Virtual Winter Driving Experience

Henrik Hvitfeldt
PhD candidate
KTH Royal Institute of Technology

Virtual Winter Driving Experience, Henrik Hvitfeldt & Carl Sandberg, Security Class: Proprietary

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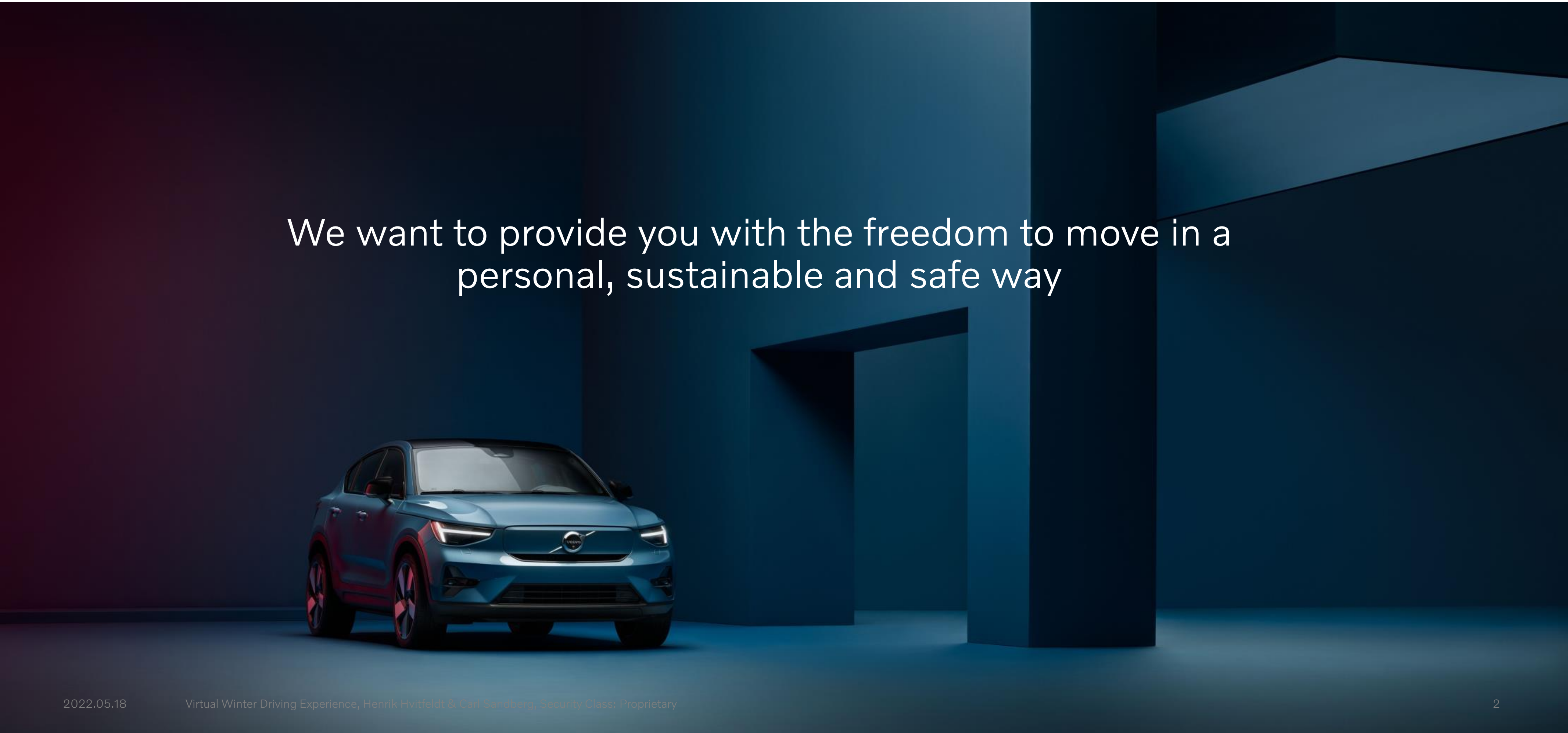
