Holistic and cross-functional approach to vehicle development catalyzed by DiM 250

Vijay Ramnath
Vehicle dynamics, CEVT

Dr. Adam Brandt
Aerodynamics, CEVT

2023-05-24

CEVT
For a different tomorrow


CEVT
China Euro Vehicle Technology
Creating mobility solutions for a different tomorrow

World-class engineering in the heart of Sweden's automotive cluster

- Established 2013 in Gothenburg, Sweden.
- European R&D and Innovation Center for ZEEKR
- Extensive international engagement with innovation hubs and start-ups
- A significant and business-oriented IP portfolio
- Delivers to ZEEKR, Volvo Cars, Lotus, Polestar and Lynk & Co

1500 researchers, designers and engineers + 200 inventions annually

Think big + Find a way + Inspire

Part of a powerful portfolio of automotive and mobility brands within the Geely Group

Volvo Car Group

ZEEKR

CEVT

Geely Auto Group

LYNK&CO

GEOMETRY

GEELY AUTO

Lotus Group

Smart

LEVC

Other

VOLOCOPTER

曹操出行
CAOCAO

We fast-track innovation and transform ideas into pioneering technology solutions

CMA platform

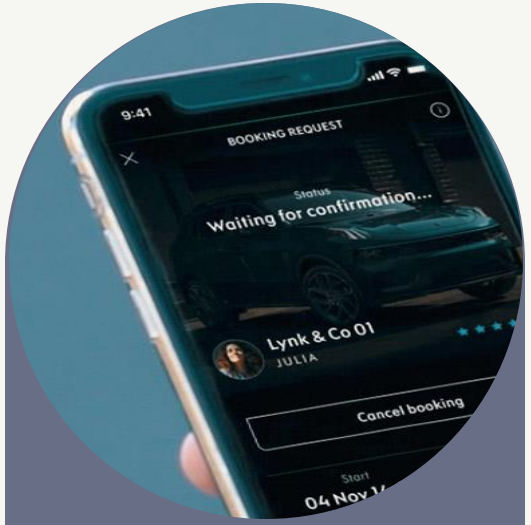
Volvo XC40/C40
Lynk & Co 01/02/03/05
Polestar 2

Developed in 3 years
Over 2 million delivered

7-speed DCT

Hybrid and prepared for electrification

Honoured with China Automotive Industry Science and Technology Award



Lynk & Co app

Control, monitor and share the car

First customer to customer car sharing app on the market using phone as a key

Waymo / Google

Vehicle supplier to Waymo One fleet

ZEEKR/CEVT and Waymo: a win-win partnership

CEVT

Automotive is in our DNA, intelligent mobility is our core

- Development of ground-breaking mobility solution
- Architecture designed for global usage and fully electric, autonomous vehicles
- Digital portfolio for the ultimate experience
- European engineering and design
- Passion for innovation and continuous improvement

Meet ZEEKR

Coming to Sweden and Netherlands Q4 2023

ZEEKR 001→ A luxury shooting brake

ZEEKR X →Urban SUV

Distinctive styling

Intelligent driving

Advanced connectivity

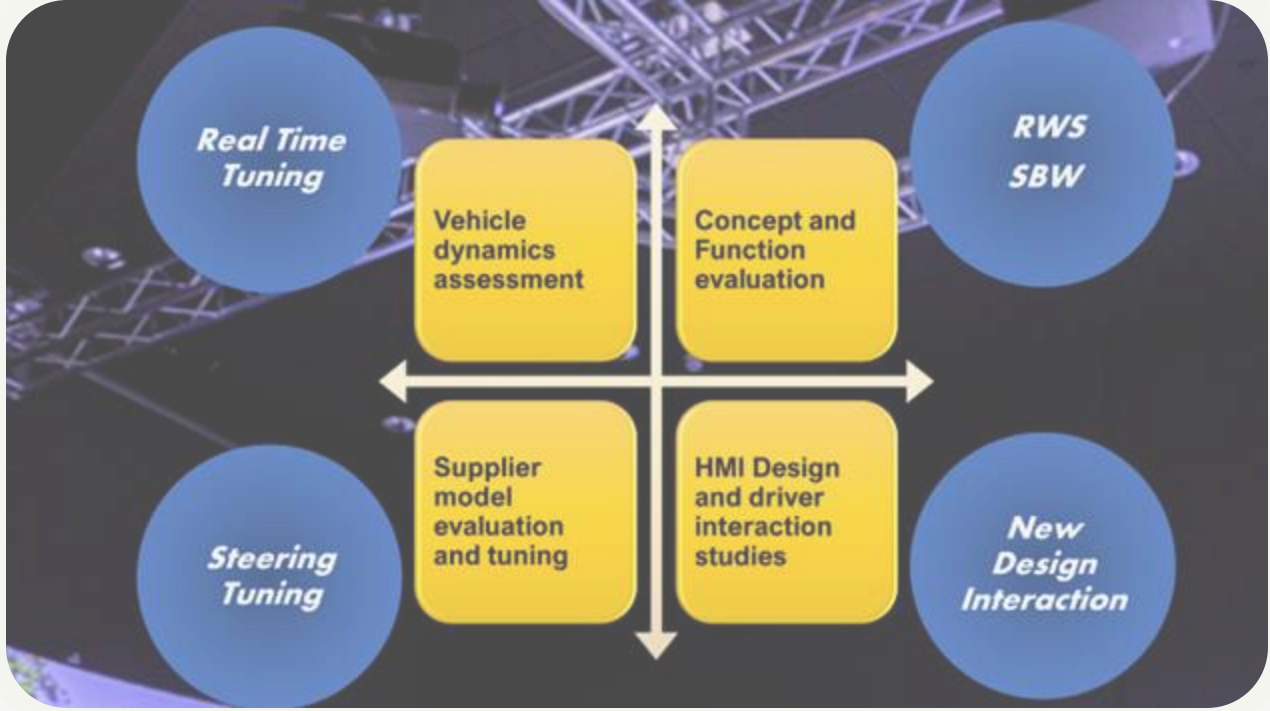
DiM250: A muti-dimensional virtual dev tool

