Hochschule Kempten
University of Applied Sciences

A drive. livinglab

ADAS Master WS 21/22
Lecture 4

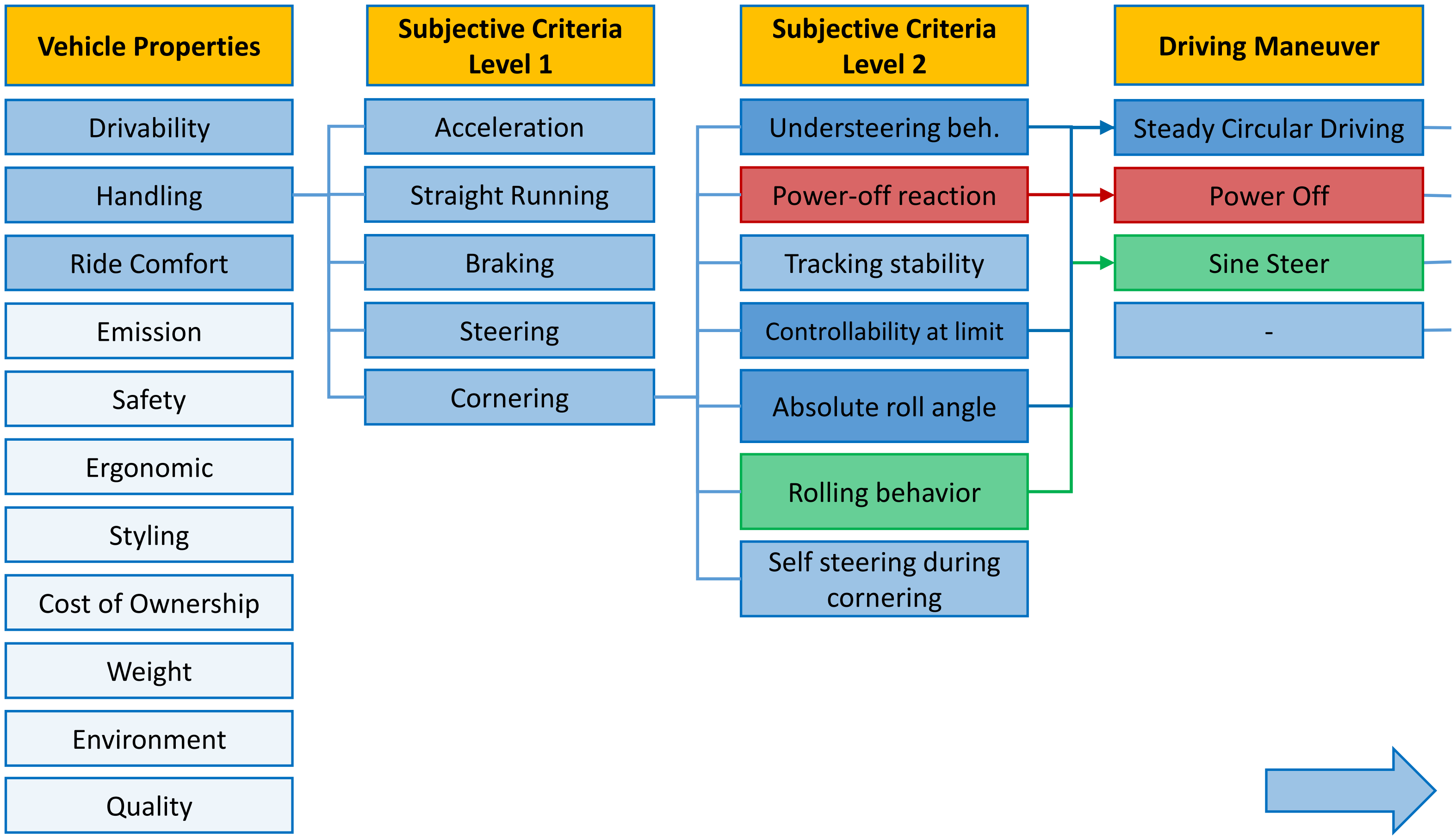
Vehicle Dynamics in context of Advanced Driver Assistance Systems and Automated Driving.

Lecture program

https://moodle2.hs-kempten.de/moodle/course/view.php?id=3698

Nr.	Datum	Inhalt	Ort	Von Wem
0		Virtual Test Driving (VTD) CarMaker Quick Start Guide	**T314**	**Self-study**
1	07.10.	Requirements for vehicles and their global attributes	T314	Schick
3	14.10.	Vehicle dynamics attributes and their target conflicts	T314	Schick
3	21.10.	Test and evaluation methods for vehicle attributes (1) **with practical simulation**	T314	Schick
4	28.10.	Test and evaluation methods for vehicle attributes (2) **with practical simulation**	T314	Schick
5	**04.11.**	**ADAS DRIVING EVENT** Measurement Tech. Introductions **PSA - Introduction**	**IFM**	Günther/Riedlmüller/ Schwandke
6	11.11.	Basic vehicle dynamics calculation and vehicle models **with exercise**	T314	Schick
7	18.11.	Chassis components and functions (1) Tire & Wheels **with practical simulation**	T314	Schick
8	25.11.	Chassis components and functions (2) Axle & Suspension **w. practical simulation**	T314	Schick
9	02.12.	Chassis controls and functions (1) Overview & Brakes & Steering	T314	Schick
10	09.12.	Chassis controls and functions (2) ESP–Functions & Application & Process	T314	Albert Lutz (BOSCH)
11	16.12.	**Chassis controls and functions (3) ESP–Application & Hands-On Workshop**	T314	Albert Lutz (BOSCH)
12	13.01.	**Chassis controls and functions (4) ESP–Application & Hands-On Workshop**	T314	Albert Lutz (BOSCH)
13	20.01.	TEND: ADAS Development for a sports car manufacturer	T314	Manuel Höfer (Porsche)

Evaluation structure and cause and effect chain



Test and evaluation methods for vehicle attributes

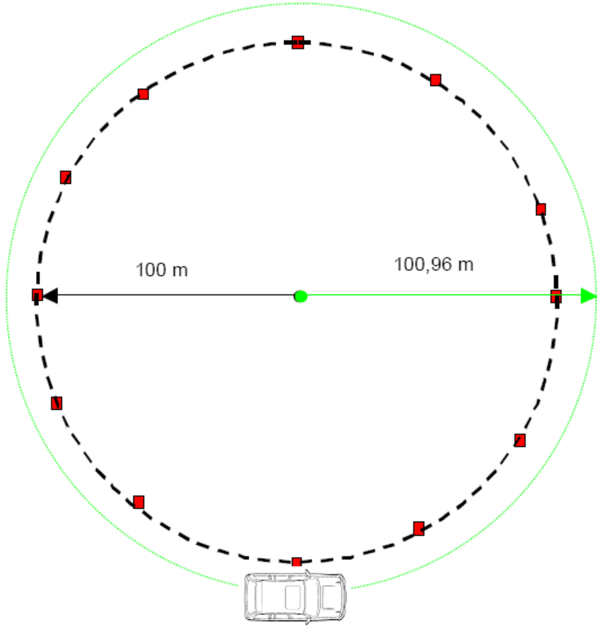
KPI and target matrix within a consistent development process

