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Procedures and criteria for active safety assessment

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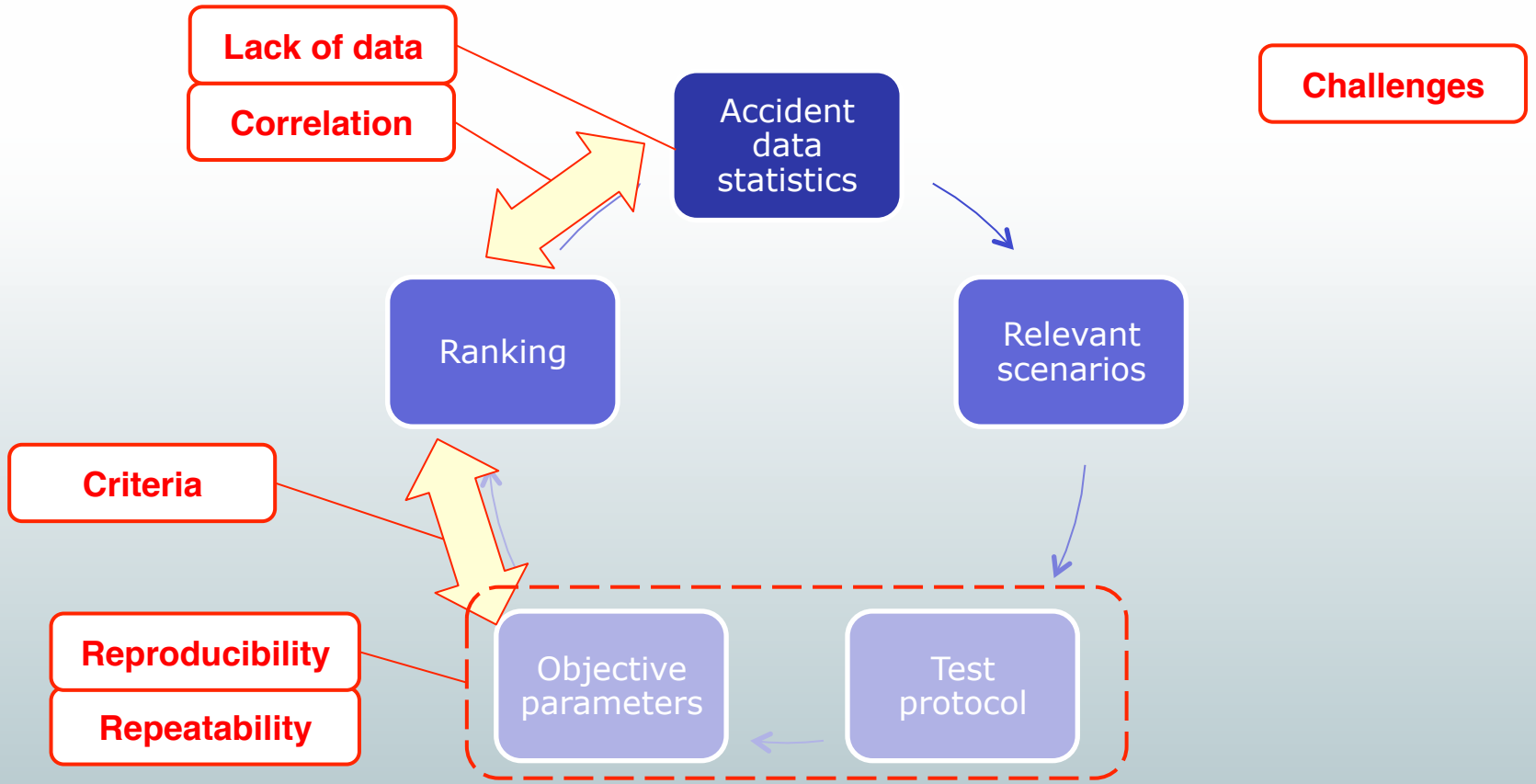
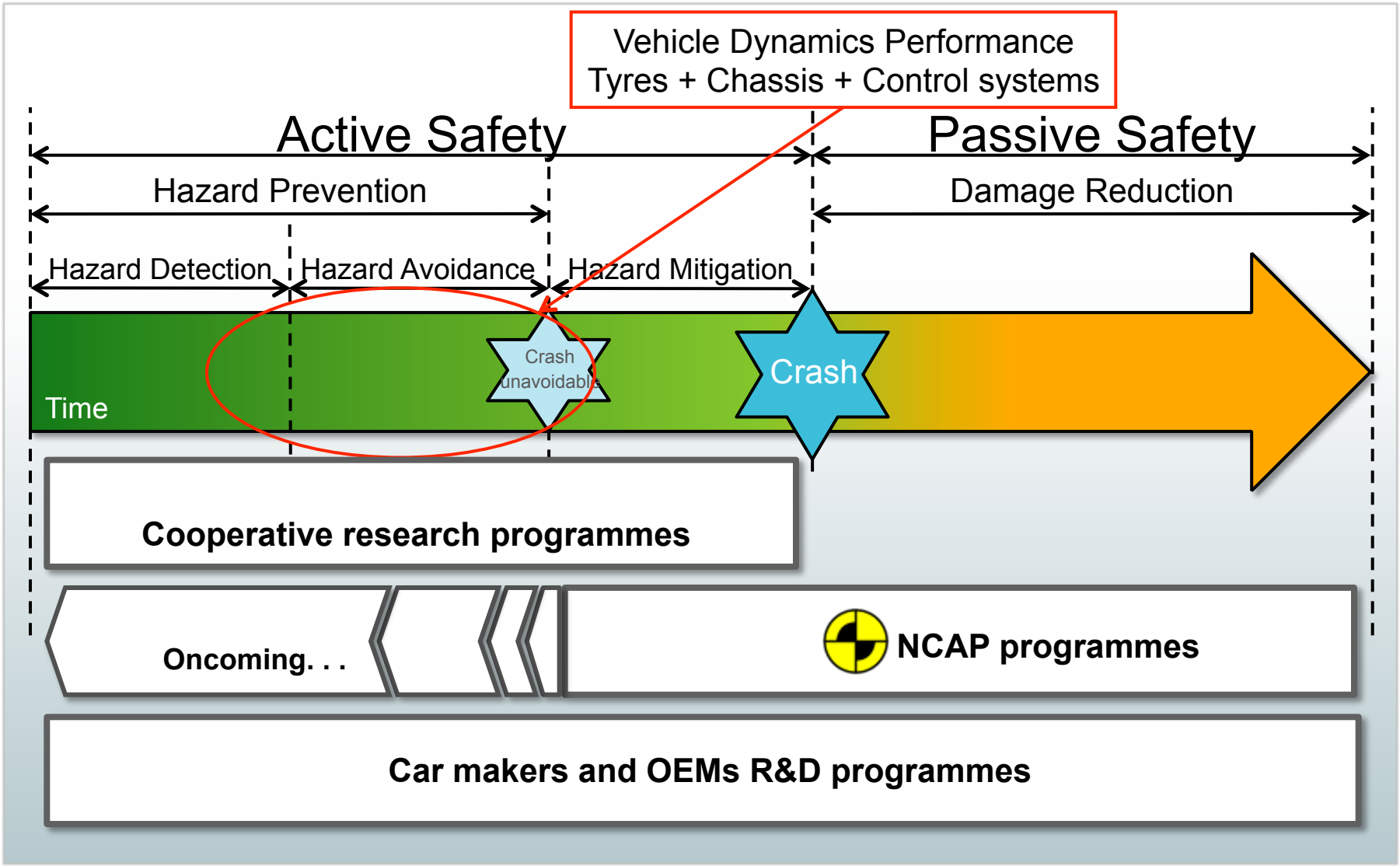
Introduction