Chassis Real Time Tuning

Model Exchange

Aerodynamics

BBW maps



CEVT

Development without architecture constraints

Rear Wheel Steer

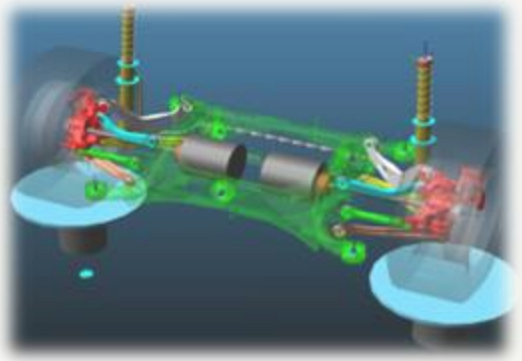
Steer by wire: 3rd actuator

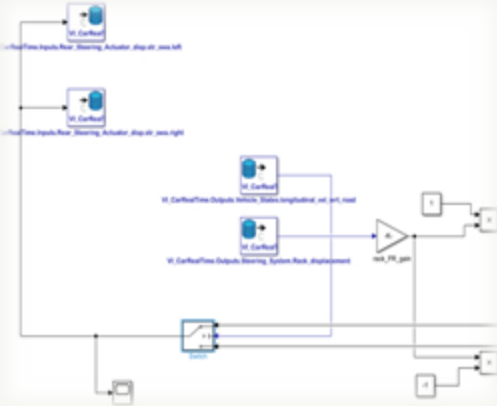
Rear wheel steer in DiM250

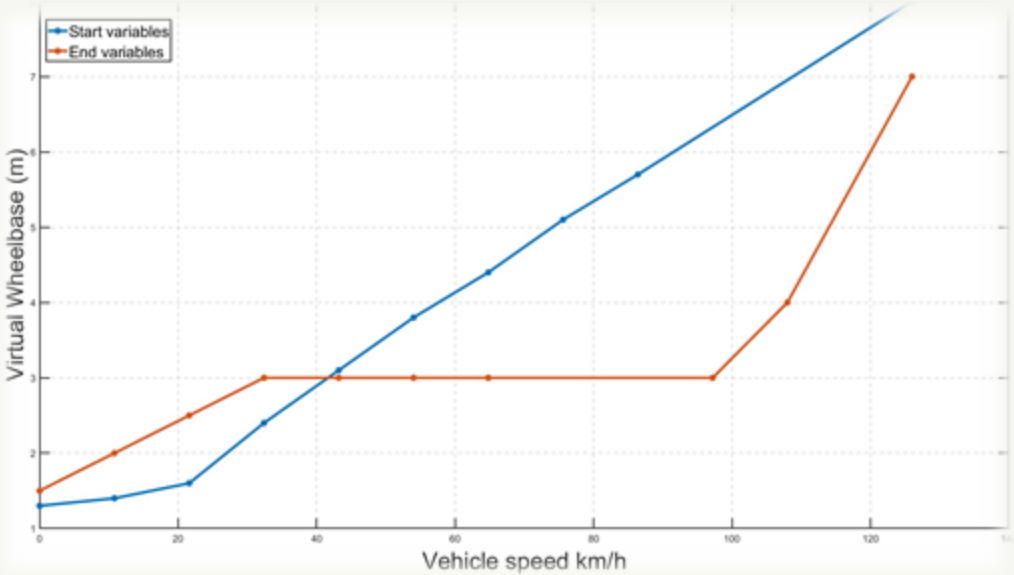
Rear suspension with RWS actuator was developed in ADAMS/Car and exported to VICRT

Controller development for the rear actuator was done in two stages :

- A simple proportional controller :
  - Out of phase at low speed
  - In phase at higher speed
- A yaw-rate based feedback controller was developed to evaluate stability and transient behavior







Stakeholder feedback

More “agile” vehicle

Less effort in tight corners (World-Sim)