Driving Maneuver	Objective Evaluation Criteria	Benchmark Result Veh 1	Benchmark Result Veh 2	Benchmark Result ...	Target
Steady Circular Driving	Ackermann Angle(SWA)	28	25	..	**25**
Power Off	Understeer Gradient	2,6	0.8	..	**> 2 < 2,2**
Sine Steer	$a_{y,max}$	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

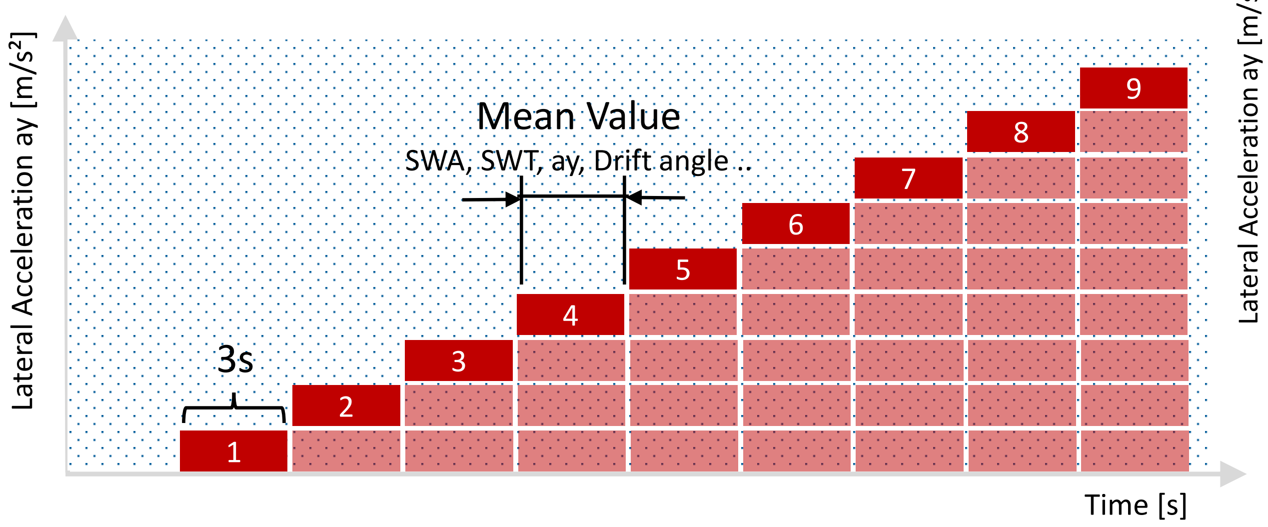
Most important maneuver: "Steady State Circular Driving"

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.

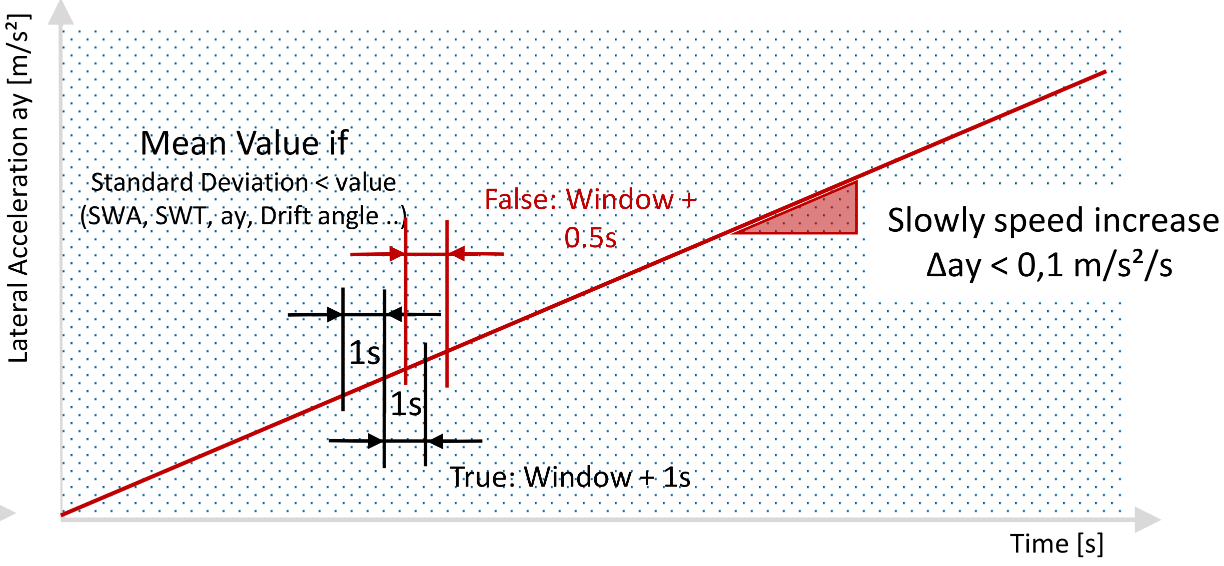


The measurement results (steering angle, sideslip angle, roll angle, toe angle, camber angle, ect.) are usually applied versus the lateral acceleration. The tire temperature should be recorded for tire stress indication, particularly when at high lateral accelerations should be applied over longer times. 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**.

Two ways to conduct “Steady State Circular Driving”



“Steady State Circular Driving”



“Quasi Steady State Circular Driving”

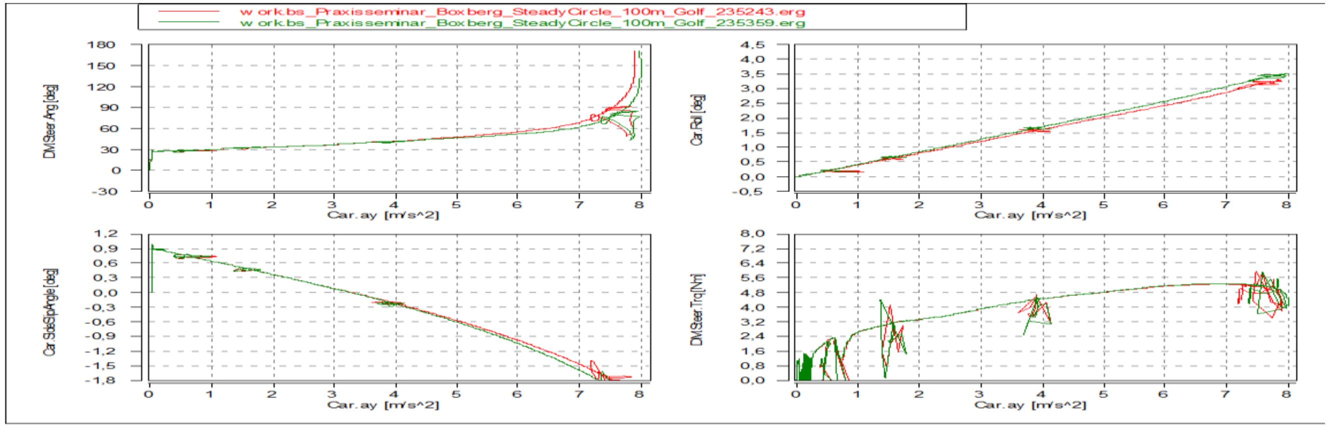
Test and evaluation methods for vehicle attributes