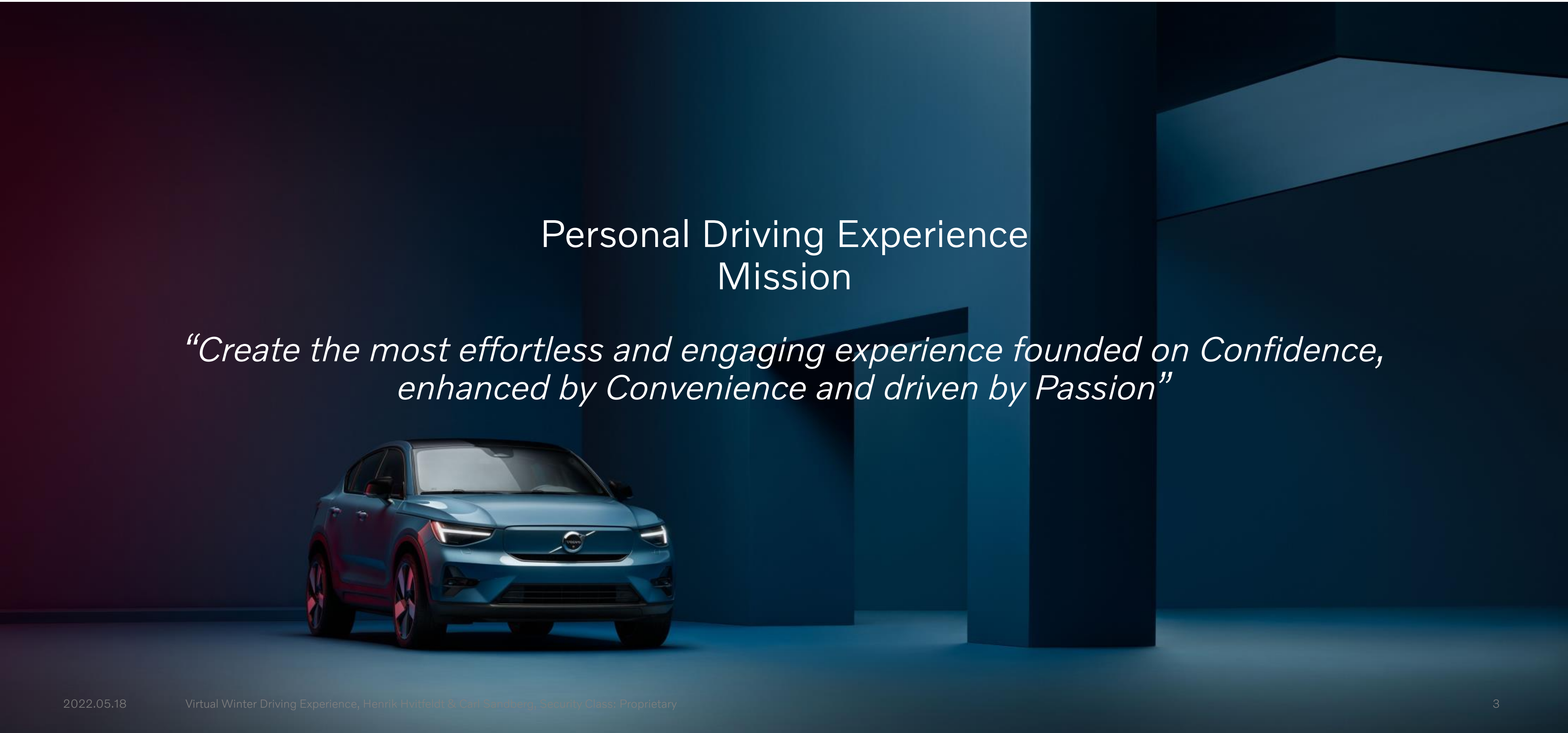
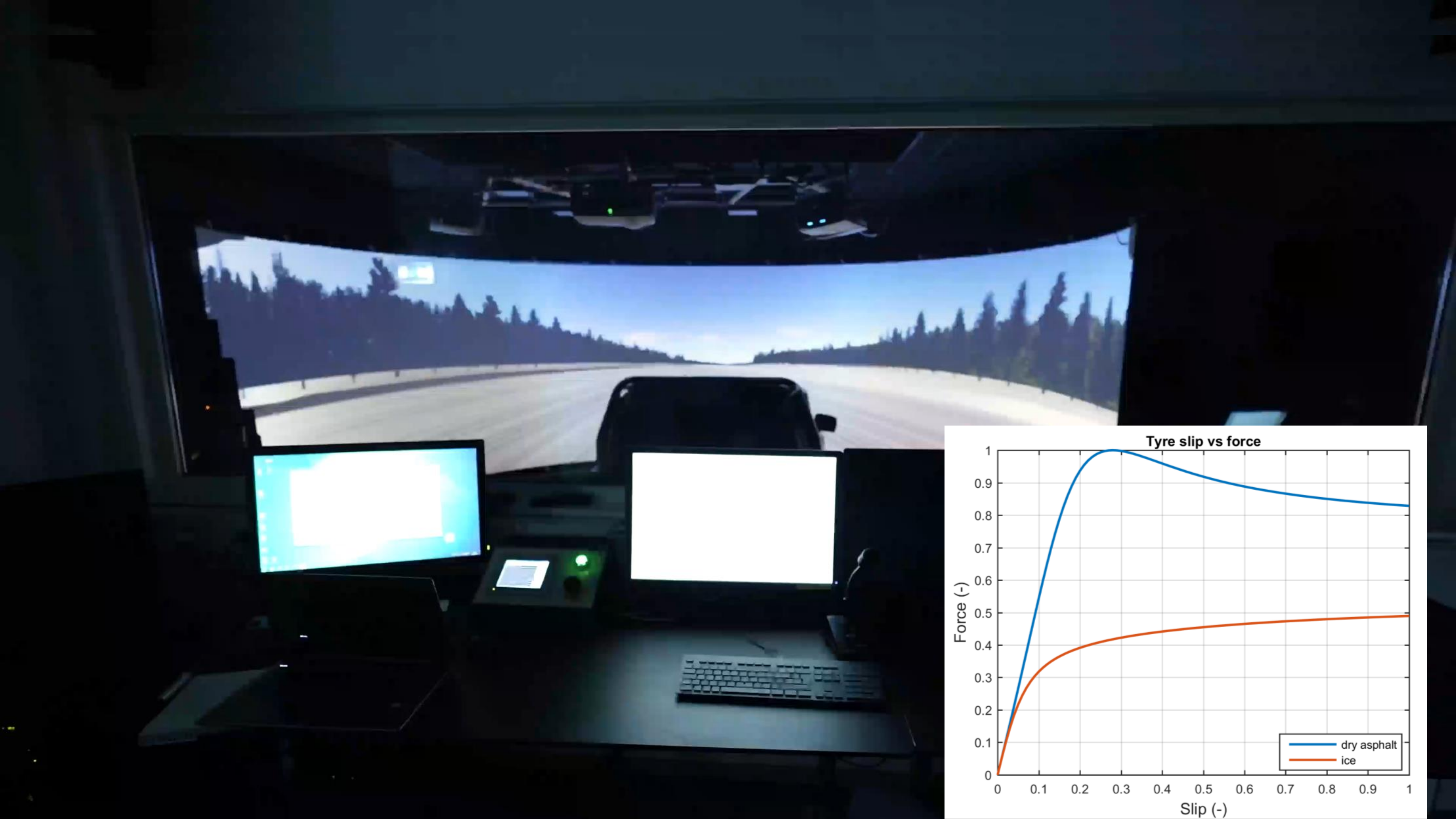
We want to provide you with the freedom to move in a personal, sustainable and safe way