Active safety assessment may be seen as a continuous process, evolving with the infrastructure (the public roads), the features of the vehicles, the habits of the road users



Relevant scenarios



Relevant scenarios

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Typical emergency scenarios, derived from experience and accident analysis, commonly used in the analysis of active systems and ADAS.

The driver realizes too late he is approaching a curve at too high speed and he tries to close the path in order to keep the vehicle on the road track	«Overspeed» curve approach (e.g. highway exit)
The driver has to avoid a sudden obstacle with a fast steering manoeuver, without having the time to brake	Obstacle avoidance
The driver has to release the gas pedal or to brake in a curve due to an obstacle ahead, with no possibility to try a steering manoeuver	Power-off in a turn Braking in a turn
The driver has to apply braking in order to stop the vehicle as quickly as possible	High mu Low mu Split mu
	Emergency braking

Relevant scenarios

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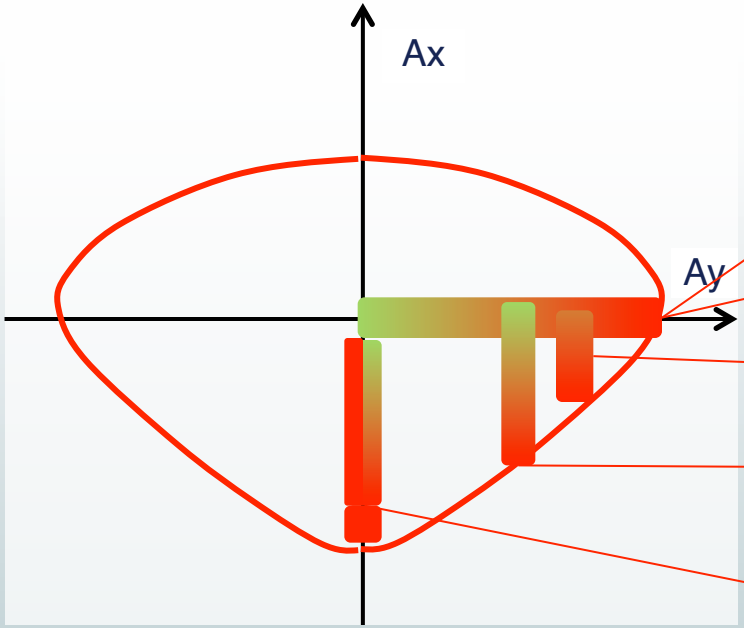
In emergency situations, the maximum performance of the vehicle, in terms of longitudinal and lateral acceleration, is requested by the driver in order to avoid an accident or a dangerous condition. This can be clearly shown by the vehicle friction circle (g-g diagram).



«Overspeed» curve approach (highway exit)

Obstacle avoidance

Power-off in a turn

Braking in a turn

High mu

Low mu

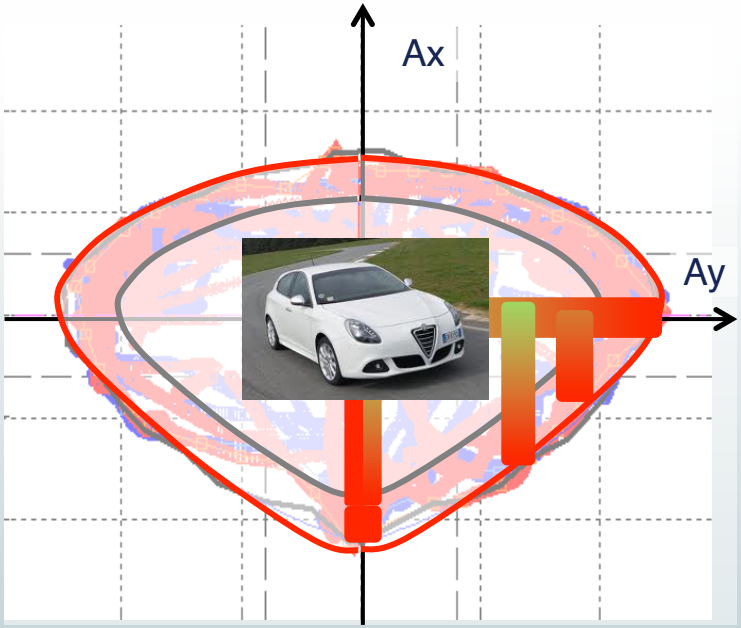
Split mu

Emergency braking

Relevant scenarios

Some analogy with a “racing” track lap can be found: max vehicle dynamics performance

On public road, in emergency situation, the car is used near its limit as well, but the driver:



1. Has to react to an unexpected danger condition. Keeping the vehicle under control in such a situation could be hard even for a professional driver.

