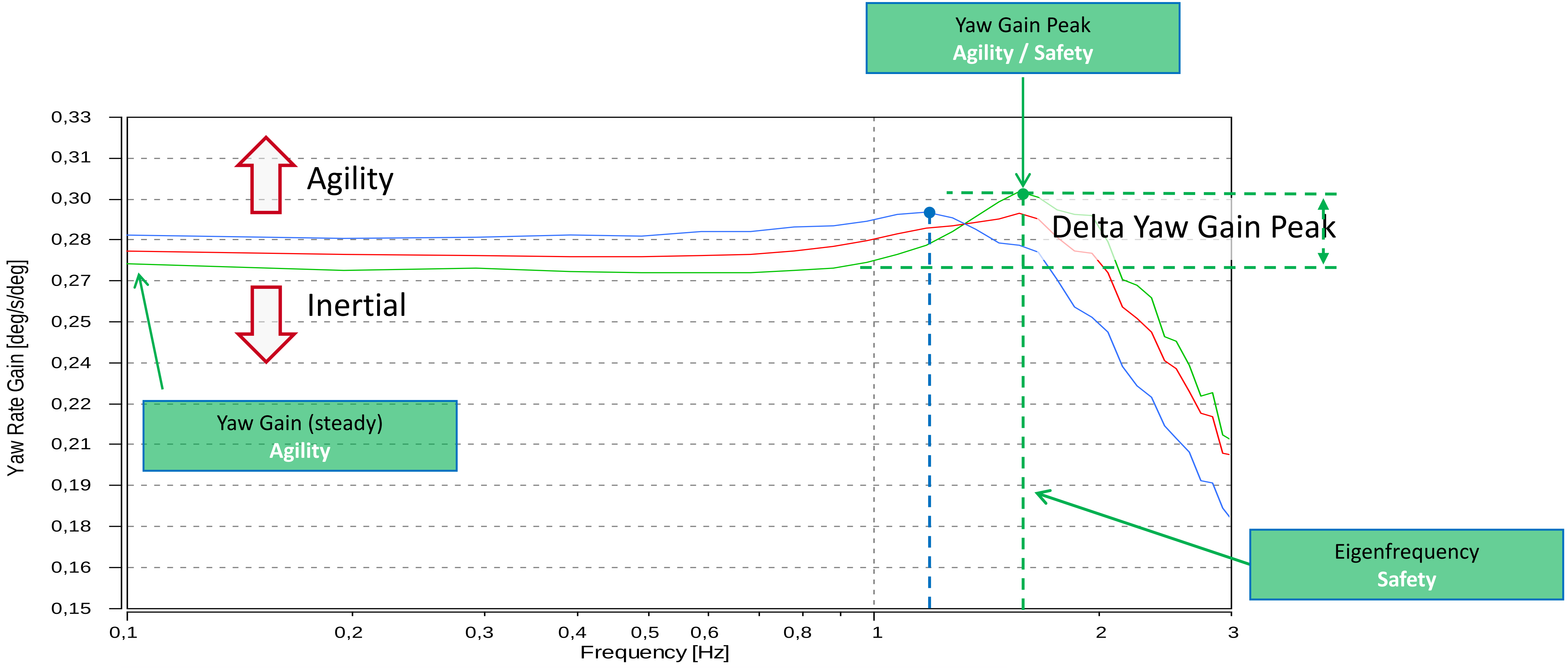

SR60 Torus Steering Robot
Swept sine

Frequency response test to evaluate transient behavior

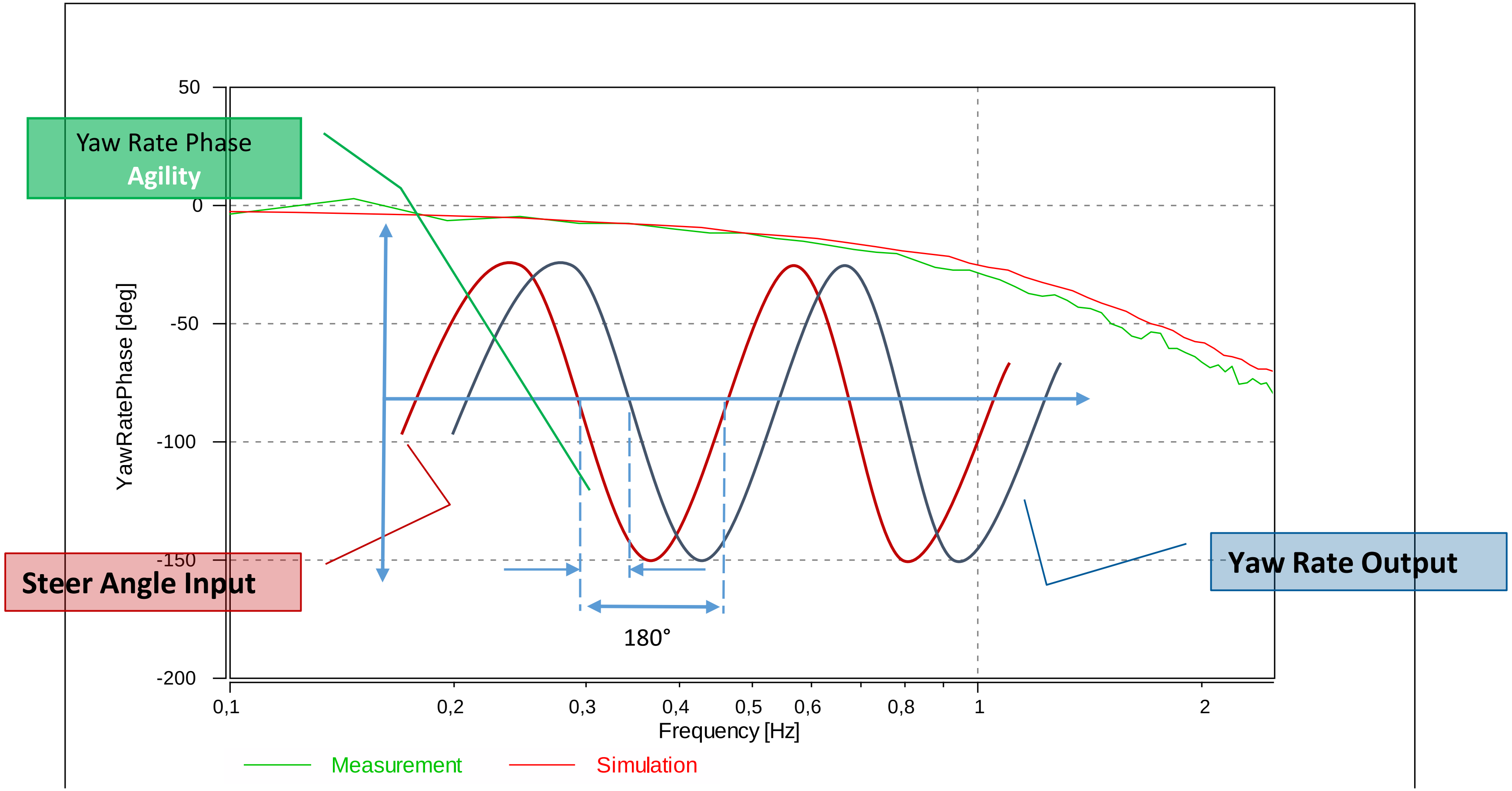




