EVASIVE MANOEUVRE ASSIST

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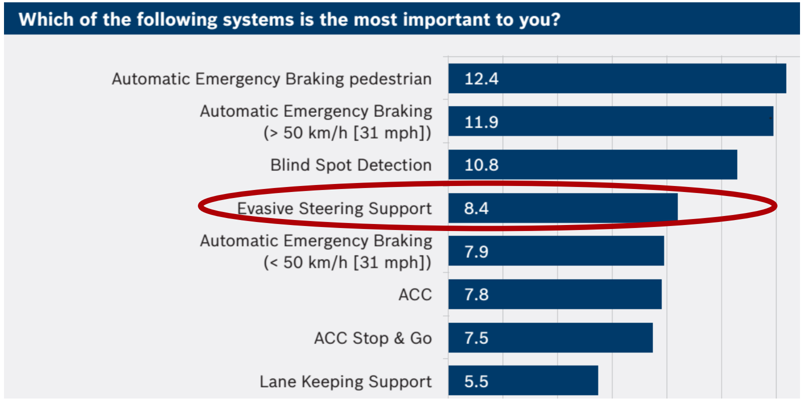
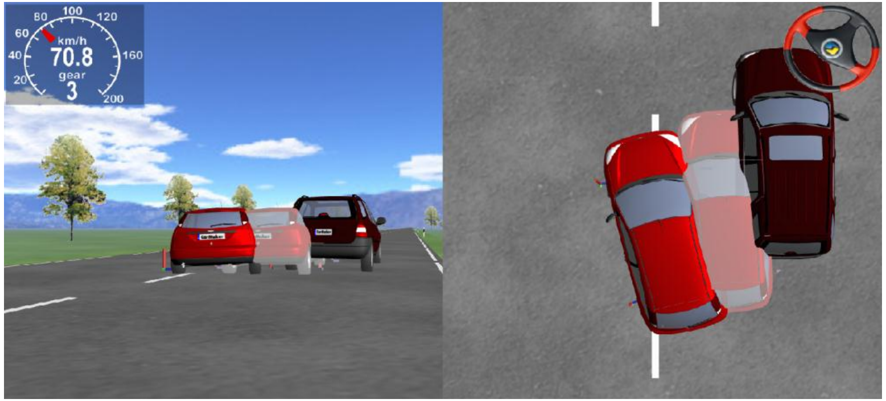
MOTIVATION

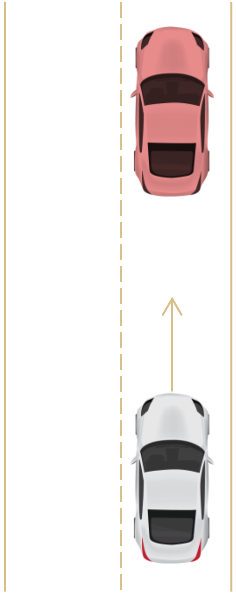
Many accidents can be avoided by evasive manoeuvres
…but drivers have difficulties to handle them
…and the state-of-the-art assistance is emergency braking