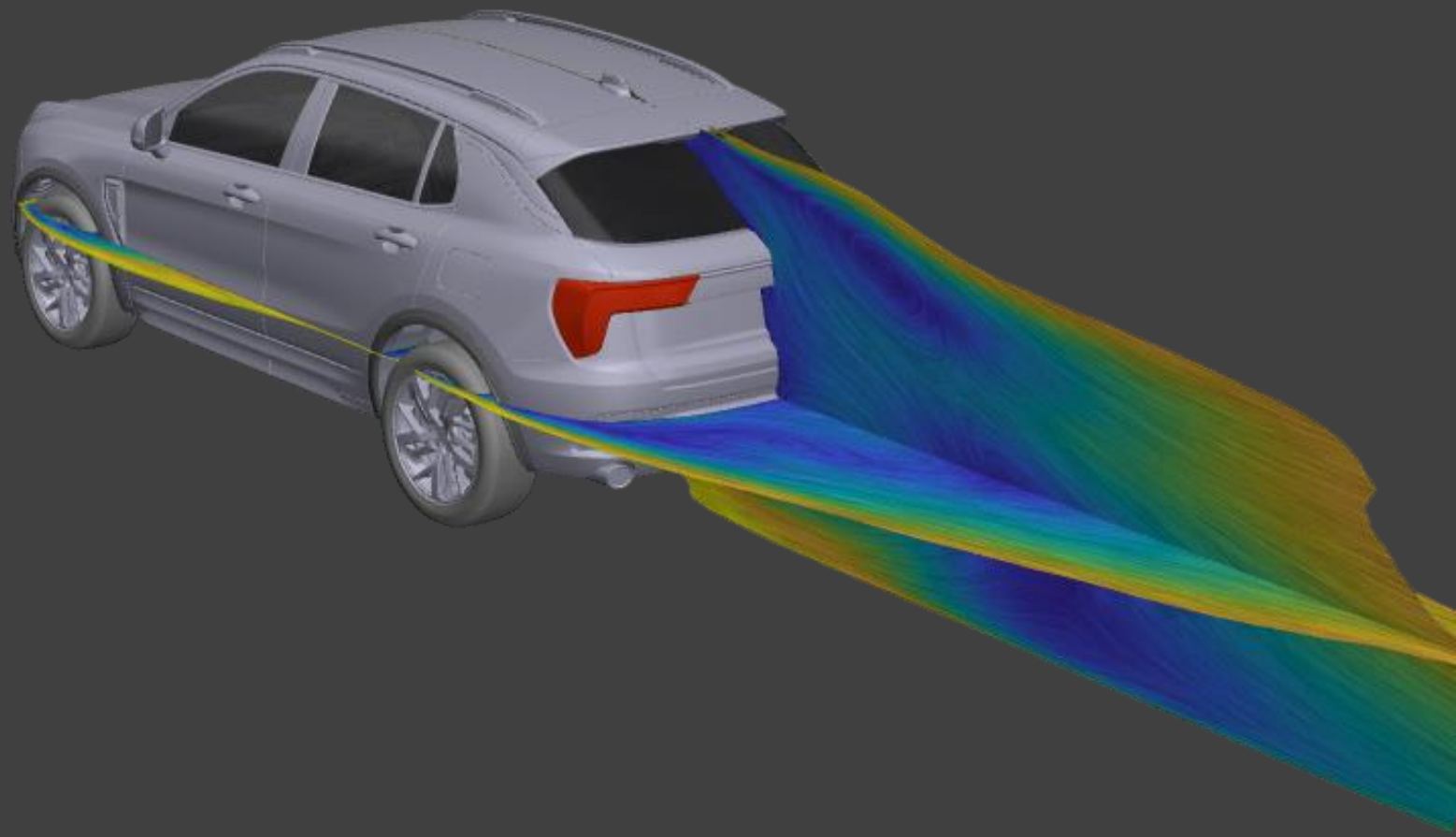
Influence on vehicle response reflects reality

Positive tuning sessions with external customer models

CEVT


2023-01-0678 Published 11 Apr 2023
Model-Based Coordinated Steering and Braking Control for a Collision Avoidance Driver Assist Function
Yiquan Li KTH Royal Institute of Technology
Simon Petrovich CEVT AB
Mikael Nybacka KTH Royal Institute of Technology
EVASIVE MANEUVER ASSIST