Personal Driving Experience Mission

“Create the most effortless and engaging experience founded on Confidence, enhanced by Convenience and driven by Passion”


Tyre slip vs force
Force (-)
Slip (-)
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
dry asphalt
ice

The winter challenge

Load transfer ↑ Grip level ↑

Drive torque distribution importance ↑

High slip angles ↑

The winter challenge

Evaluating low-μ handling objectively is even more challenging than high-μ

- Subjective assessments are needed for rapid functional prototyping.
- 3 months of winter is not enough.

Case Study Low-μ EPAS functionality

DiM-150 was used to evaluate low-μ EPAS functionality
before winter expeditions began

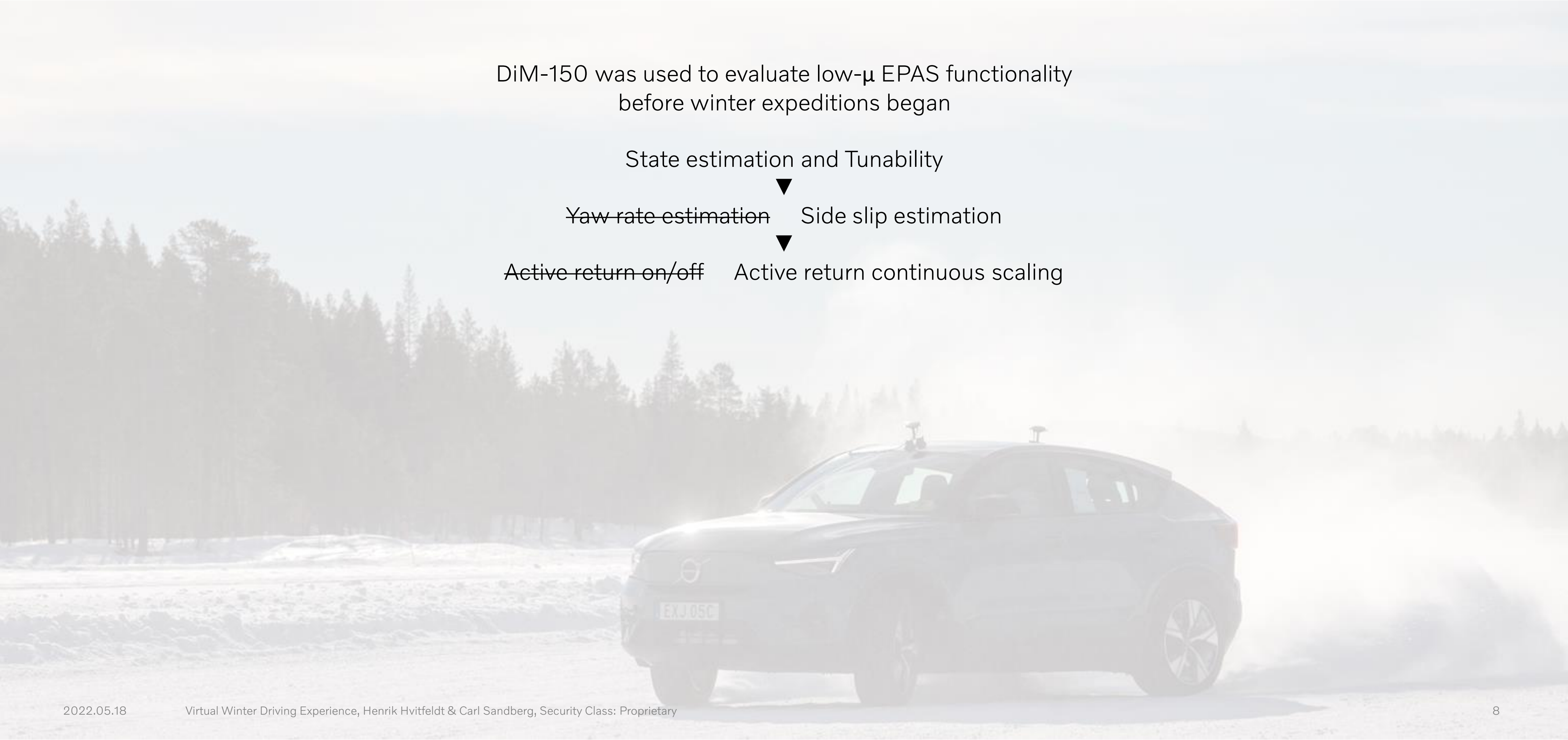
State estimation and Tunability

▼

~~Yaw rate estimation~~ Side slip estimation

▼

~~Active return on/off~~ Active return continuous scaling



Case Study eAWD tuning

Plug-in hydrid cars from Volvo use a direct drive rear electric motor and a petrol engine for the front axle.

→ Response of e-machine needs to be carefully tuned to match petrol engine.

Case Study eAWD tuning

E-motor and battery performance upgrade

▼

~~Feedforward controller~~ Feedback controller

Torque distribution based on reference levels model compensating over- and understeer

▼

Torque distribution and response mapping in DiM-150

▼

Final tuning upon first arrival to the winter proving ground

1-2 expeditions were avoided

PhD Overview: Objective human centered motion cueing

Research aim:

Use a human centred approach to understand which areas of motion cueing is important for simulator fidelity.

Develop a methodology for objective motion cueing algorithm (MCA) evaluation.

Further improved MCA moving towards closing the virtual development loop

Lateral slip feedback in winter testing: Background

For winter driving and limit handling, slip angle and slip rate is important feedback of vehicle stability