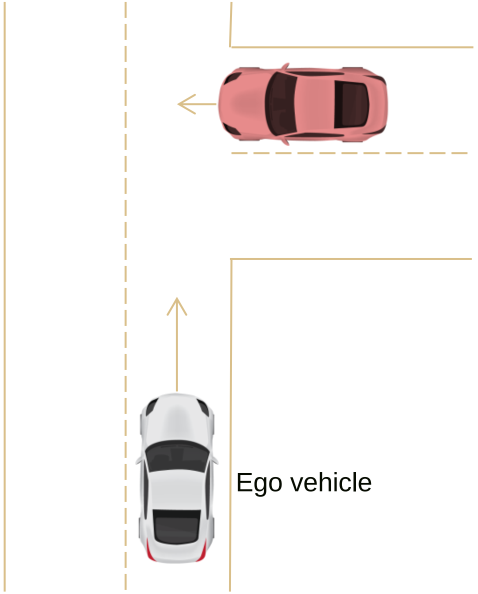
Bosch 2012

DECISION MAKING IN EMERGENCY SITUATIONS



Bosch 2010
50% of rear-end collisions can be avoided by turning around object

…82% do not steer



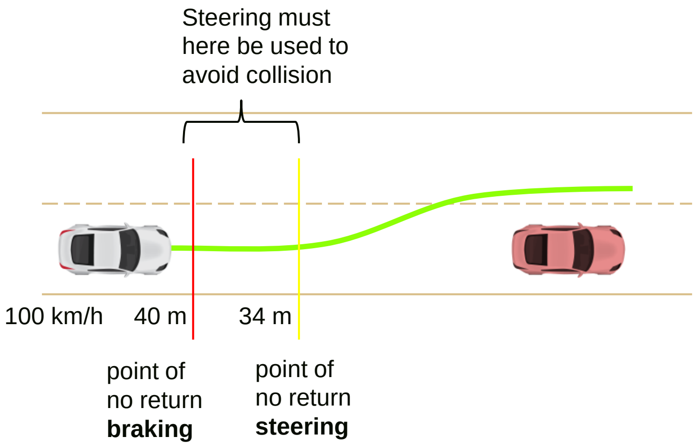
Iowa studies 1990
Drivers brake when TTC is high
Drivers steer when TTC is low

Eckert 2011
TTC=2.0 s and full overlap
Brake 46%, steer 16%, combined 38%

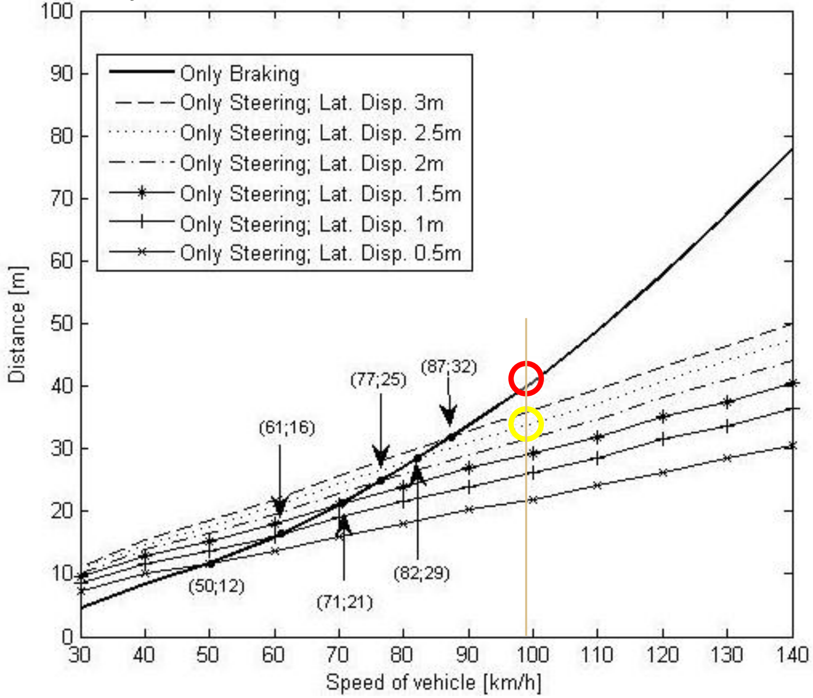
Half overlap: 38% steer
TTC=1.5 s: 57% combined

Ferrandez, Fleury, and Lepesant, 1984
The driver “reacted too late, or too violently, or tried to combine braking with a sideways avoidance movement, which often resulted in loss of control”

VEHICLE POTENTIAL TO BRAKE VS. STEER



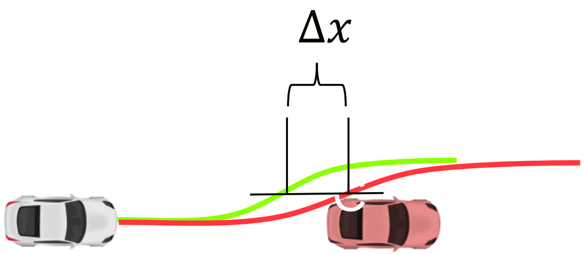
Analysis from CarMaker



Particle model approximations

$$x_{brake} = \frac{1}{2\mu g} (\nabla v)^2 \qquad x_{steer} = \sqrt{\frac{2w}{\mu g}} \nabla v$$