Unsteady aerodynamic evaluations using the driving simulator



Dr. Adam Brandt, Aerodynamics

CEVT

For a different tomorrow

Introduction to driving stability

- Vehicle nervousness
- Driver c
- Discom

Driving stability

Crosswind sensitivity

- Effect from external conditions
- Lateral aerodynamics

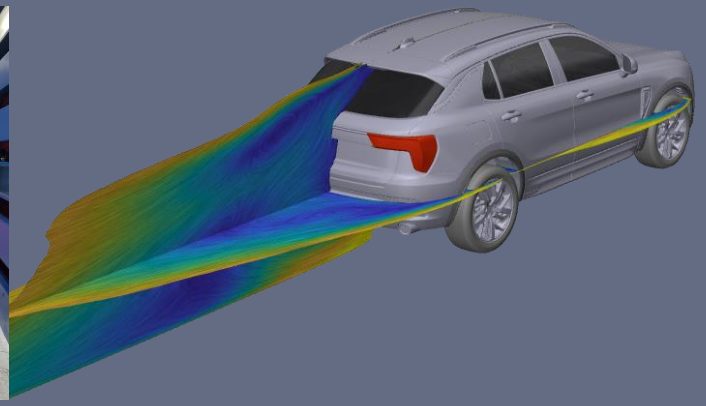
High speed stability

- Self-induced stability effects
- Vertical aerodynamics

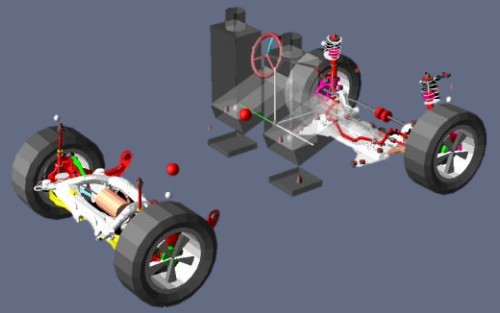
Introduction

- Driving stability is usually evaluated late in the development

Road

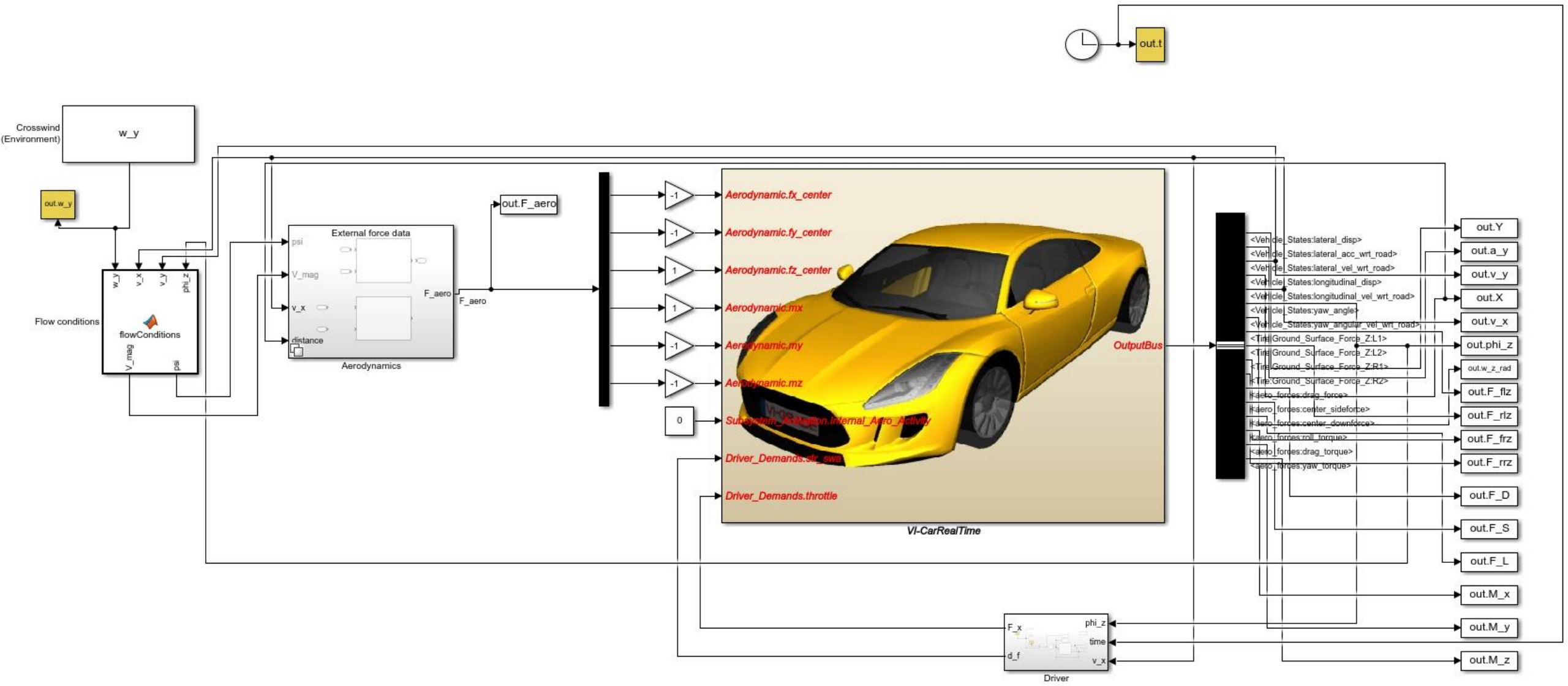


Lab