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

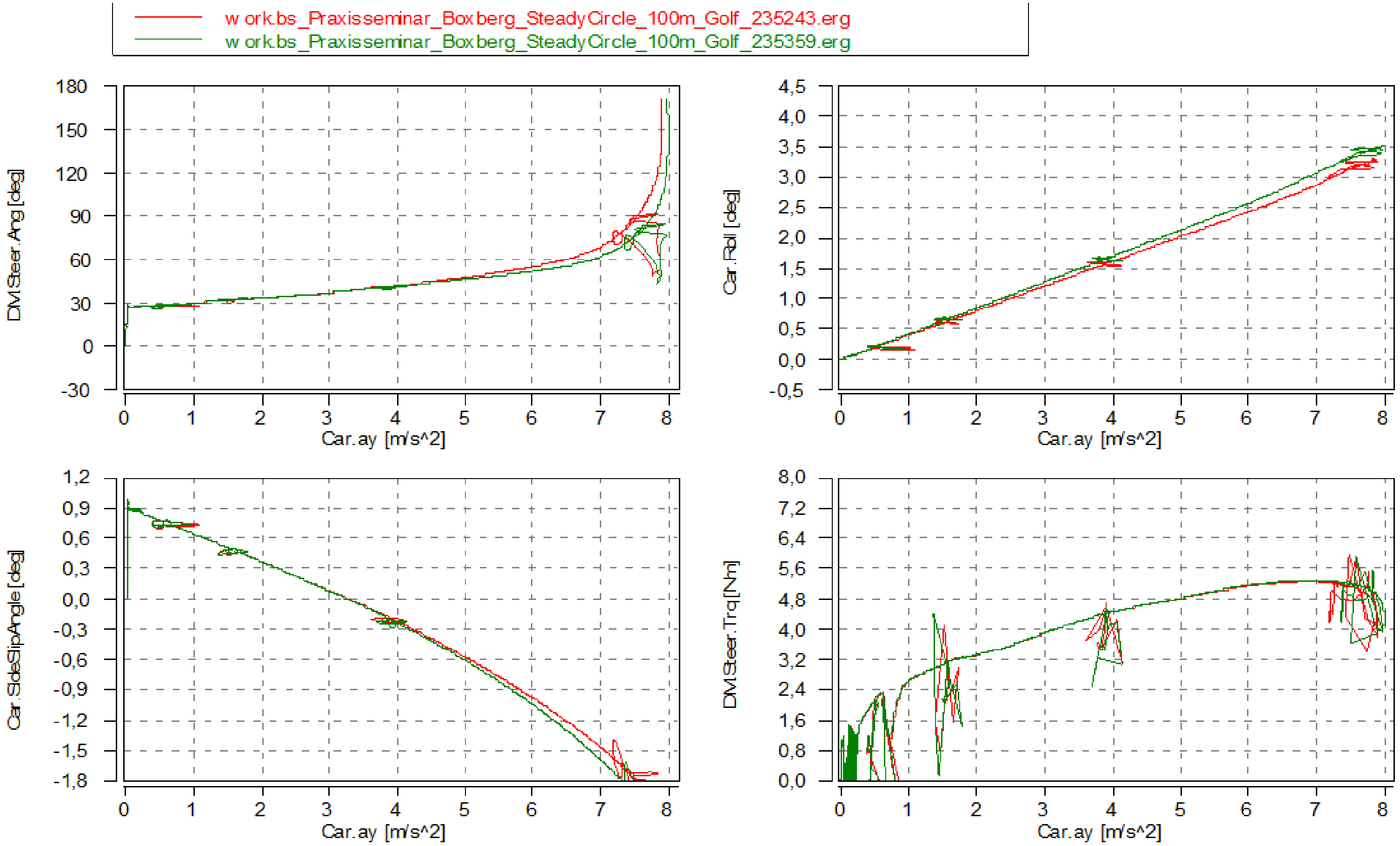
- **Its increase with increasing lateral acceleration is an indicative of** understeering behavior. For reasons of stability and safety feeling of the driver an understeering shall be aspired.
- Achieving the limit zone with correspondingly large lateral acceleration shall signaled by sharply increasing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

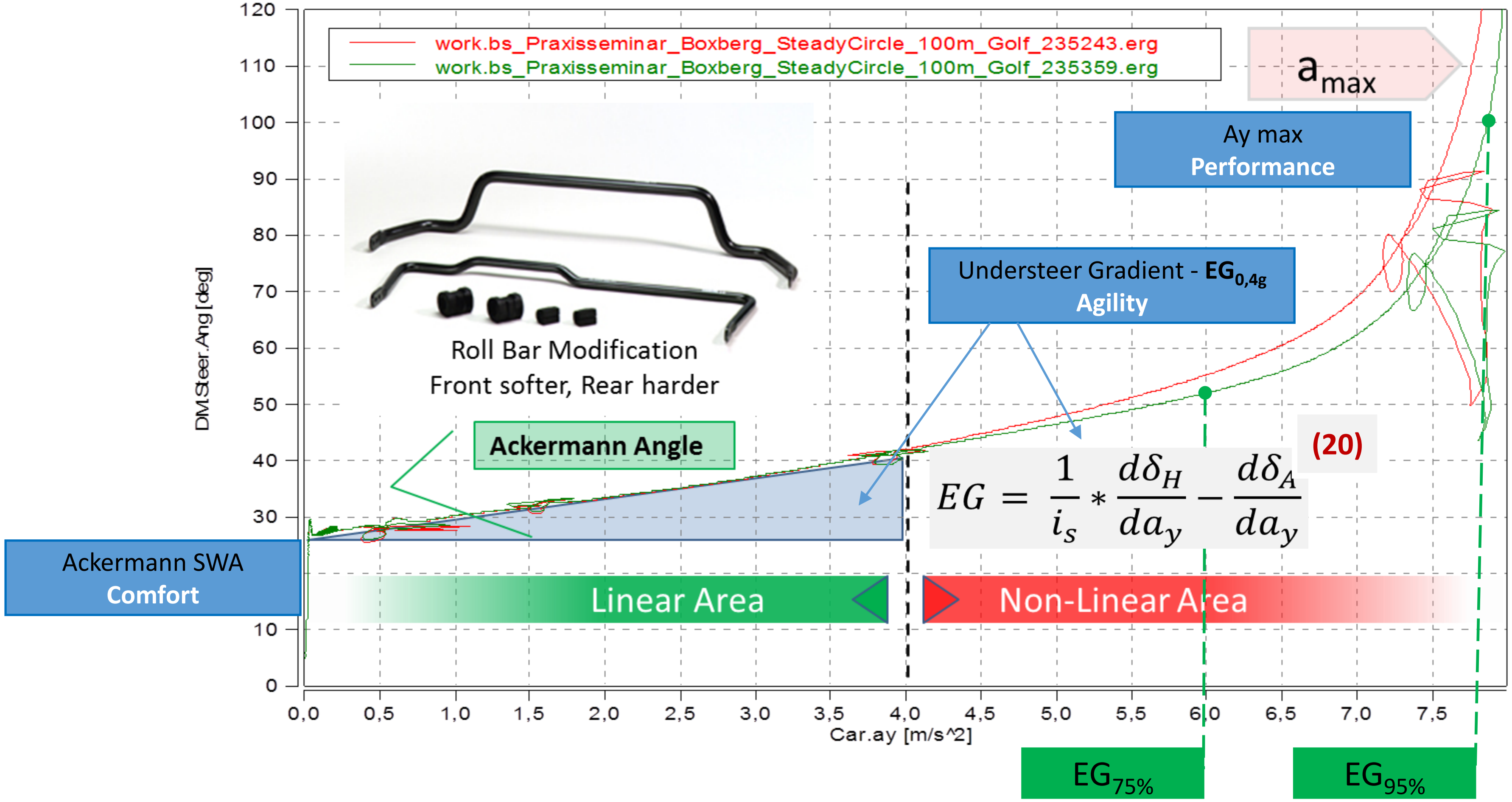
- Steer characteristics (Steer angle = f(Ay))
- Roll stiffness
- Maximum lateral acceleration
- Ackermann angle
- Maximum side slip angle on the front axle
- Understeer gradient in the linear range
- Steering torque/effort