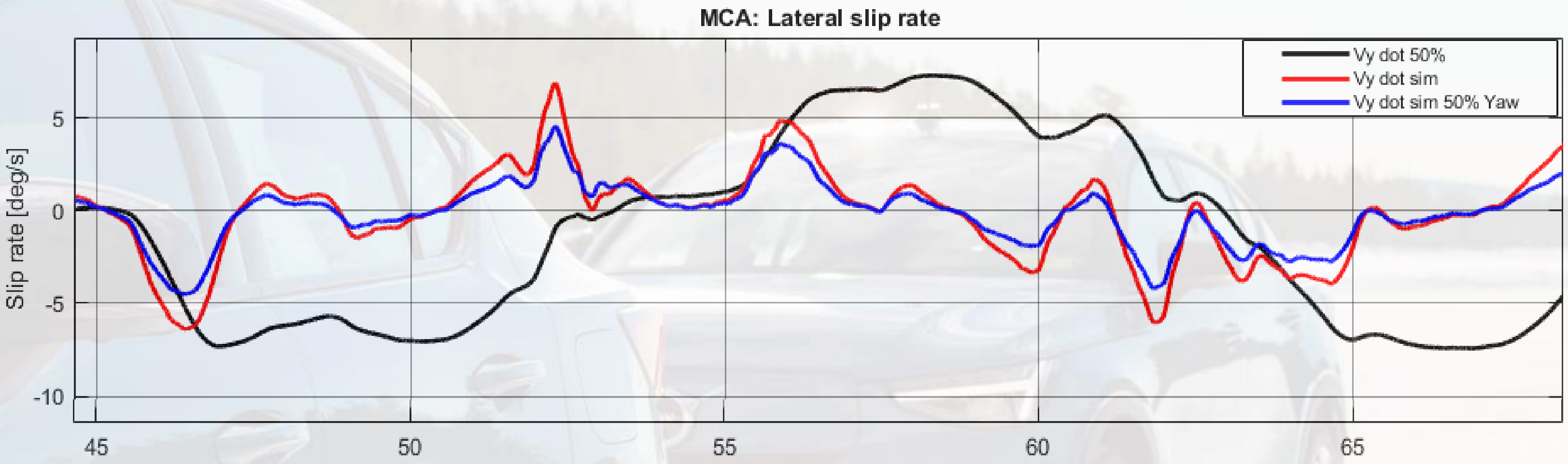
To represent the vehicle stability characteristics in a simulator, how important is slip rate feedback?

Feedback of slip rate and slip angle is obtained from:

- Steering torque feedback (movement of “zero torque angle”)
- Visual feedback
- Motion perception

This study aims to investigate the importance of relative scaling of lateral acceleration a_y and yaw rate $\dot{\psi}$ on perceived transient stability.

Lateral slip feedback in winter testing: Background



Lateral slip feedback in winter testing: Test summary

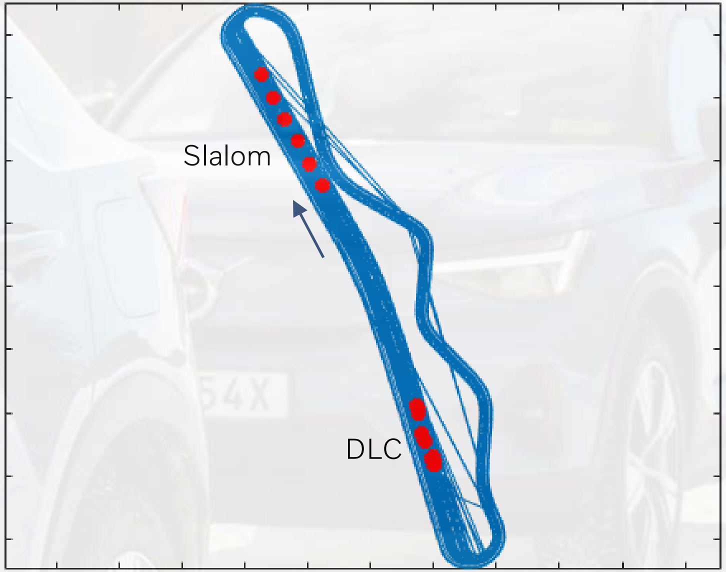
Vehicle A (reference)

Vehicle B (120kg added in the trunk)

Vehicle C (95kg added in the frunk)

Subjective assessment of transient and steady state stability using pairwise comparison (A vs B and A vs C test) with 4 test drivers on ice track.

A slalom manoeuvre and a DLC was added to the test track



Lateral slip feedback in winter testing: Test summary

The subjective part of the physical test was repeated in the DiM150

Vehicle A

Vehicle B (120 in the trunk)