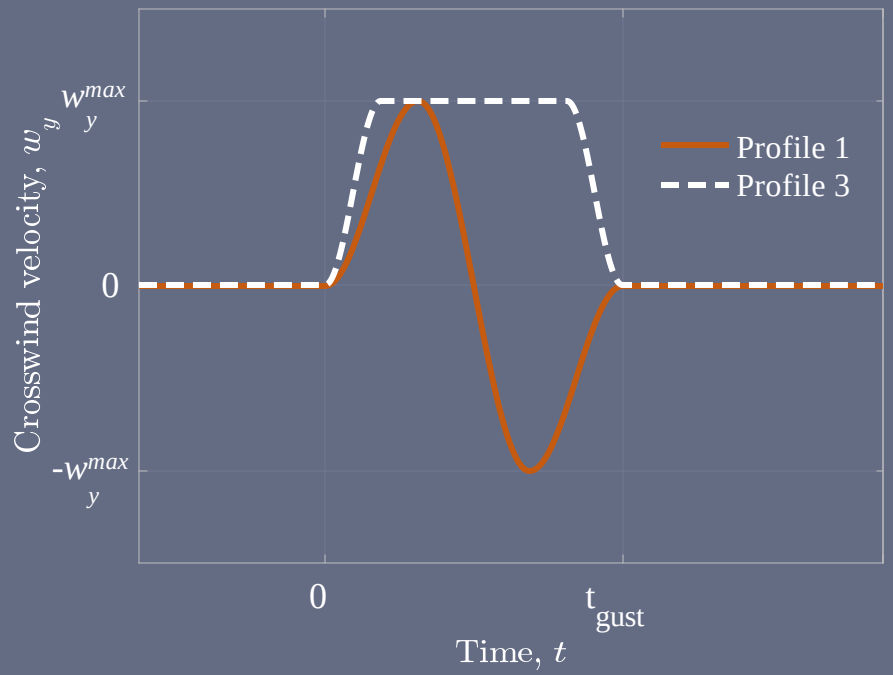
Math

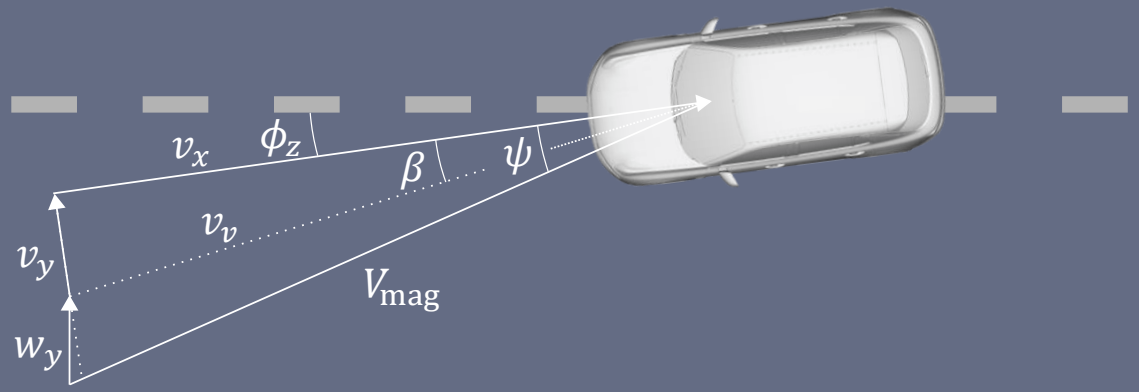
Unsteady aerodynamic loads in the driving simulator



Crosswind sensitivity – Methodology

- Gust profiles
- 2-way road perpendicular coupling





$$V_{mag} = \sqrt{v_v^2 + w_y^2 + 2v_v \sin(\beta + \phi_z)}$$

$$\psi = \tan^{-1}\left(\frac{w_y + v_v \sin(\beta + \phi_z)}{v_v \cos(\beta + \phi_z)}\right) - \phi_z$$

Crosswind sensitivity – Methodology

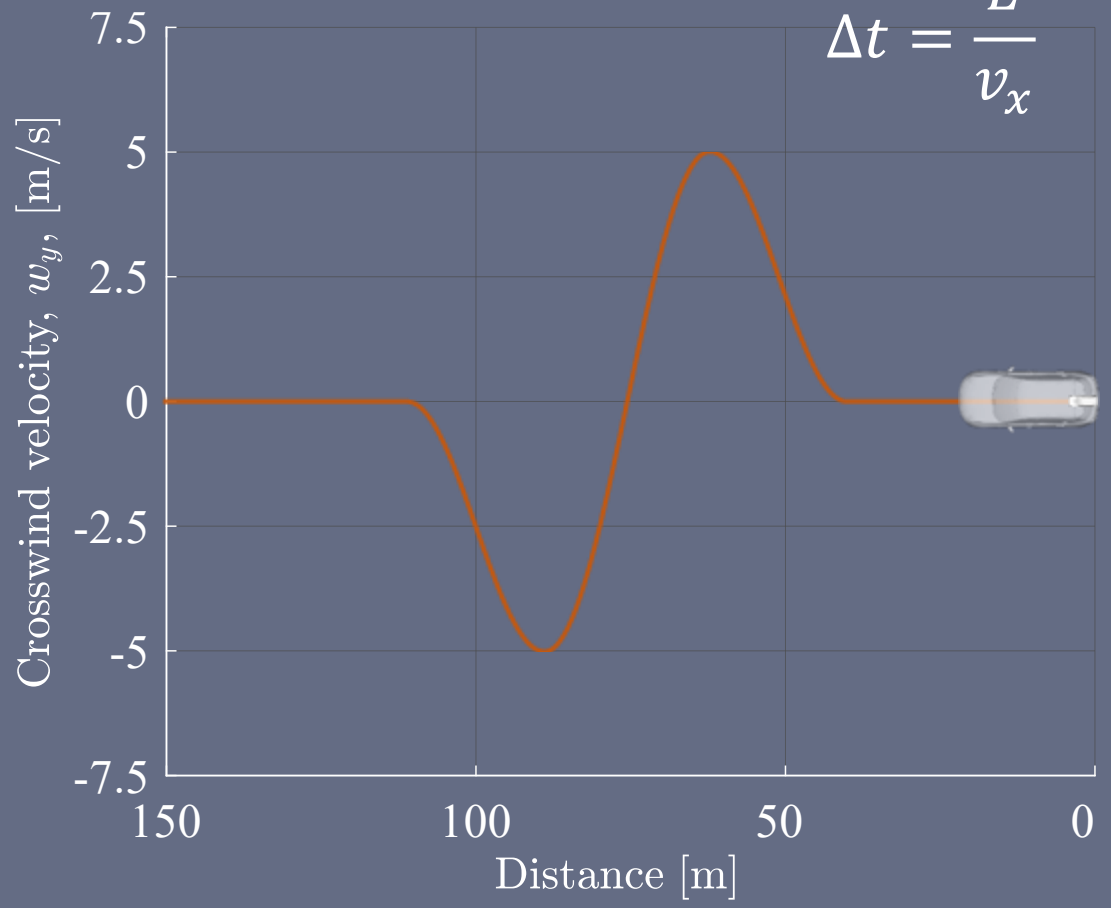
- Most crosswind variations occur from driving into different wind conditions [1]
- The aerodynamic QSD (Quasi-steady with axle Delay) model [2] was used