2. In most cases is not so familiar with controlling the car near the limit. Most drivers spend more than 95% time below 0.2g.

A test protocol for active safety assessment should include tests able to provide information about

Max performance ➔ Agility

Driver’s control effort ➔ Stability

Test protocol & Objective parameters

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Regulations, public standards and “best practices”

Item	Domain of interest	Goal
Regulations ECE 13-H FMVSS 126	**Homologation** ESC	Certification of ESC functionality and minimum level of performance
Public standards ISO 4138 ISO 7401 ISO 7975 ISO 9816 ISO 21994 …	Steady state cornering Transient response Braking in a turn Power off reaction Stopping distance …	Vehicle dynamics objective evaluation in: - pure lateral - cross-coupling X-Y - longitudinal
OEMs internal standards Low-μ braking Split-μ braking Slowly Increasing Steer Step steer Double lane change …and more	Overall vehicle dynamics characterization	Objective and subjective assessment, vehicle and control systems tuning and validation under a wide range of conditions

Related to relevant scenarios for active safety

Test protocol & Objective parameters

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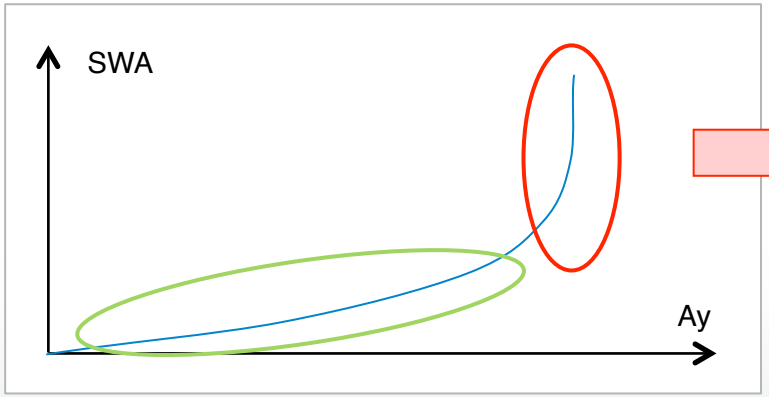
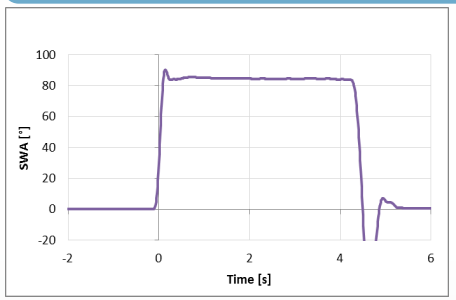
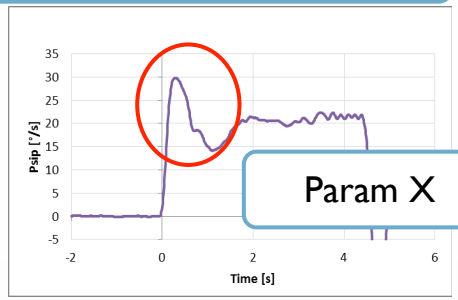
Steady state and transient lateral dynamics