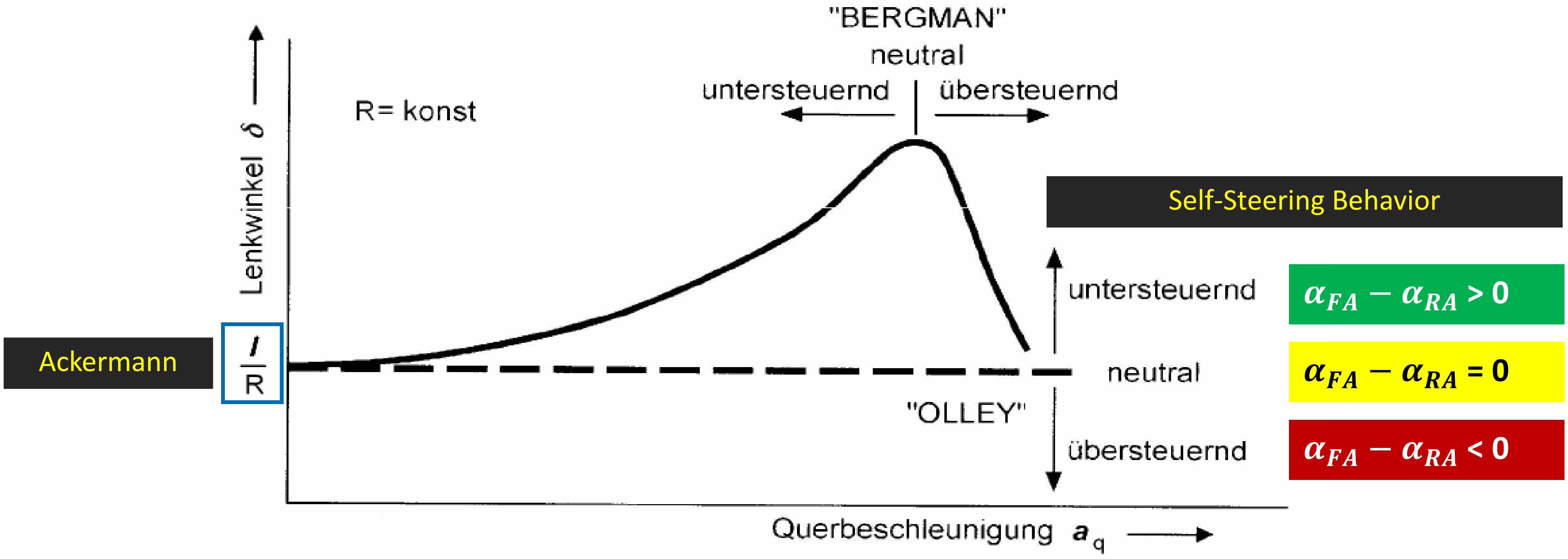
Typical evaluation graph “Steady State Circular Driving”



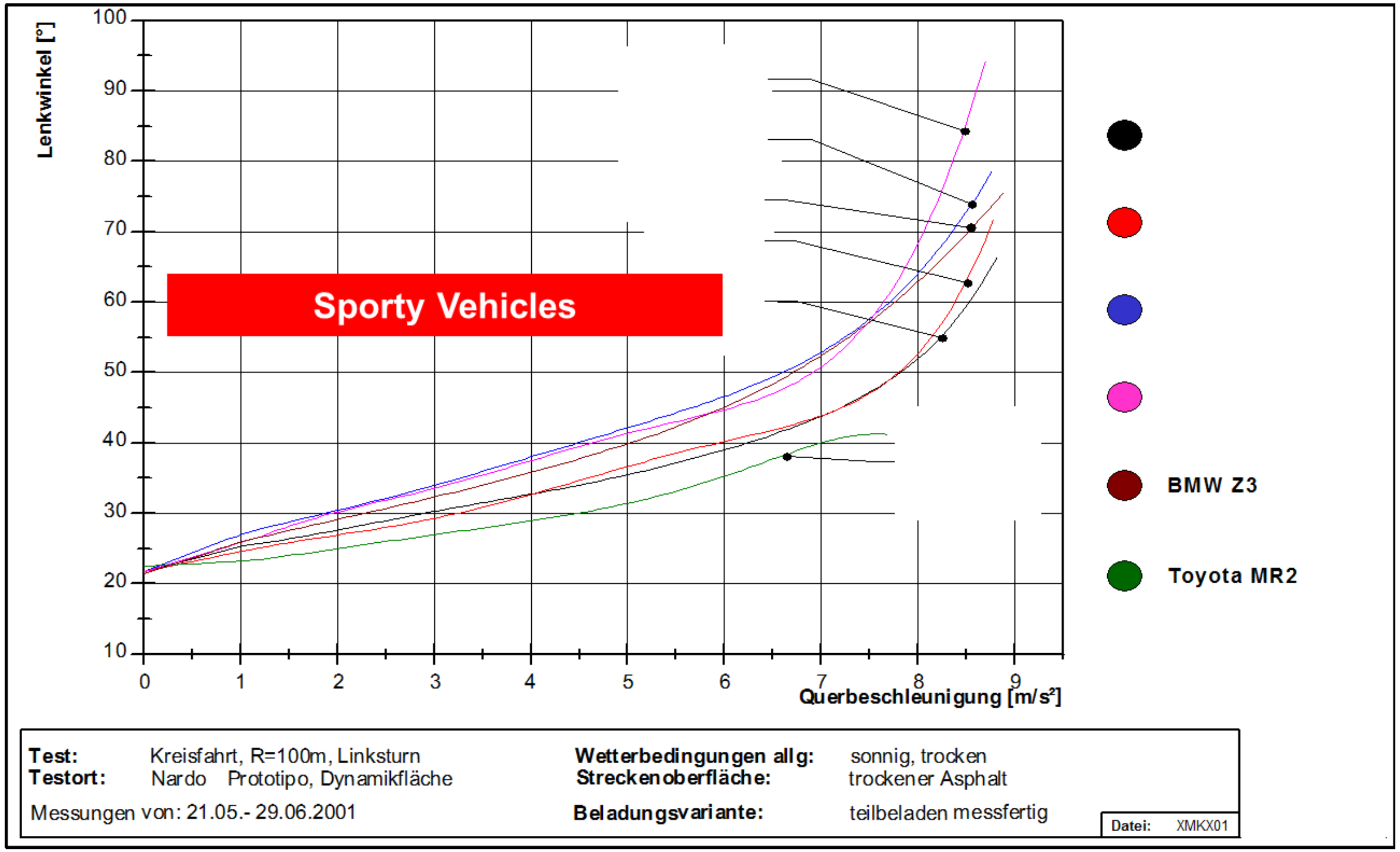
Typical evaluation criteria for steering angle demand behavior