PROBLEM TO BE SOLVED



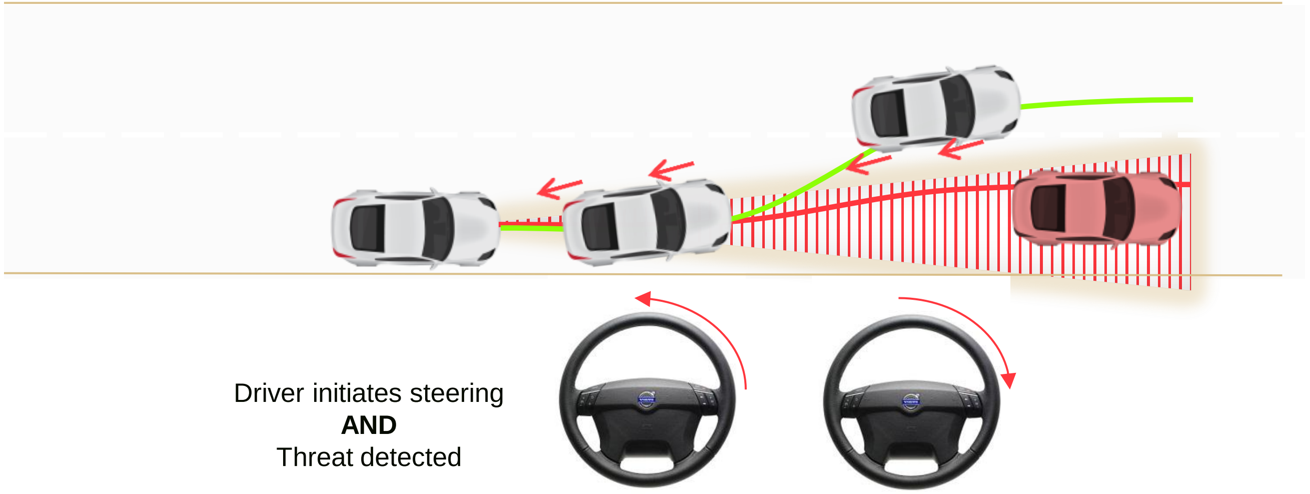
Can we help the driver to move Δx without compromising vehicle stability?

HOW TO ASSIST THE DRIVER?

- Autonomously or driver assist?
- Driver trigged?
- Intrusiveness?
- Which actuators to use?

CONCEPTUAL FUNCTION DESIGN
– EVASIVE MANOEUVRE ASSIST (EMA)

Normal driving | Function trigg | Evasive Control | Function deactivation



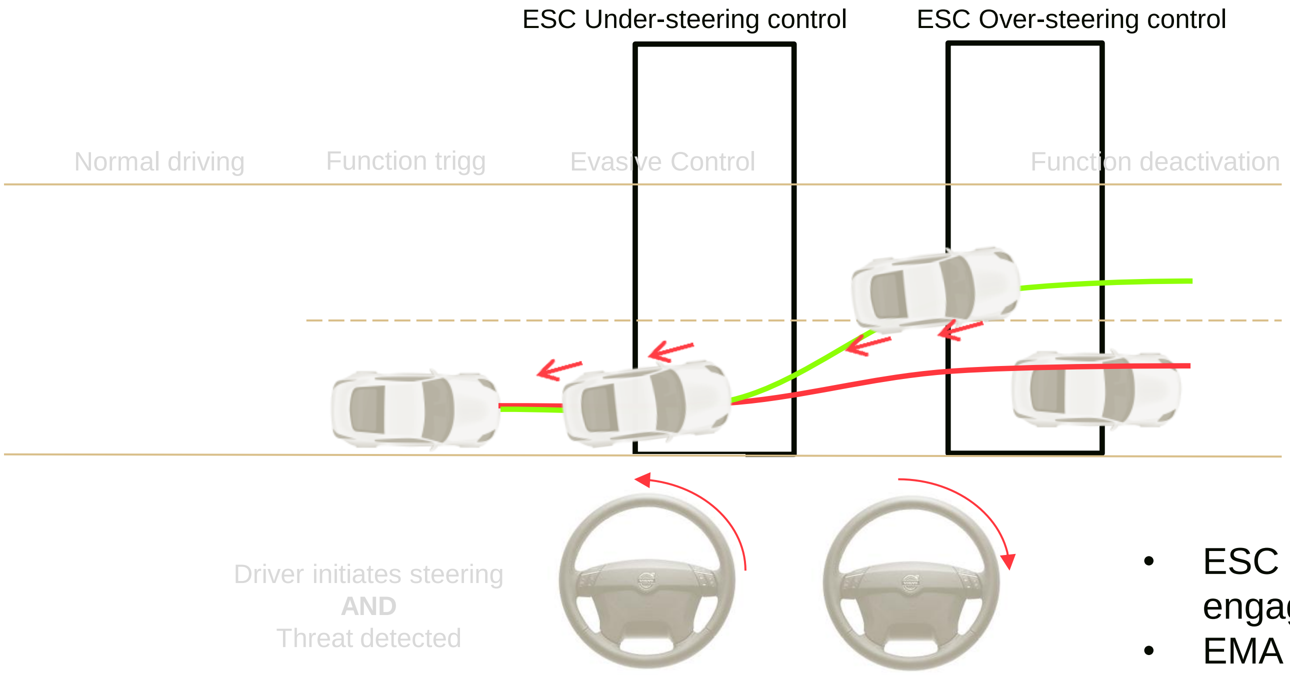
Driver initiates steering
AND
Threat detected