Steady state cornering

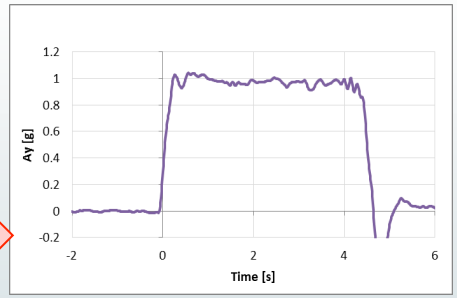


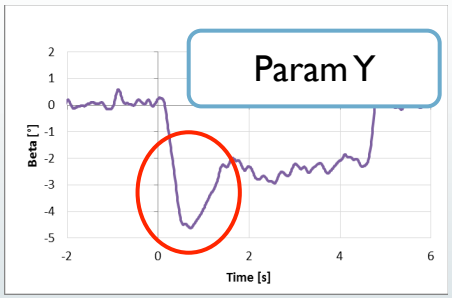
Transient: Step Steer in the max Lat Acc range





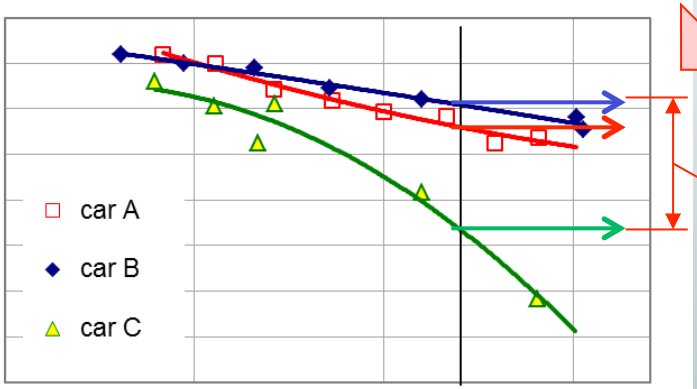
Param X





Param Y

Analysis: param Y vs. steering wheel angle



Compare cars at a given reference SWA.
Increasing the steering wheel angle may stretch the differences in dynamic behaviour.

Test protocol & Objective parameters

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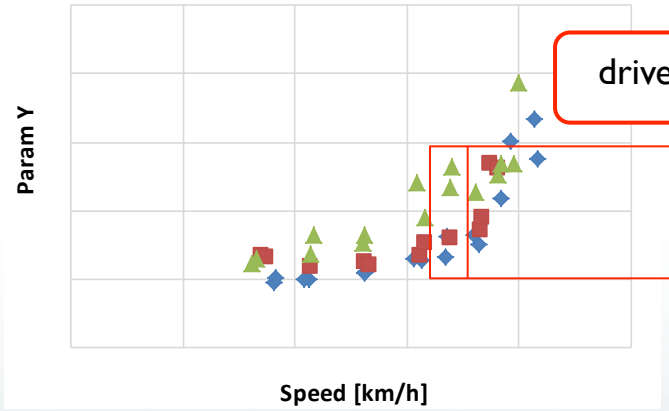
Steady state and transient lateral dynamics

Double Lane Change (ISO 3888-1 and -2)

Same speed, 3 different drivers

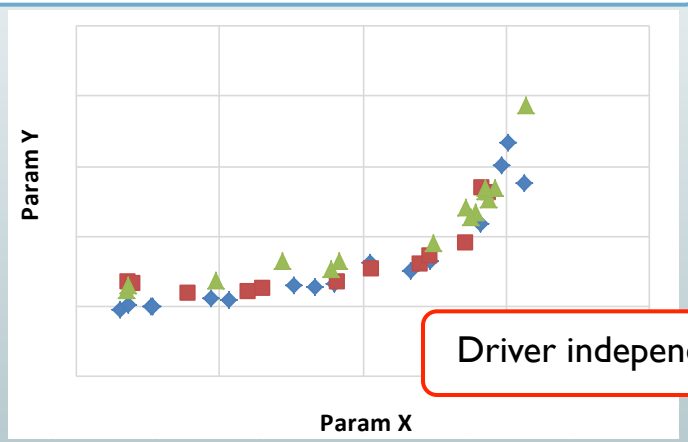
Plot param Y vs. speed



driver effect

Normalization

Plot param Y vs. param X



Driver independent !