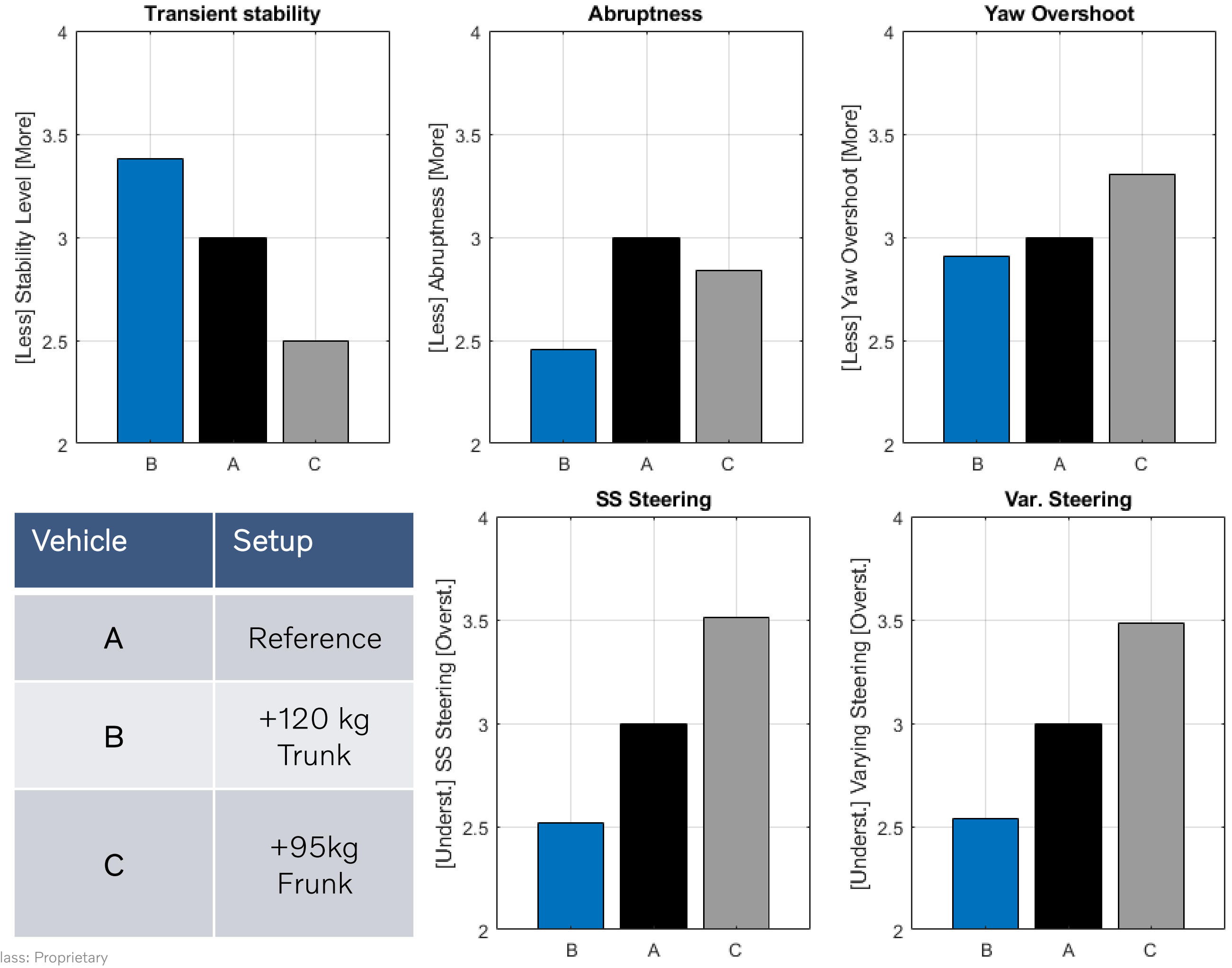
Vehicle D (Vehicle A with motion cueing replicating vehicle B)

Subjective assessment of transient and steady state stability using pairwise comparison (A vs B and A vs D test) with 3 test drivers on ice track.

Lateral slip feedback in winter testing: Results

Vehicle B
Most transient stable
Most steady state understeered

Vehicle C
Least transient stable
Less abruptness than reference
Most oversteered in steady state



Vehicle	Setup
A	Reference
B	+120 kg Trunk
C	+95kg Frunk

Lateral slip feedback in winter testing: Results

Vehicle A vs Vehicle B Slalom data (24 lap average):