An escape path is generated

Steering-wheel torque overlay
AND
Differential braking

Excessive steering will deactivare EMA

WHAT ABOUT ESC?



- ESC understeering is engaged too late
- EMA deactivated if vehicle becomes too over-steered

EVASIVE MANOEUVRE ASSIST (EMA)

- EMA is a threat depending under-steer control
- EMA gives over-steering, which is dangerous
- However, risk of instability/nervousness behavior must be balanced with risk of collision

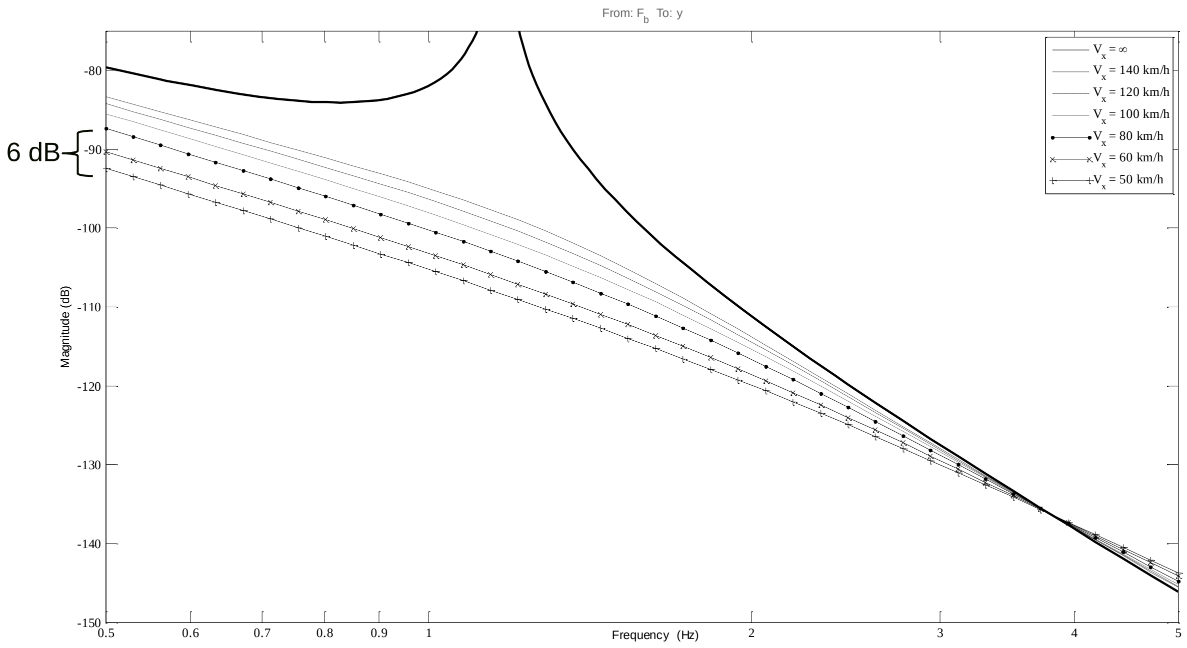
ANIMATION

ANALOGY – EMERGENCY BRAKE ASSIST

EBA increases **brake gain** if **brake pedal** is rapidly engaged
EMA increases **lateral displacement gain** if **steering wheel** is rapidly engaged