Test protocol & Objective parameters

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Emergency braking

Emergency braking on mu-split

The effect of the braking surface must be taken into account, as a major factor to deal with when comparing results of test performed on different tracks:

- Global friction coefficient → Mean deceleration
- Difference of friction coefficient between high-μ and low-μ sides → Yaw moment

The "global" friction coefficient represents the actual use of adherence of the vehicle, being strictly related to the average deceleration.

Need for additional tests to evaluate the behaviour of the vehicle on the high-μ and low-μ surfaces:

- Braking on high adherence surface → μ_{HIGH} global coefficient
- Braking on low adherence surface → μ_{LOW} global coefficient

Normalization

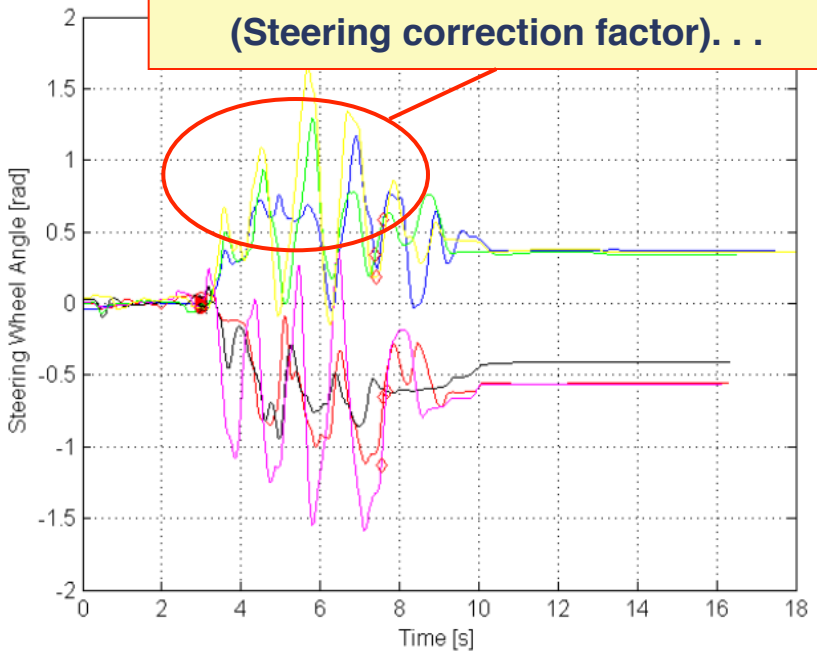
Test protocol & Objective parameters

Emergency braking

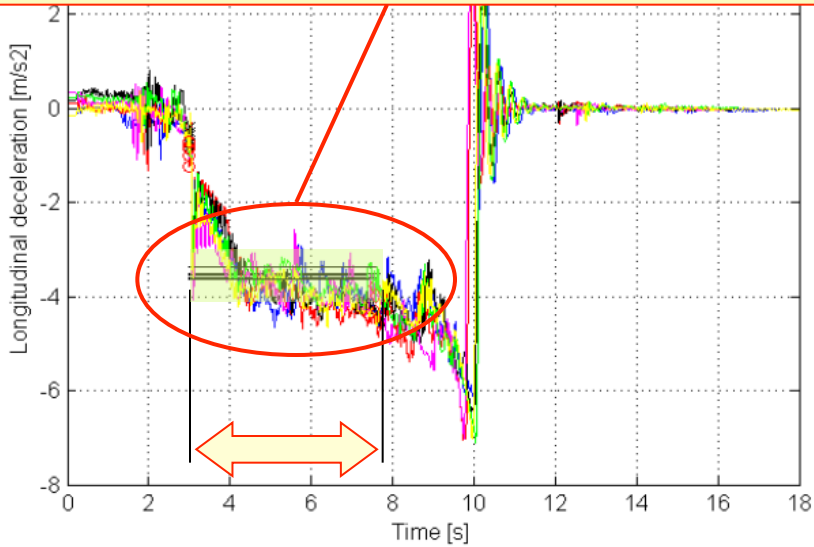
Emergency braking on mu-split

Same driver, same car, same test surface: several run

Quite different driver's behaviour (Steering correction factor). . .