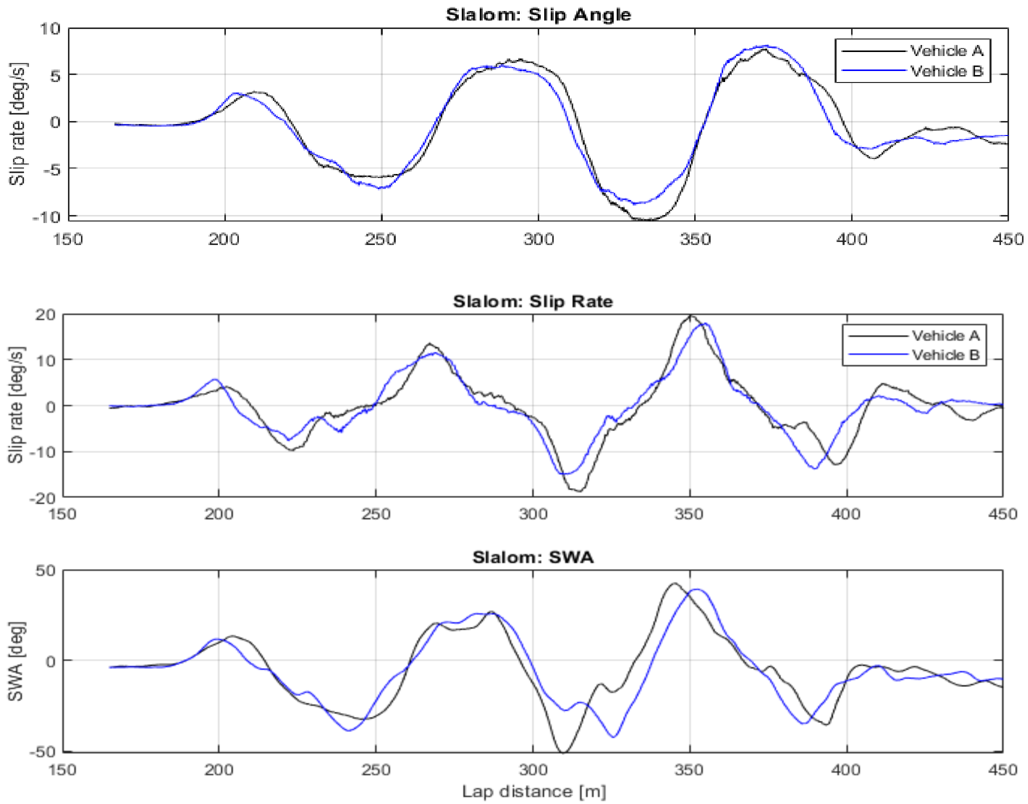
Average slip angle response of vehicle A and B is similar

The slip rate for vehicle A is slightly higher in peak compared to B

Steering behaviour shows larger corrections for A (20% over B peak to peak)

Average yaw rate is ~11% lower for B than for A (for similar velocity)

Vehicle	Setup
A	Reference
B	+120 kg Trunk

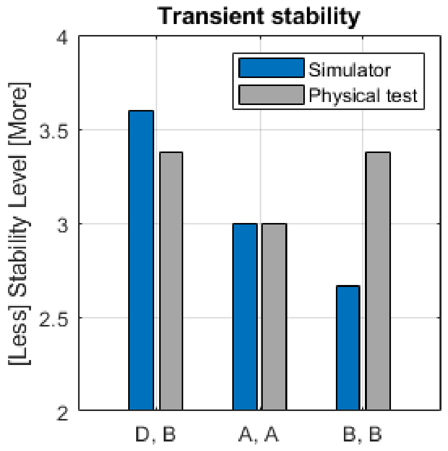


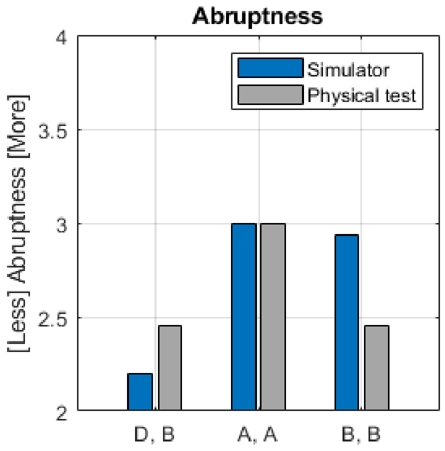
Lateral slip feedback in winter testing: Simulator results

The motion cueing was changed to make vehicle A emulate vehicle B by reducing motion cueing yaw gain by 10%

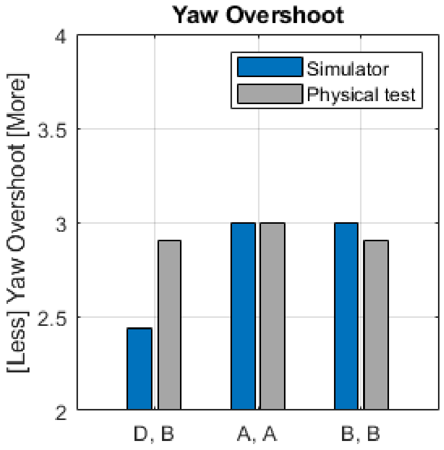
Vehicle D was deemed the most stable in all transient metrics, and with a similar delta to the reference as Vehicle B in physical testing