$$F_{sf} = \frac{F_S}{2} + \frac{M_z}{L} \quad \text{and} \quad F_{sf} = \frac{F_S}{2} - \frac{M_z}{L}$$

$$F_S(t) = F_{sf}(t) + F_{sr}(t - \Delta t)$$

$$M_z(t) = \frac{L}{2}\left(F_{sf}(t) - F_{sr}(t - \Delta t)\right)$$

$$\Delta t = \frac{L}{v_x}$$

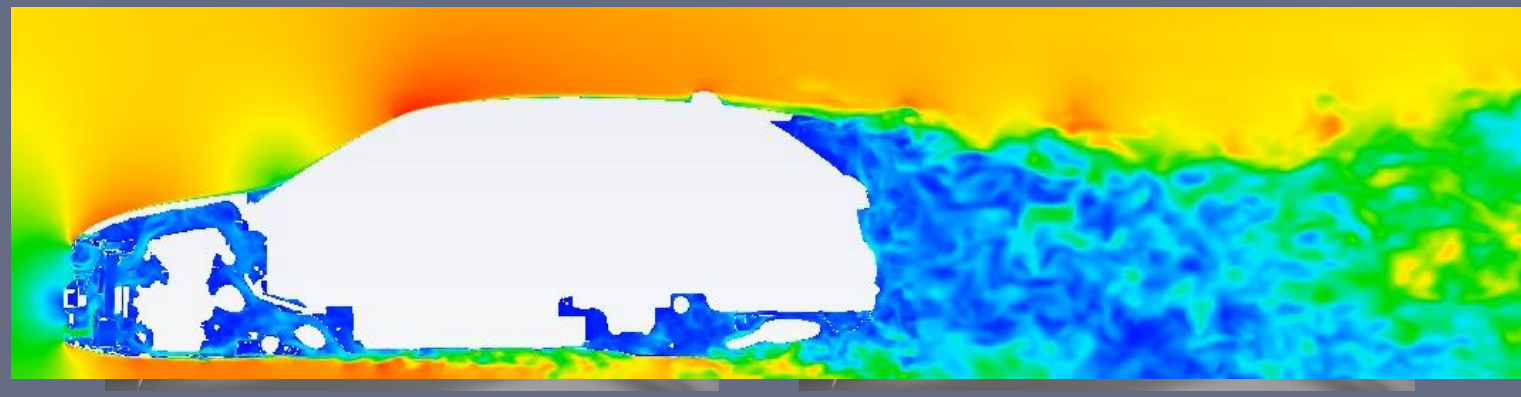


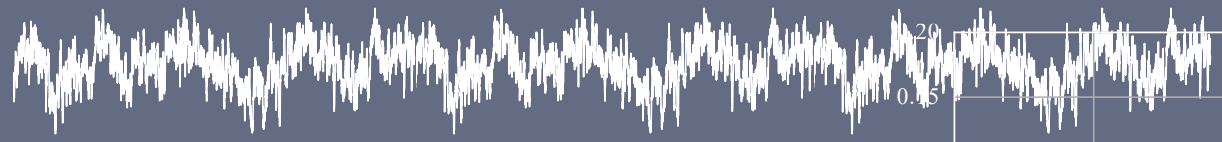
[1] Sims-Williams, D. "Cross Winds and Transients: Reality, Simulation and Effects", SAE International Journal of Passenger Cars – Mechanical Systems (2011), doi: 10.4271/2011-01-0172