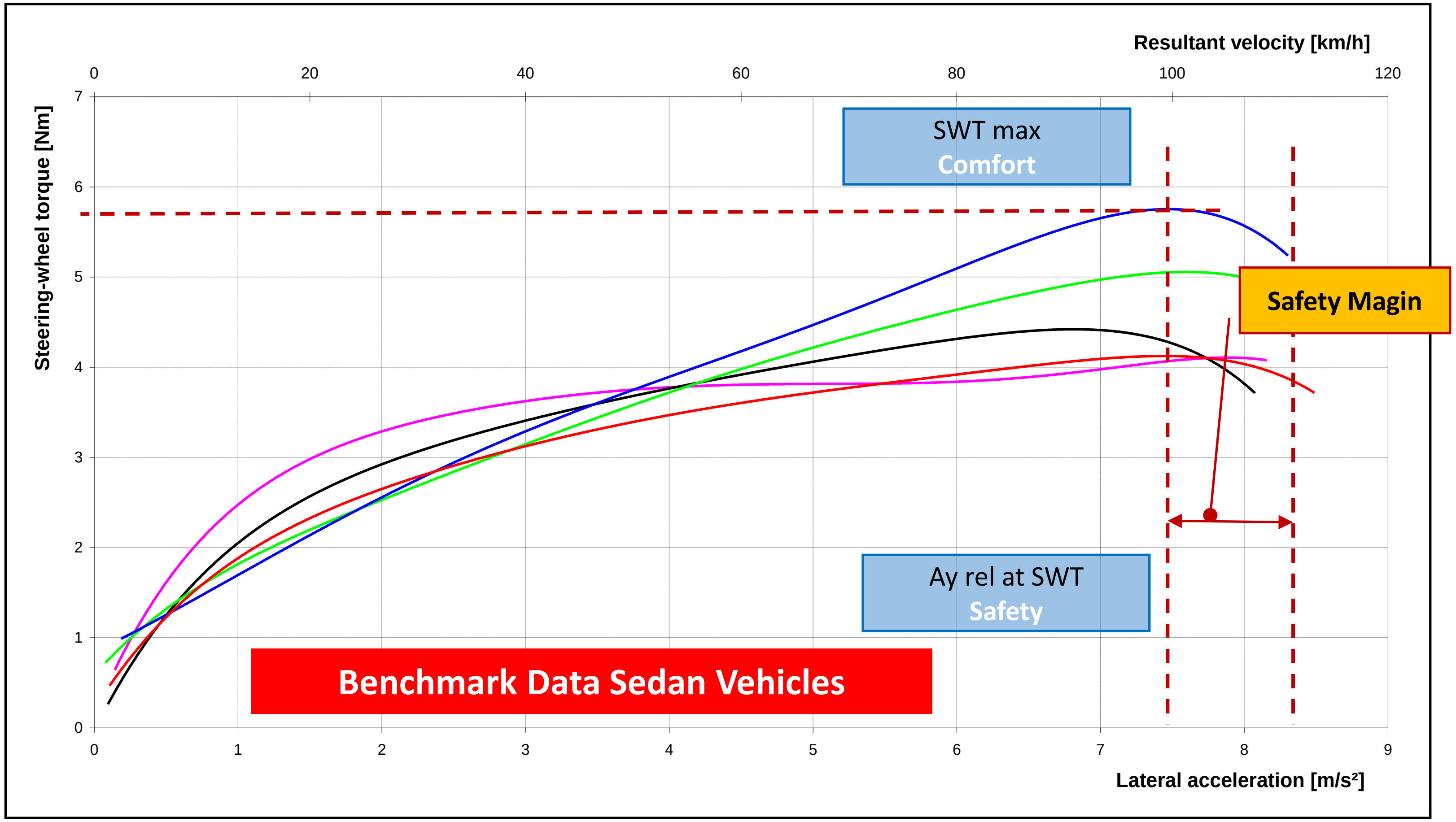
Understeer and oversteer definition



Understeer and oversteer behavior of sporty vehicle benchmarking



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

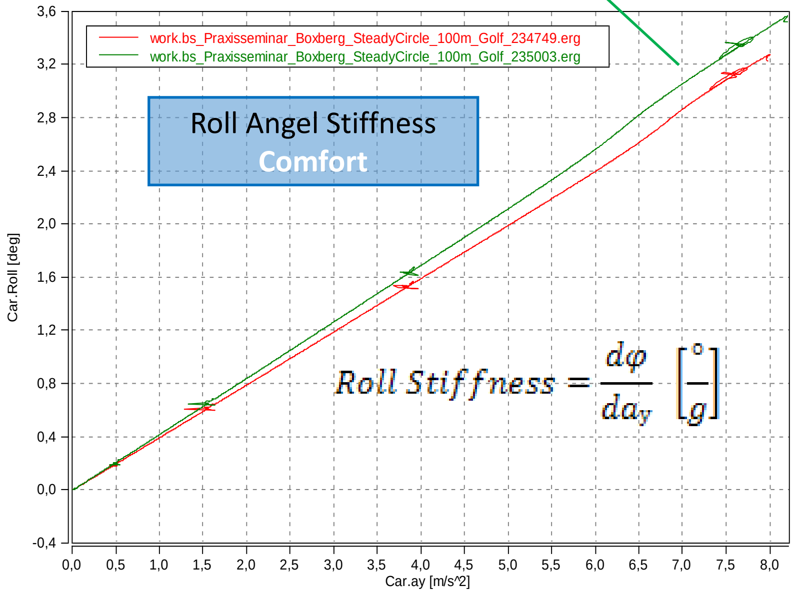


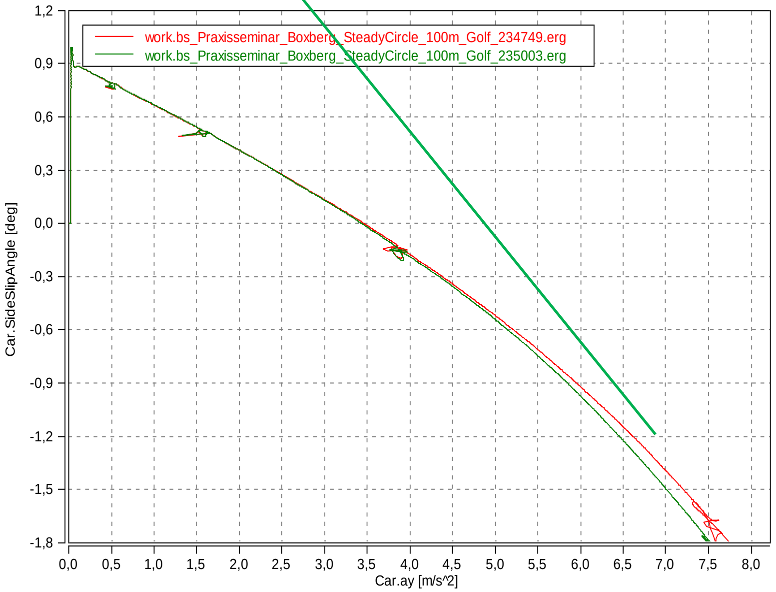
Typical evaluation criteria roll and drift behavior