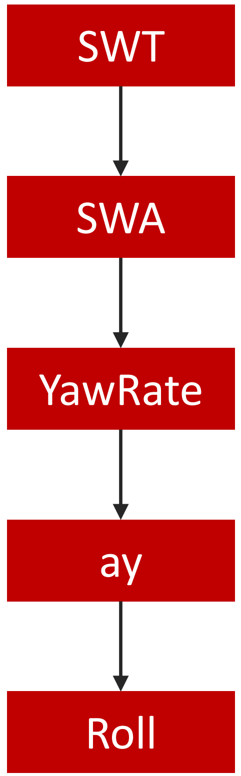
Bode Diagram: Amplitude Gain



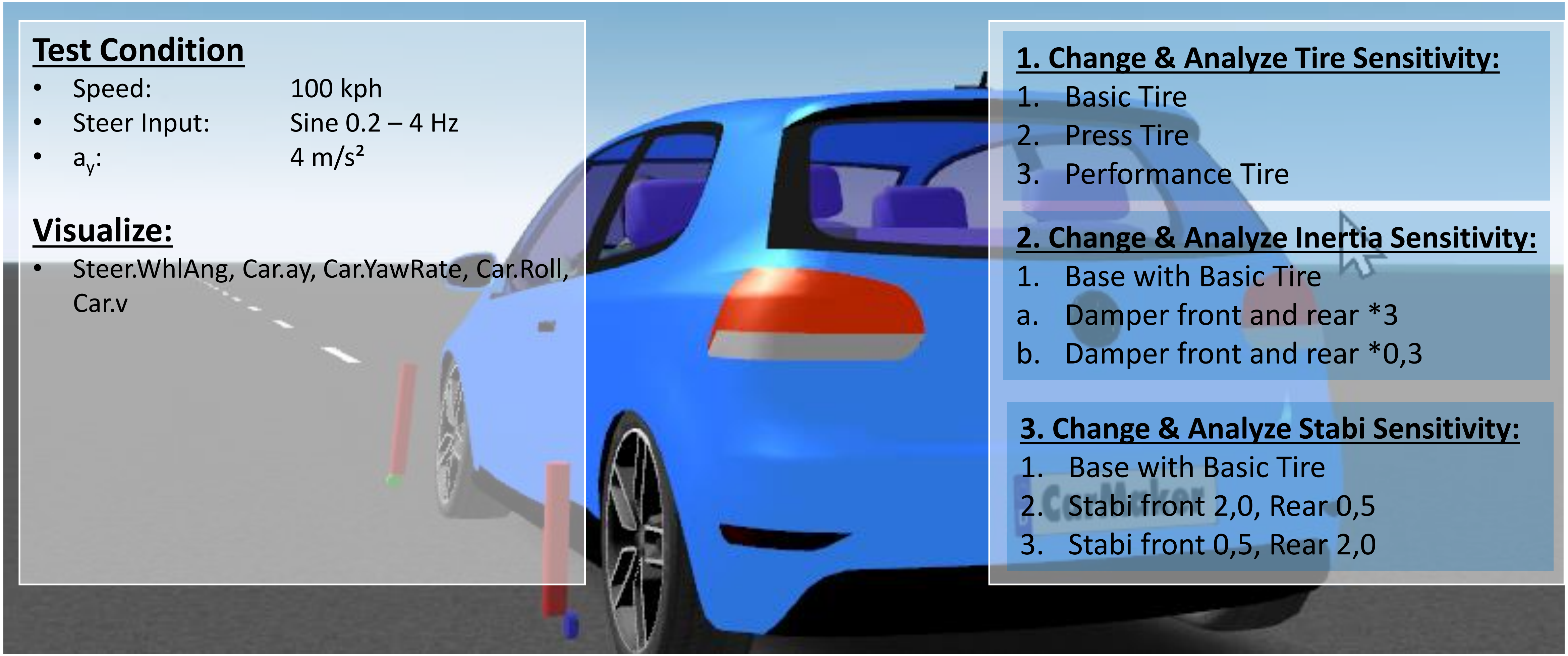
Bode Diagram: Yaw Rate Phase



Cause &Effect Chain



Exercise 9: Frequency response behavior



Test Condition

- Speed: 100 kph
- Steer Input: Sine 0.2 – 4 Hz
- a_y: 4 m/s²

Visualize:

- Steer.WhlAng, Car.ay, Car.YawRate, Car.Roll, Car.v

1. Change & Analyze Tire Sensitivity:

1. Basic Tire
2. Press Tire
3. Performance Tire

2. Change & Analyze Inertia Sensitivity:

1. Base with Basic Tire

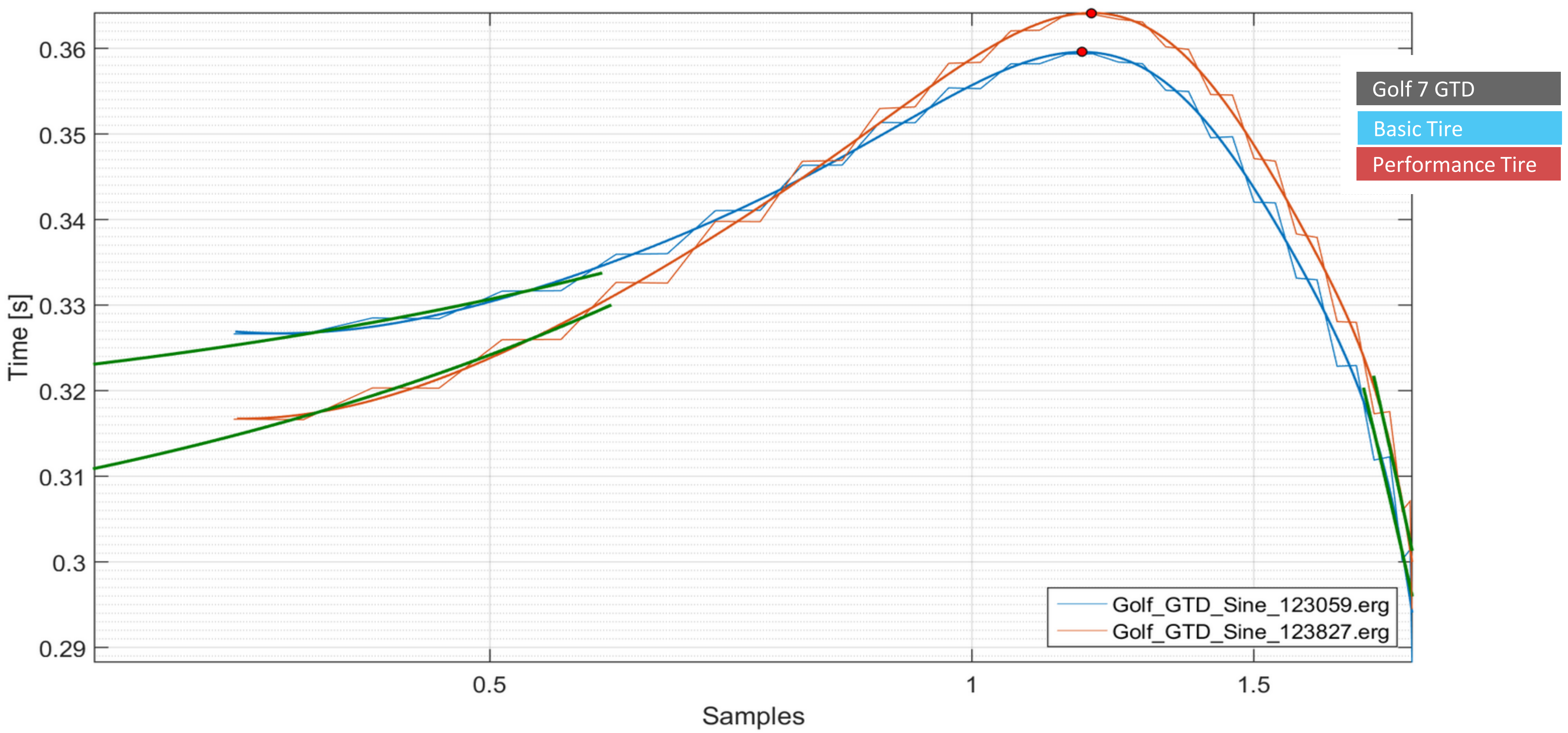
a. Damper front and rear *3

b. Damper front and rear *0,3

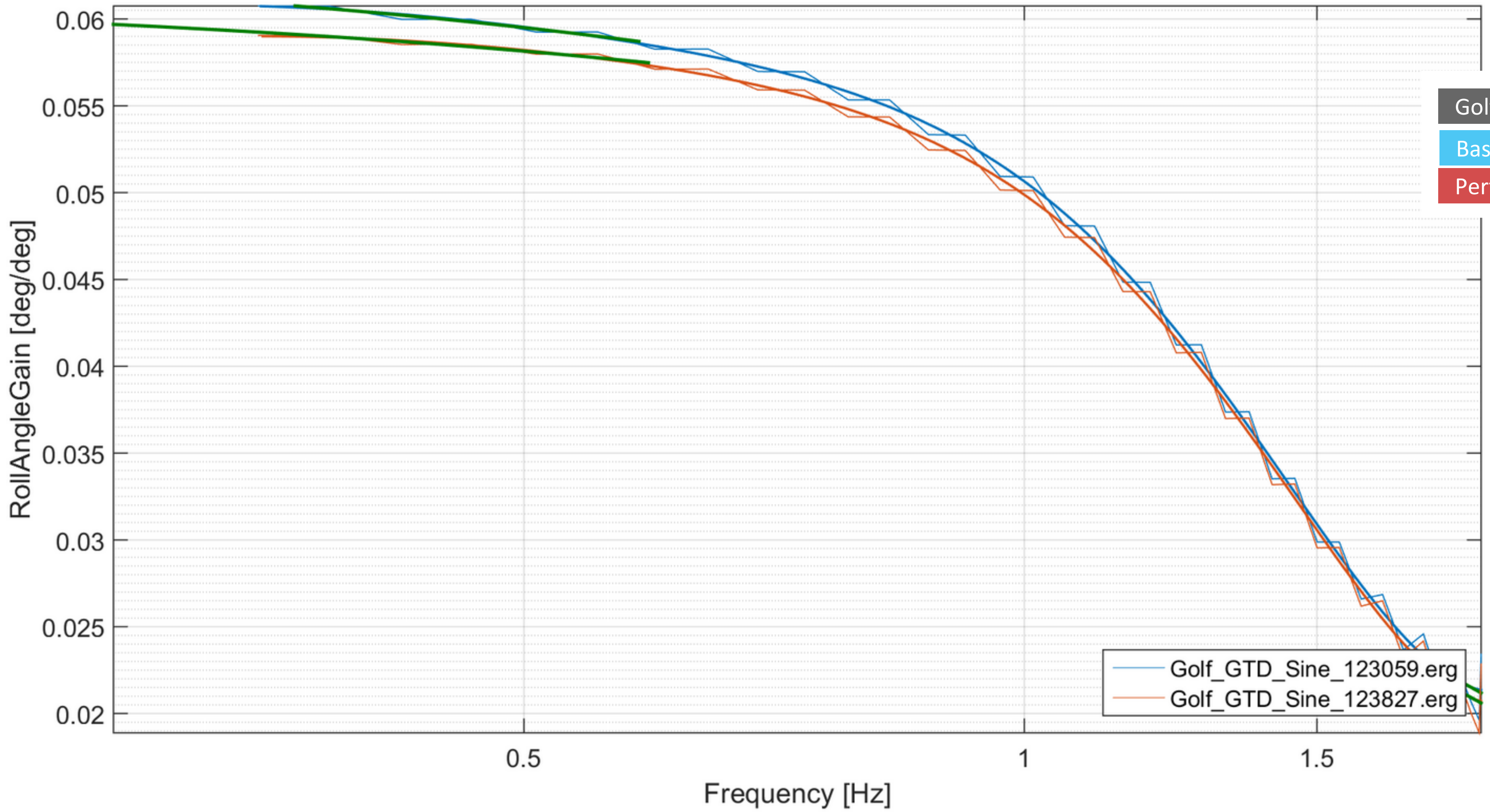
3. Change & Analyze Stabi Sensitivity:

1. Base with Basic Tire
2. Stabi front 2,0, Rear 0,5
3. Stabi front 0,5, Rear 2,0

Bode Diagram: Amplitude Gain



Bode Diagram: Roll Gain



Golf 7 GTD

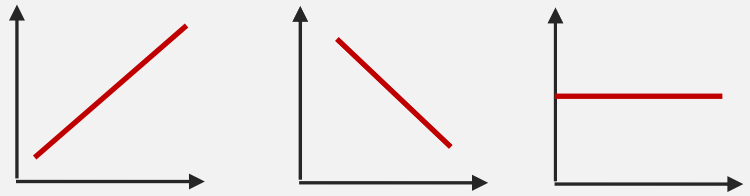
Basic Tire

Performance Tire

Create a test plan with realistic parameter ranges

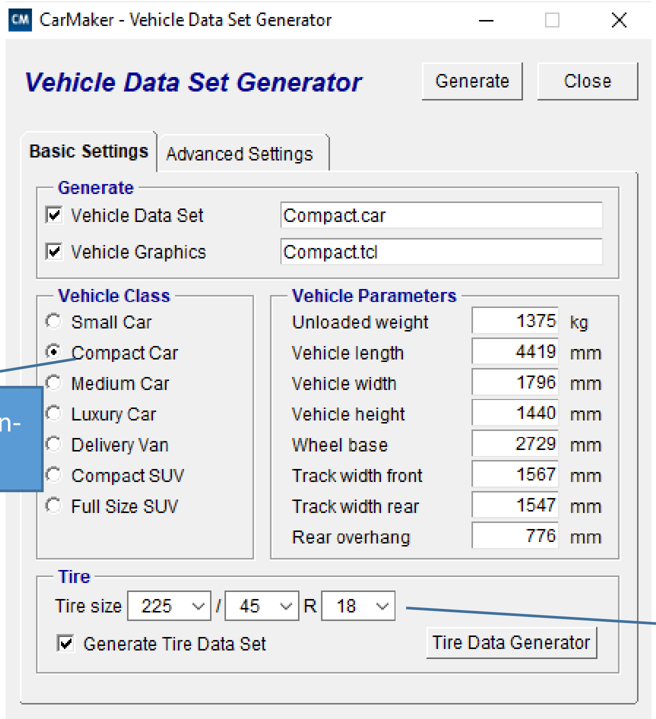
	Parameter								Response			
	CoG X position	CoG Z position	Wheel Base	Track Width	Roll Bar front	Roll Bar rear	Tire Side Slip Stiffness front	Tire Side Slip Stiffness rear	Ackermann	understeer gradient	$a_{y\,max}$	roll stiffness
Reference												
Variant 1	+											
Variant 2	-											
Variant 3		+										
Variant 4		-										
Variant 5			+									
Variant 6			-									
Variant n				+								

Sensitivity



2. Identify the linear sensitivity of different parameters.
3. Define the unit of the sensitivities.
4. Define total equation by approximation.
5. Find a solution for the given target.

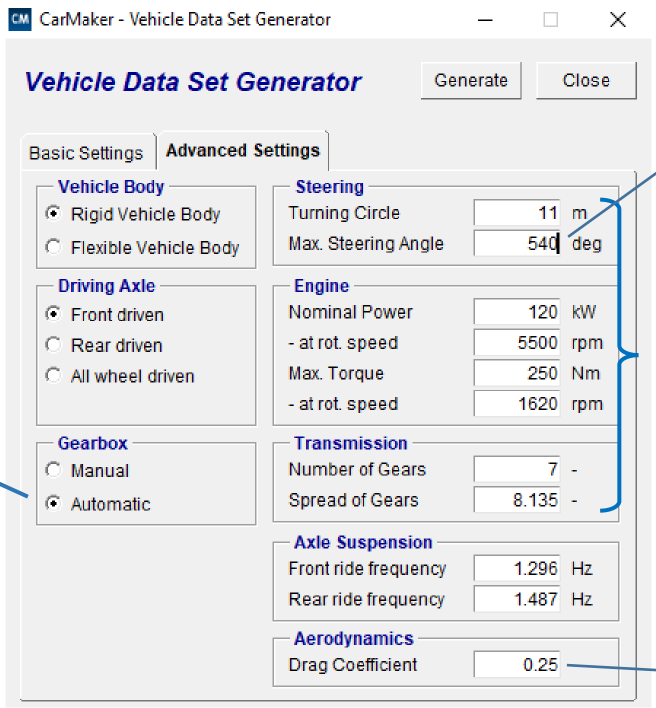
Exercise 10: Vehicle Data Set Generator



Fahrzeugklasseneinstufung nach [4]

Aus technischen Daten übernommen [2]

von Reifenflanke abgelesen, der Luftdruck von VA und HA wurde nicht angepasst



Im Fahrzeug abgeschätzt: ca. 3 volle Umdrehungen von ganz Links nach ganz rechts -> 1080°/2 = 540°

Aus technischen Daten übernommen [2]

Aus Pressemitteilung [5]