. . . has a limited influence on the deceleration (Use of adherence)



The steering wheel activity by itself does not look like a robust quantity to describe the vehicle behaviour, whereas the longitudinal deceleration looks quite stable despite the driver's actuation.

Ranking

Development of assessment metrics

Regulations
ECE 13-H
FMVSS 126

Param 1
Param N

MUST
Acceptability condition, but no vehicle ranking

Public standards
ISO 4138
ISO 7401
ISO 7975
ISO 9816
ISO 21994 …

Param A
Param B
Param C

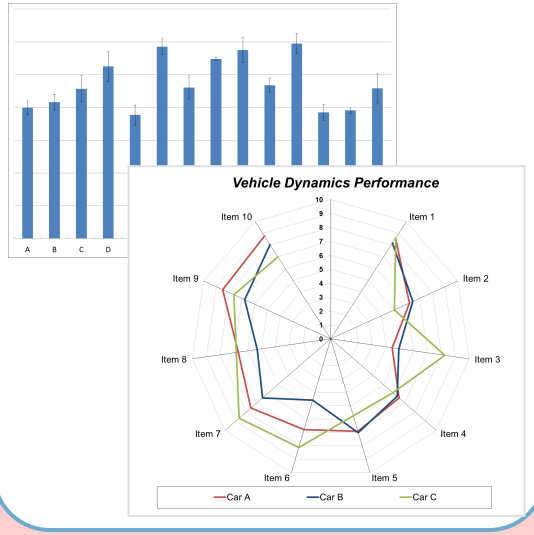
Objective vs. subjective correlation

Car makers / OEMs expertise & know how

OEMs internal standards
Low-m braking
Split-m braking
Slowly Increasing Steer
Step steer
Double lane change
…and more

Param X
Param Y
Param Z
…

Industry internal metrics for vehicle dynamics performance and active safety assessment



Correlation with Accident data

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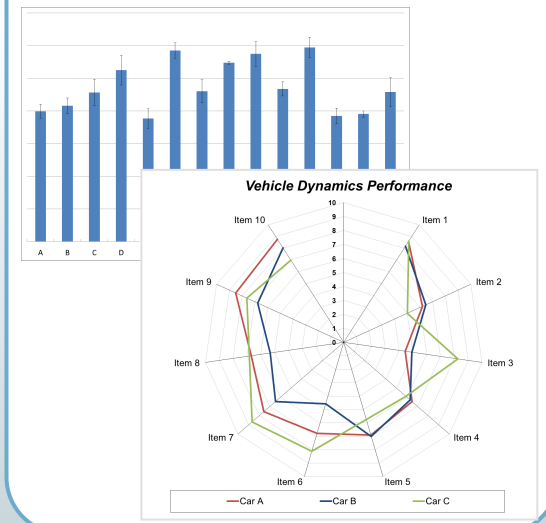
Industry internal metrics for vehicle dynamics performance and active safety assessment



Structured DataBase of accident data

Disturbance effects analysis:

Driver [illegible] d

Driver [illegible] hicle class

e.g. sports [illegible] d 300kph for sure has t[illegible]el dynamics performance under public road limits, but might have higher accident index due to driver behaviour

Active Safety Vehicle rating based on correlation of objective performance parameters vs real world data

This is actually a major open point!

Conclusions & open issues

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Conclusions, or better to say: Starting point

- Analysis of relevant scenarios, from cooperative research projects and common real world experience
- Wide range of testing standards for objective evaluation of vehicle behaviour in conditions strictly related to the relevant scenarios
- Experience of car makers, OEMs, research and testing organizations in vehicle dynamics assessment

Open issues

- To reduce the driver influence in the assessment of vehicle behaviour in some “closed loop” relevant tests
- To develop robust criteria for the comparison of objective test results obtained on different tracks
- To define assessment criteria for vehicles ranking, taking into account the subjective perception and the correlation with real world accident data.

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Thank you for your attention

Questions