Roll Bar Modification
Front softer, Rear harder

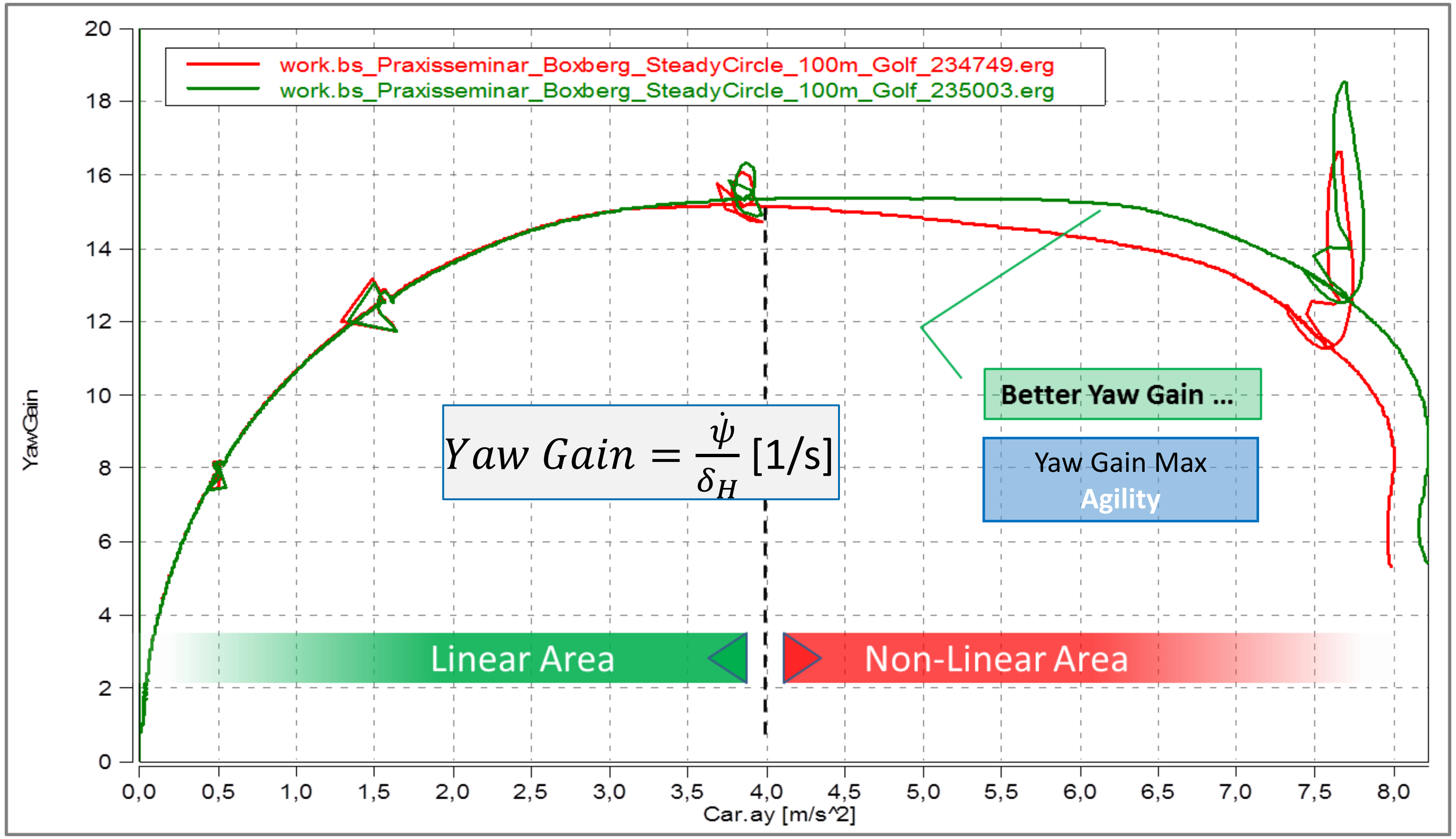
Bigger Roll Angle

… bigger Side Slip Angle

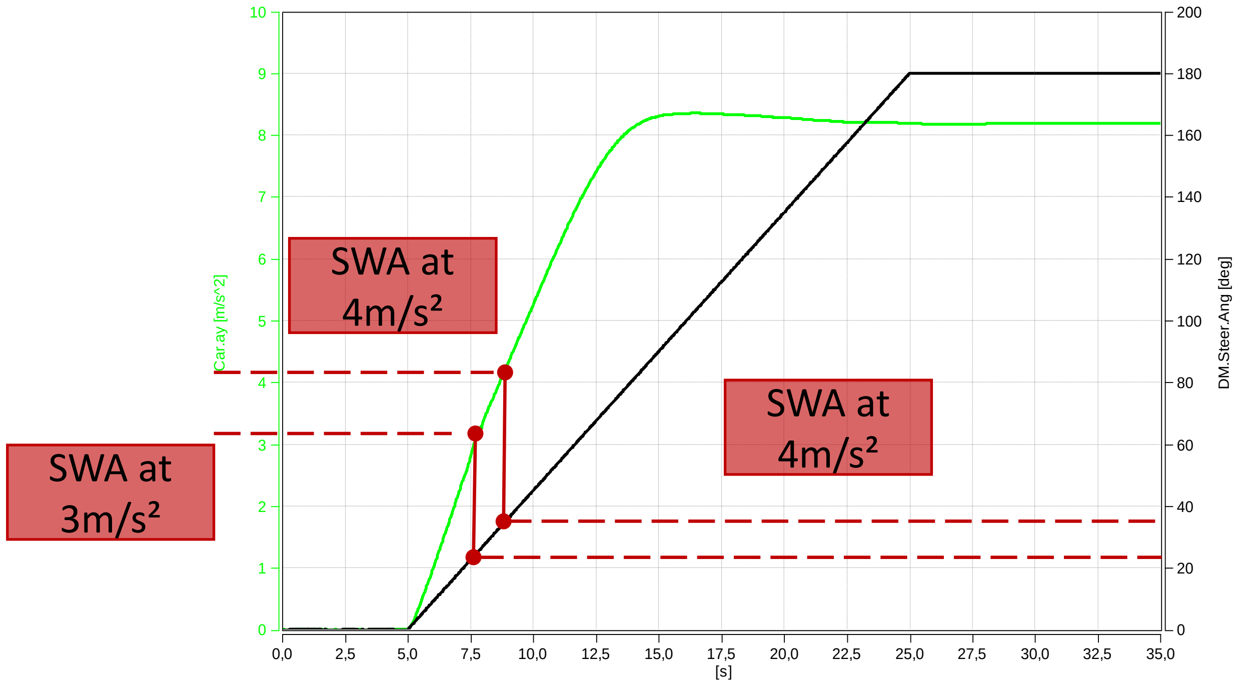




Typical evaluation criteria for yaw gain



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