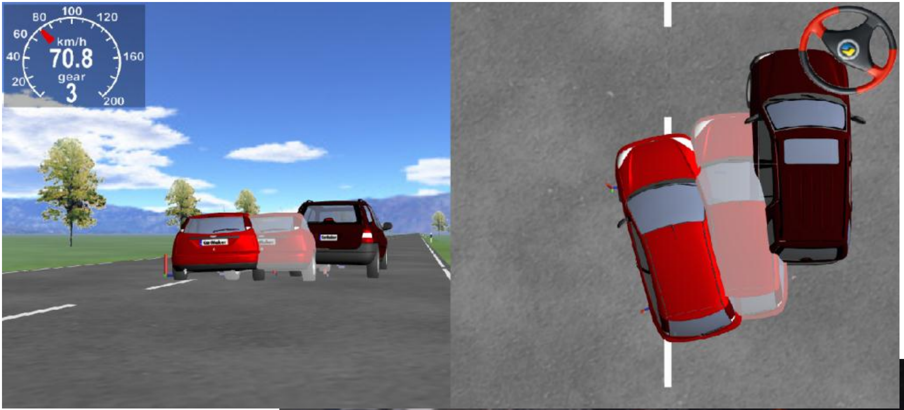
EBA is deactivated by ABS to avoid wheel lock
EMA is deactivated by ESC to avoid over-steering

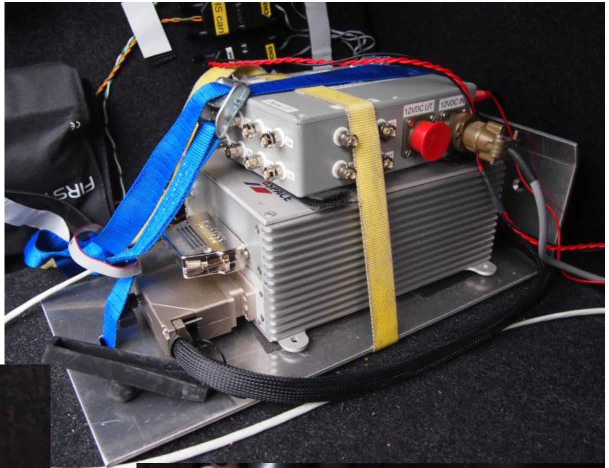
STEER BY DIFFERENTIAL BRAKING



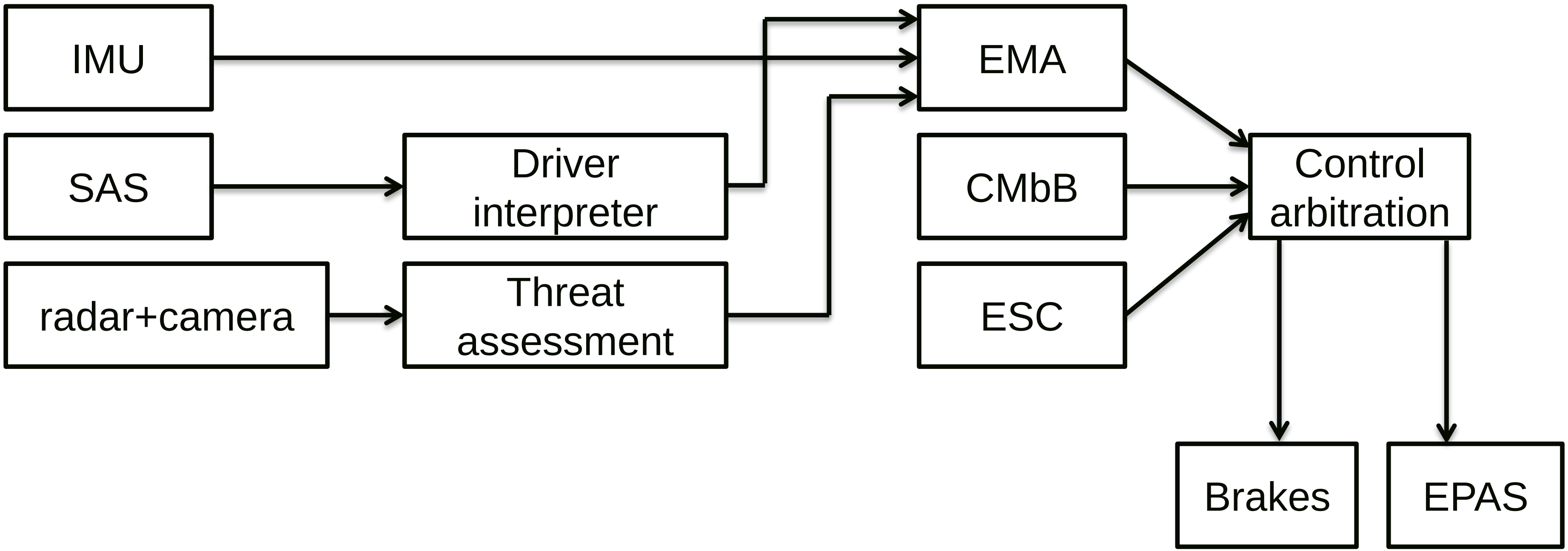
Bode plot ”bicycle model”, magnitude of transfer function from F_b to Y