[2] Brandt, A., Jacobson, B. and Sebben, S. "High Speed Driving Stability of Road Vehicles under Crosswinds: An aerodynamic and vehicle dynamic parametric sensitivity analysis", Vehicle System Dynamics (2021), doi: 10.1080/00423114.2021.1903516

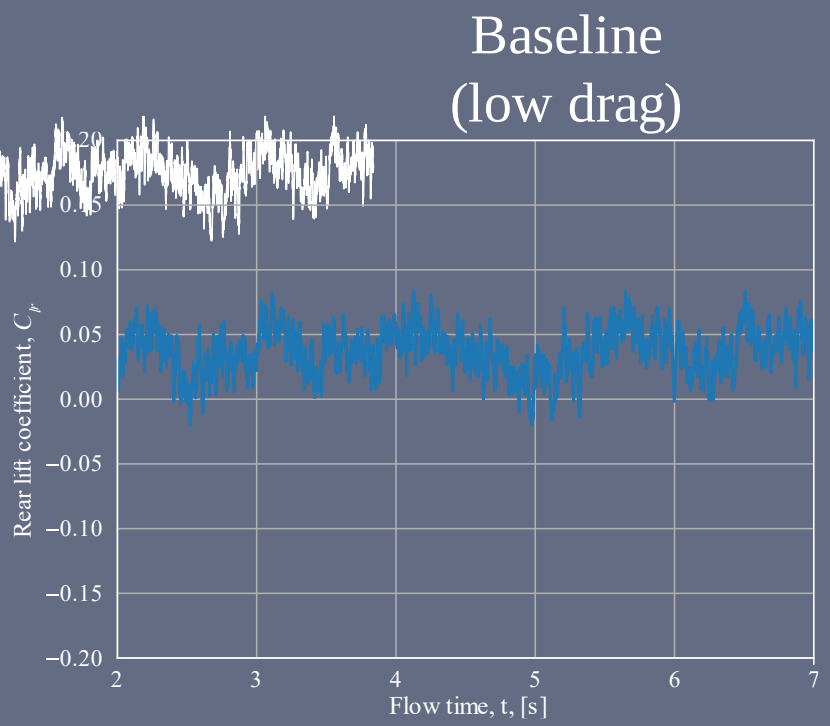
High speed stability – Methodology

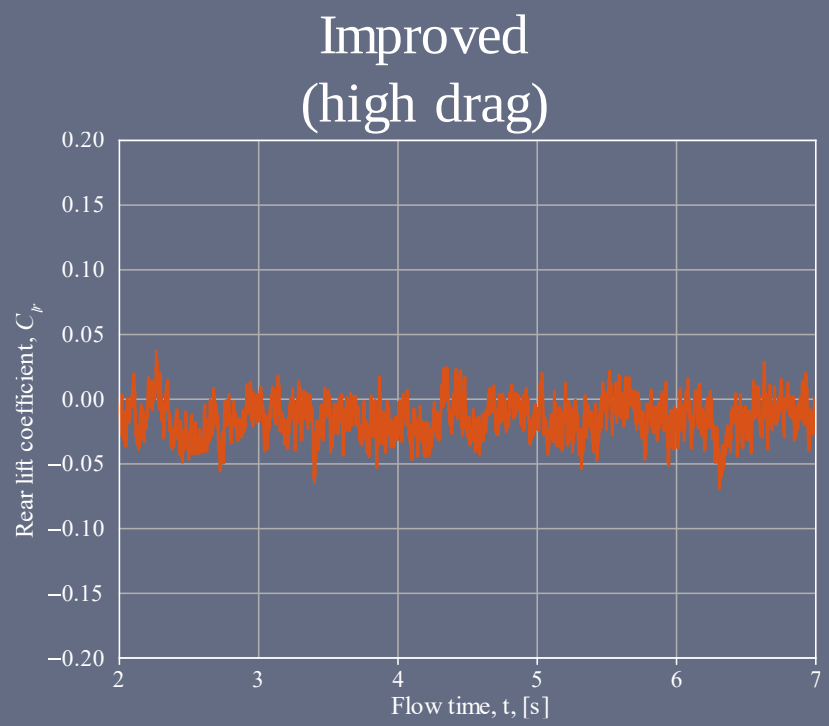
- Scale-resolving CFD simulation
  - SBES (hybrid RANS-LES)
  - 190 million cells
  - 5 s physical time
  - 10 days on HPC cluster