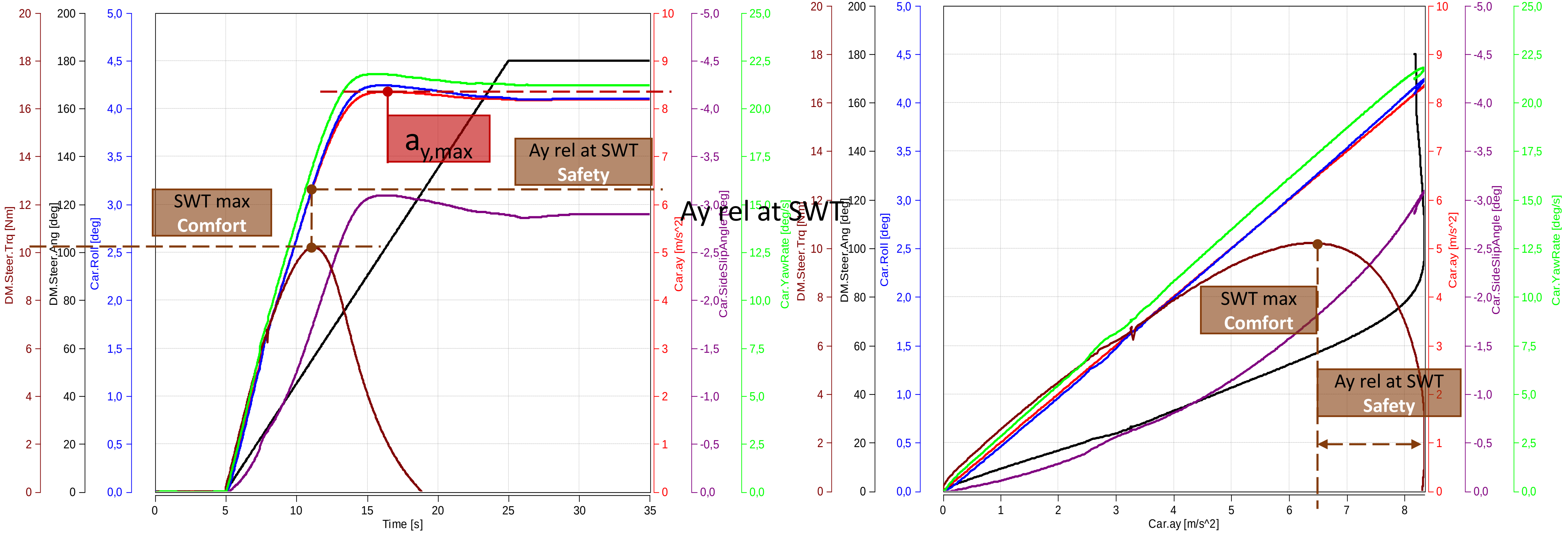


V= 80/100 kph constant SWA Gradient < 13,5°/s

SWA at 4m/s² used for steering angle identification

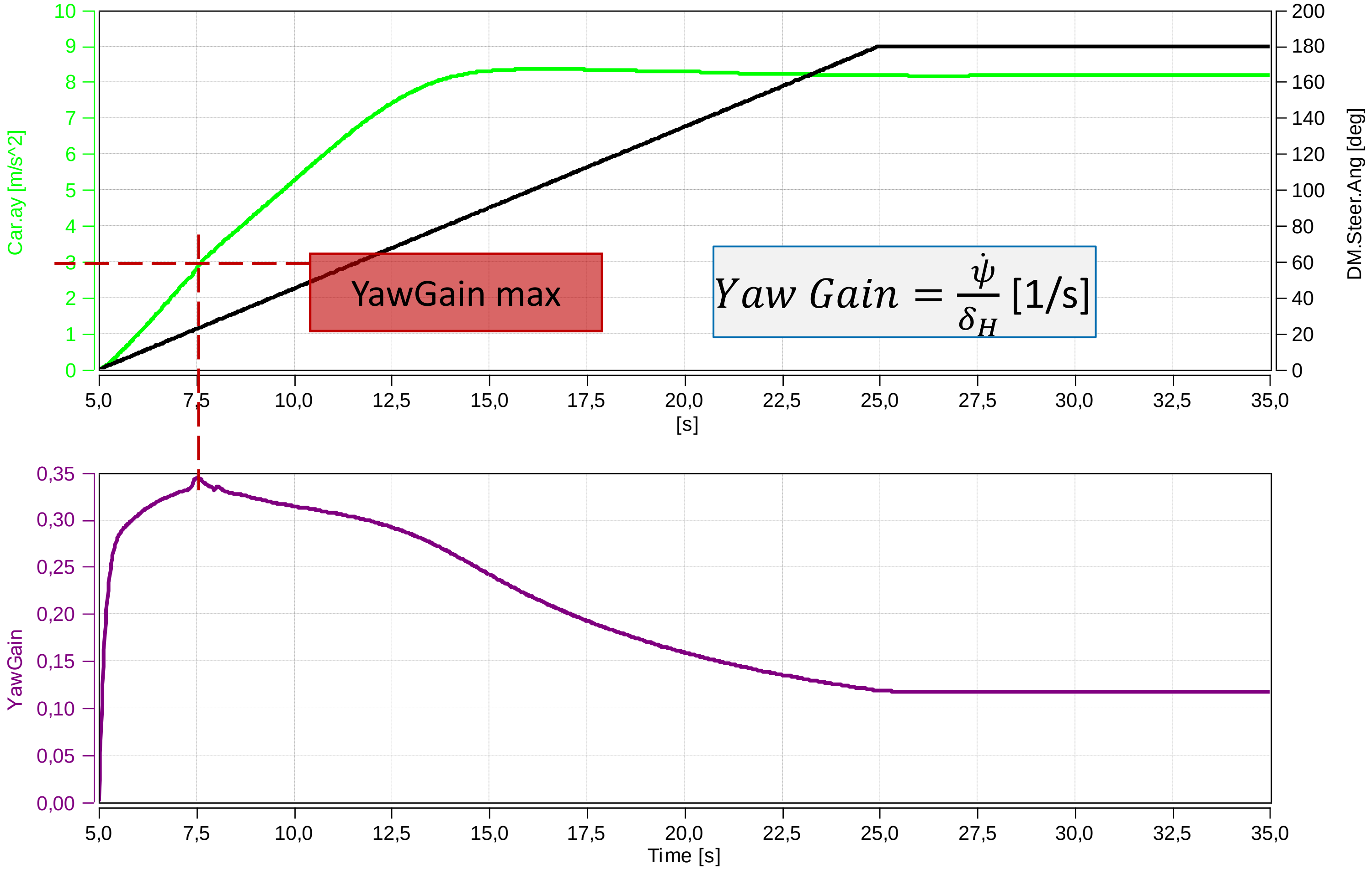
- Step steer (4m/s²)
- Sine steer (4m/s²)
- Sine with Dwell (3m/s²)
- …