Motion cueing change had little effect on steady state feedback





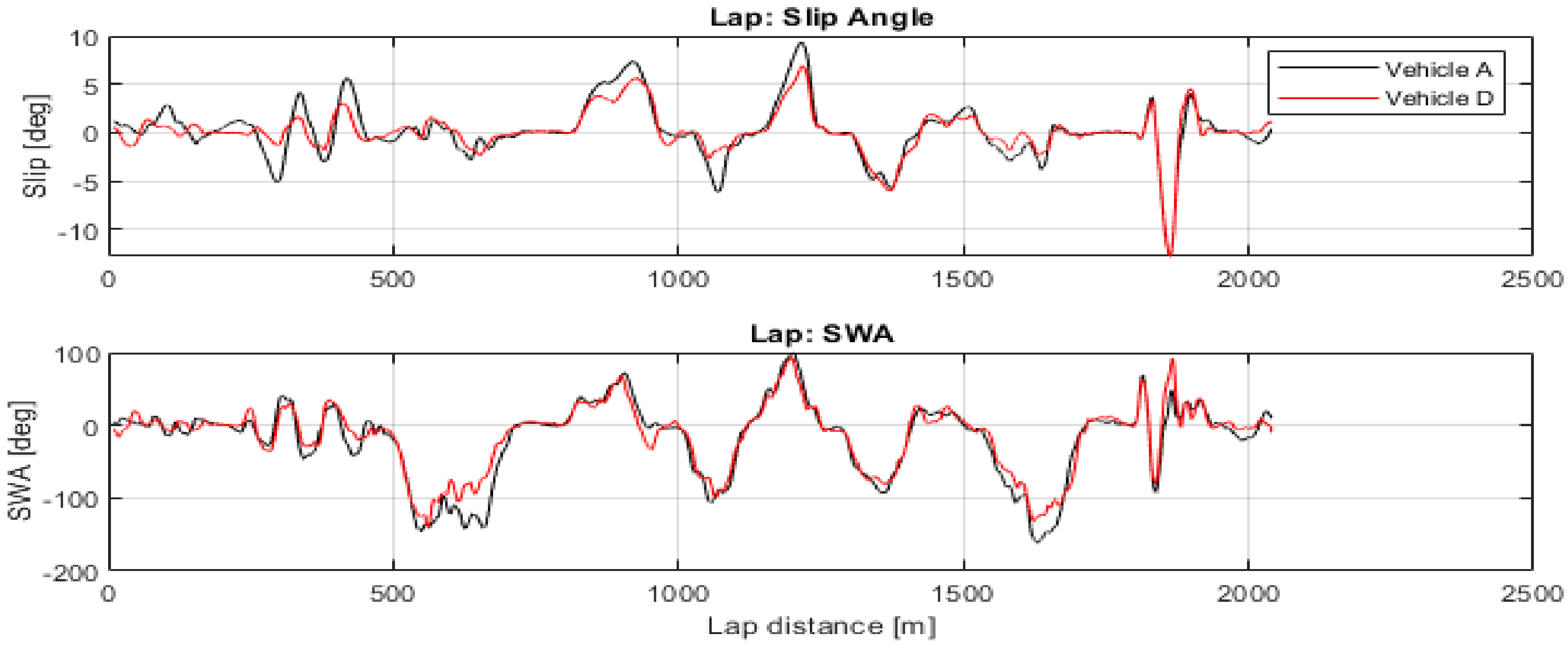
Vehicle	Setup
A	Reference
B	+120 kg Trunk
D	Reference with Yaw cueing gain -10% (based on B)



Lateral slip feedback in winter testing: Simulator results

Even though Vehicle A and Vehicle D is the same vehicle, the change in motion cueing causes differences in driving behaviour over the course of a lap (12 lap average).

Most dominant differences are found in the vehicle slip angle.



Lateral slip feedback in winter testing: Conclusion

The simulator test shows that the perceived transient dynamics of the vehicle changes when adjusting the yaw feedback

The feedback as expected, i.e. less yaw feedback gives more perceived stability during transients.

Proper balancing between yaw feedback and lateral acceleration is necessary and needs more investigation

Future work:

Include lateral acceleration in the study

Investigate the sensitivity of the balance between lateral acceleration and yaw rate

Conduct the study with more participants and more settings to identify trend.


VOLVO