RAPID PROTOTYPING TOOLS FOR ALGORITHM DEVELOPMENT



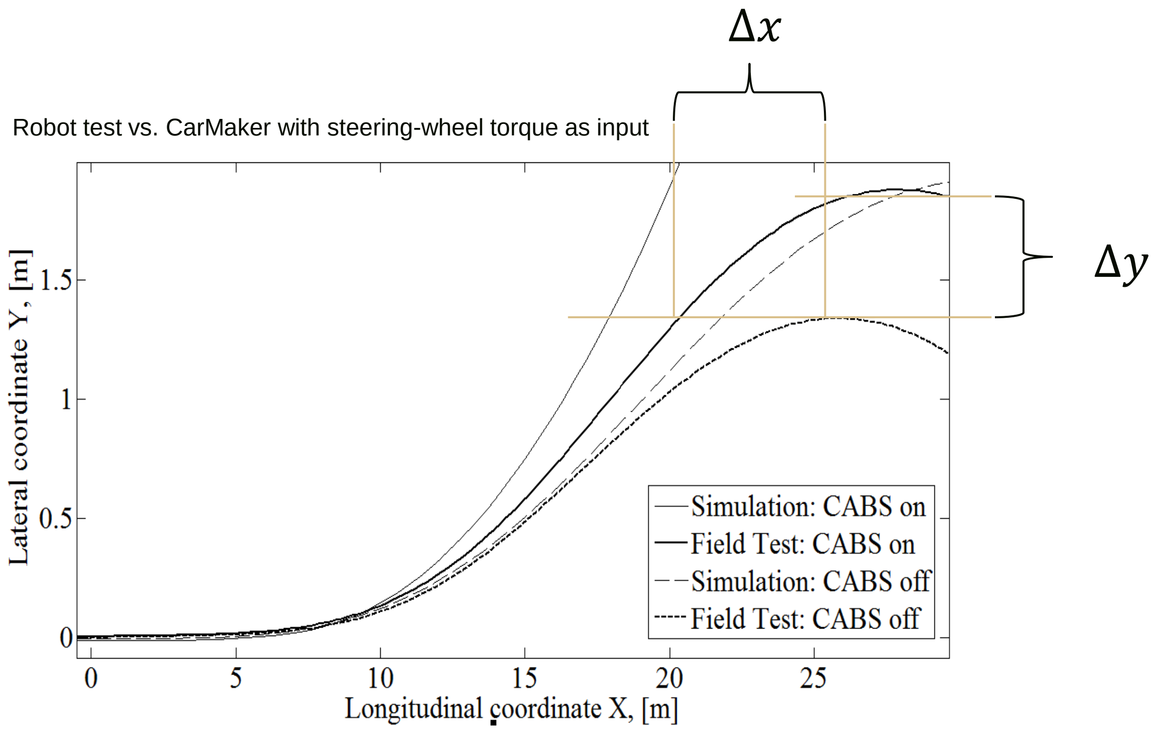


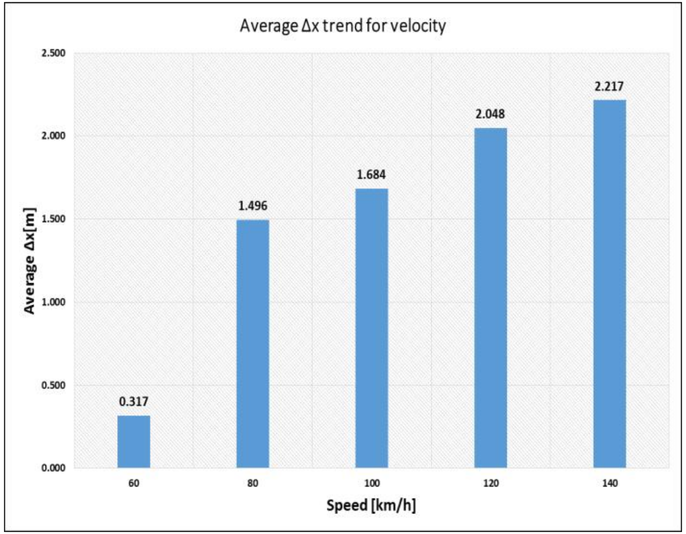
CONCEPTUAL SYSTEM ARCHITECTURE



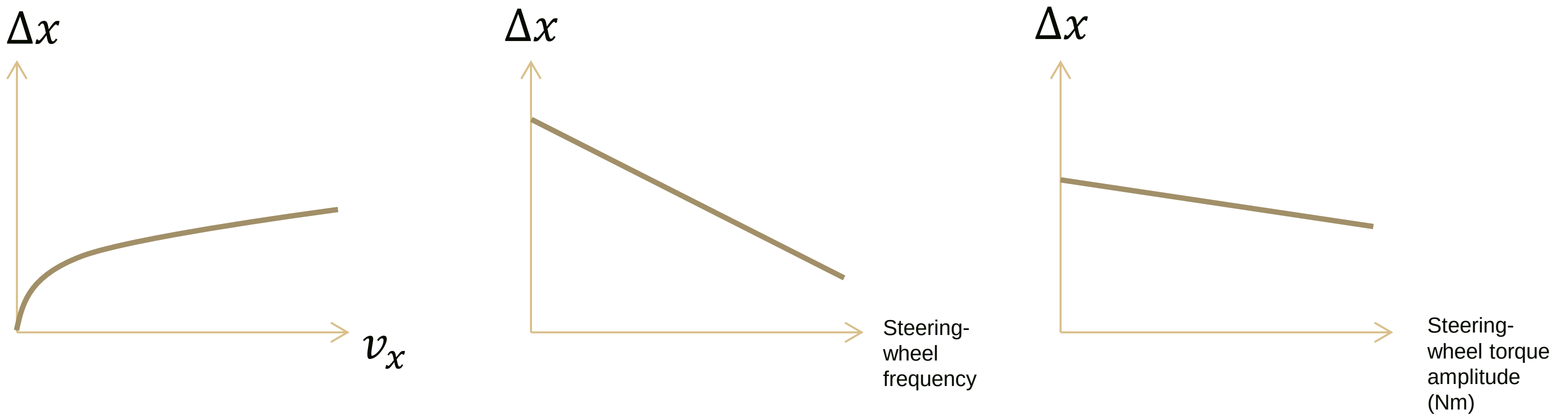
FUNCTION RESULTS

Robot test vs. CarMaker with steering-wheel torque as input





FUNCTION RESULTS



Δx large when:

- vehicle speed is high
- steering-wheel frequency low
- steering-wheel torque amplitude low

Intepretation: drivers with low steering input would benefit from function

DRIVER EXPERIENCE OF EMA

Initial real car test from test subjects have shown:

- Drivers feel ”a magic hand on the car body”
- Drivers find it more easy to evade
- Drivers have fun (was not intended)
- Drivers particularly appreciate the ”push back kick”

CONCLUSION

- EMA increases Δx, which is roughly in the order of 1m
- Δx higher for weak steering-wheel torque and high vehicle speed
- The view of understeer control must be changed by balancing the risk of collision
- EMA is an example of where Collision Avoidance and Electronic Stability Control are merged