Slowly increase steer test (SIS) - signals as time history and vs. ay



V= 80 kph; SWA Gradient < 13,5°/s

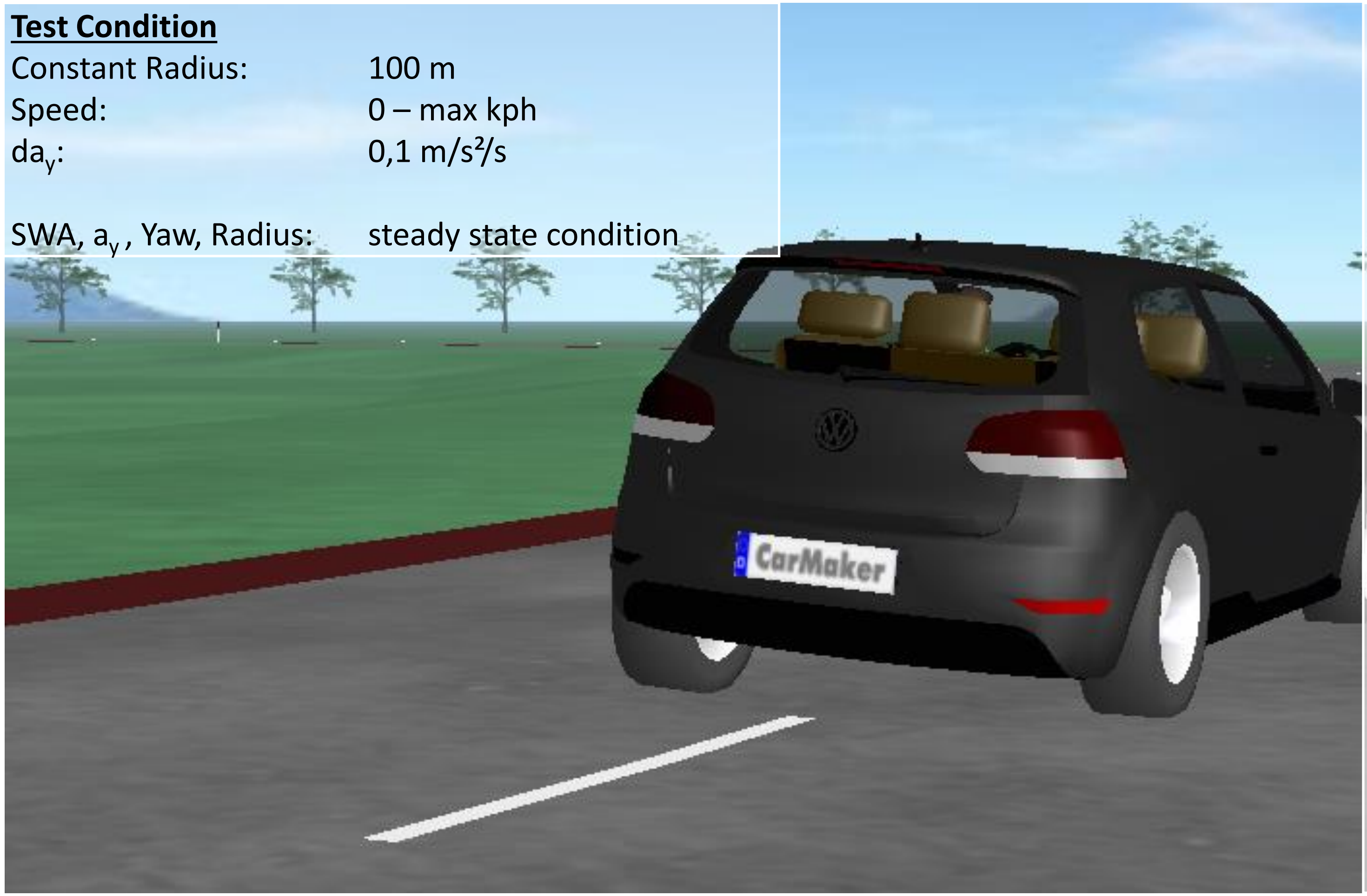
Yaw Gain at slowly increase steer test (SIS)



Hands-On Workshop: 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



Optimaization Task:

- Improvement of $a_{y\ max}$ as much as possible
- Decrease of roll stiffness of >15%
- Reduction of understeer gradient to < 2,5 °/g
- Reduce Ackermann >10 %

Make a Cause & Effect Tree (Wirkkettenmodell)

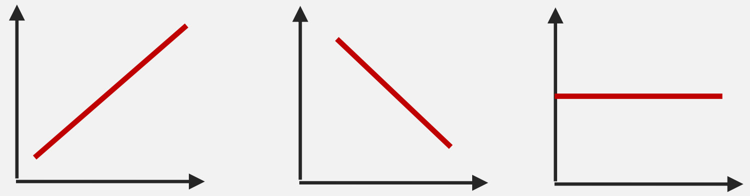
Find Variations such as

- Tire
- Weight distribution and CoG
- Wheel Base / Track Width
- Roll bar stiffness
- Spring / damper
- …

1. 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.