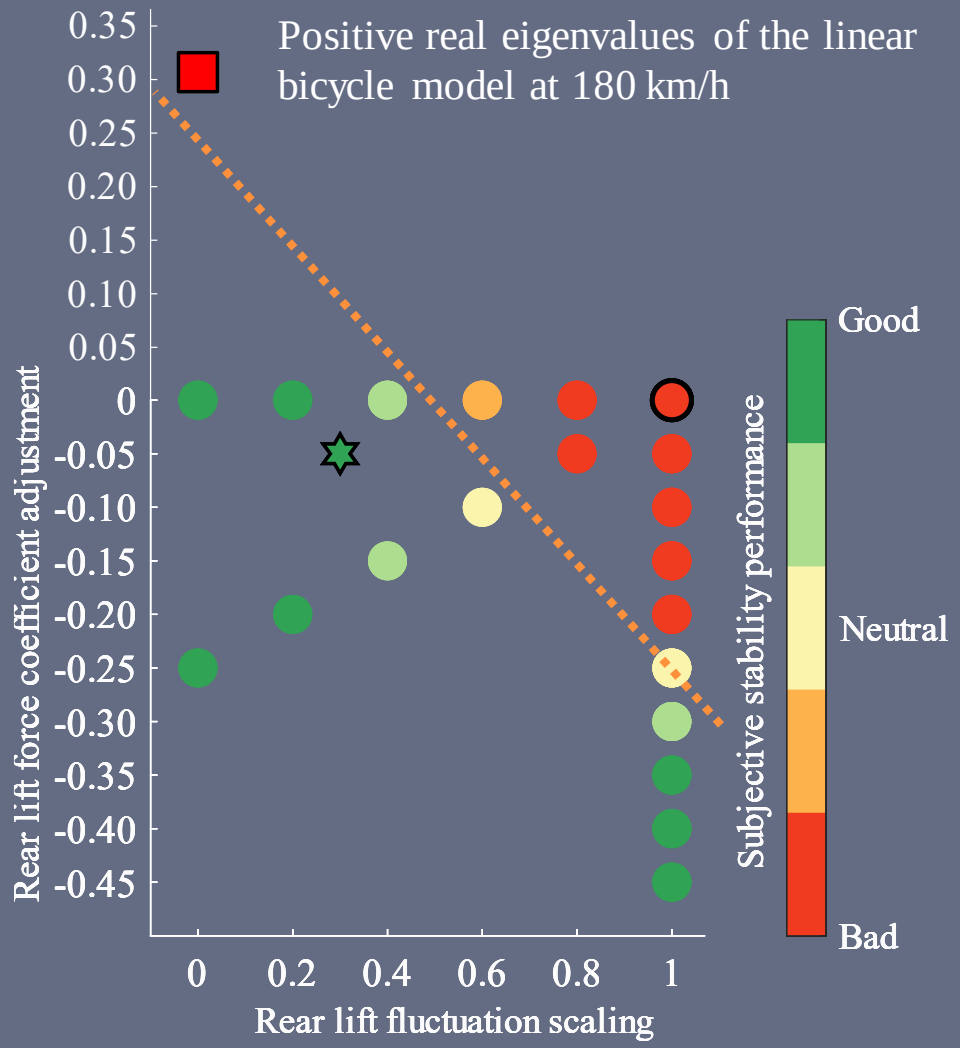
- 3 professional test drivers

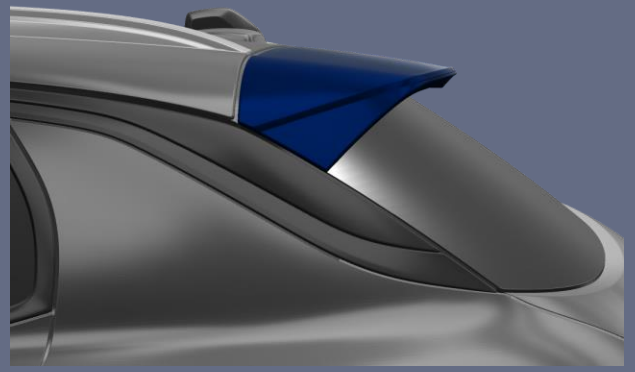




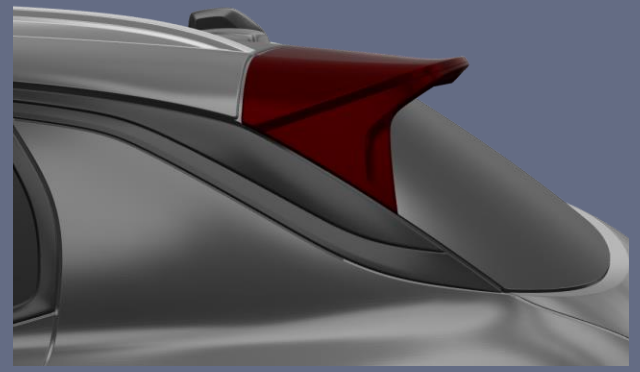
[3] Brandt, A., Sebben, S. and Jacobson, B. "Base wake dynamics and its influence on driving stability of passenger vehicles in crosswind", Journal of Wind Engineering and Industrial Aerodynamics (2022), doi: 10.1016/j.jweia.2022.105164

High speed stability – Results





Baseline



Improved

Conclusions

- The driving simulator can be used to assess both crosswind sensitivity and high speed stability
- Aerodynamic rear lift fluctuations greatly influence high speed stability
- The aerodynamic properties and loads can be altered while driving, enabling back-to-back comparisons and investigations on active aerodynamics
- For an electric and autonomous future:
  - Comprehend the cross-functional sensitivity of design choices
  - Dim250 is the ideal tool to provide the needed holistic understanding

Thank you for listening!

CEVT

For a different tomorrow

cevt.se

instagram.com/cevt_sweden

linkedin.com/company/cevt