VDCA Swedish Vehicle Dynamics Competence Area

Proceedings from 2023 Vehicle Dynamics seminar

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The contents of these proceedings include both **presentations and poster material** and are published at https://research.chalmers.se/en/publication/539363. It will also be available at https://kth.diva-portal.org/ and https://www.sveafordon.com/.

The seminar was arranged by Vehicle Dynamics Competence Area and Swedish Vehicular Engineering Association (SVEA, https://www.sveafordon.com/).

VDCA Swedish Vehicle Dynamics Competence Area

a workgroup in

SWEDISH VEHICULAR ENGINEERING ASSOCIATION
SVERIGES FORDONSTEKNISKA FÖRENING

member of FISITA

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Poster 3: *Continuously controlled damping tuning on four poster rig* Jesper Ramsberg, VCC & Chalmers

Poster 4: *Optimised force distribution algorithm and model* Guglielmo Nappi and Sanjay Banerjee, Scania & KTH

Poster 5: *Modelling and measurements of singularity-induced vehicle motion during low-speed driving* Luca Mereu, Politecnico di Torino & Chalmers

Note that the pdf file is generated with these “headings as pdf bookmarks”, so you can also navigate via the “bookmark pane” in your pdf reader.

Announcement of the Seminar

Vehicle Dynamics seminar 2023

Testing, development, and verification for Vehicle Dynamics

About the seminar

The seminar will be in "hybrid format", meaning that both participation is possible either in-real-life and on-line.

In-real-life

Wednesday 2023-05-24, CET 09:00-16:30 at

AstaZero Test Track, https://www.astazero.com/

Göksholmen 1, SE-504 91 Sandhult

Location code (Plus Code): QQHH+9V Sandhult

On-line:

Link to on-line meeting will be sent to those who register as on-line.

Registration

Registration is made via https://www.sveafordon.com/event/test-development-and-verification-for-vehicle-dynamics-2023/. If you are member, it is good if you log in before registration.

You will get a confirmation that you are registered.

Seminar costs

The seminar is free for SVEA members. SVEA will sponsor food (fika and light lunch) for members (incl. pending membership applicants) who attend in-real-life.

For non-members attending in-real-life there will be a fee of 210 SEK (>membership fee).

So, we encourage to apply for SVEA membership (https://www.sveafordon.com/en/for-members/register/). SVEA membership fee is 200 SEK/year (junior 0 SEK, senior 100 SEK).

Purpose with the seminar

- Present and discuss interesting issues within and challenges for Testing, development, and verification for Vehicle Dynamics
- Create understanding and interest for vehicle dynamics
- Develop, increase, and spread competence
- Networking between engineers, organisations, and students

SVEAs objectives

- To make vehicular technology's voice heard in an increasingly more challenging debate among different vehicle types and transport modes both domestic and globally
- To build a network for efficient distribution of technological information
- To attract the next generation of Swedish vehicular engineers

Agenda

Moderator: Ingemar Johansson, Chairman of SVEA

09:00-09:40	**Coffee and registration**	
09:40-09:50	**Welcome**	Ingemar Johansson (SVEA), Bengt Jacobson (VDCA), Håkan Andersson (AstaZero)
09:50-11:30	**Session 1:** Presentations (20+10 min each):	
	1. Development of frame test rig with MBS simulations	Joakim Eriksson, Scania
	2. Vehicle dynamics testing in a moving-base driving simulator	Sogol Kharrazi, VTI
	3. *Cold Climate Testing: Why Arjeplog and Colmis in northern Sweden become a hub for the global automotive industry every winter*	Per Gyllenberg and Benjamin Minshaw, Colmis
	Micro presentations of posters (3 min each):	
	Quantify and mimic the feedback through the steering wheel at some driving conditions	Aron Dalemo, Polestar & Chalmers
	Using torque vectoring to improve steering predictability while minimizing energy use in Heavy electric vehicles	Jonas Persson Jonathan Åkesson, Volvo Trucks & Chalmers
11:30-12:30	**Demo tour**	
	4. *AstaZero tracks*. Starts with small presentation, then we join in a bus to go out to the tracks.	Håkan Andersson (AstaZero)
12:30-13:30	**Light lunch** with networking and poster discussion	

13:30-14:45	**Session 2:** Presentations (20+10 min each):	
	5. Suspension design as part of complete vehicle development	Yansong Huang, VCC and Chalmers
	6. Tyre rolling resistance at various operational conditions and limitations in current tyre labelling	**J**ukka Hyttinen, Scania and KTH
	Micro presentations of posters (3 min each):	
	Continuously controlled damping tuning on four poster rig	Jesper Ramsberg, VCC & Chalmers
	Optimised force distribution algorithm and model	Guglielmo Nappi and Sanjay Banerjee, Scania & KTH
	Modelling and measurements of singularity-induced vehicle motion during low-speed driving	Luca Mereu, Politecnico di Torino & Chalmers
14:45-15:15	**Coffee** with networking and poster discussion	
15:15-16:15	**Session 3:** Presentations (20+10 min each):	
	7. Tyres and the purposes of models	Edo Drenth and Niklas Fröjd, Volvo Trucks
	8. Swedish vehicle engineering education ○ *KTH, Vehicle engineering* ○ *Chalmers, Mobility engineering* ○ Discussion	○ Mikael Nybacka, KTH ○ Dag Henrik Bergsjö, Chalmers ○ All
16:15-16:30	**Wrap-up** • Feedback on present years seminar. Proposals for next year. • Discussion on smaller events beside yearly seminar (“workshops”)	

Poster exhibition

There will be an exhibition of posters. It can be, e.g., master theses or PhD theses, both concluded and almost concluded. Please contact Lars Drugge larsd@kth.se or Bengt Jacobson bengt.jacobson@chalmers.se if you would like to propose a poster.

Each poster presenter should do a poster and a "micro presentation" with a few slides. Then also be available for questions at the poster stands.

Proceedings

There will be proceedings from the seminar. This means that the presenters, including poster presenters, are welcome with a paper, or at least a public version of their presentation material. The proceedings will be published on the web. It will include a list of seminar participants, unless you ask us to not list your name.

The seminar is arranged by the Swedish Vehicle Dynamics Competence Area (VDCA) and hosted by SVEA. The seminar is arranged with VDCA representatives from:

AstaZero
CEVT
Chalmers
KTH
VTI
AFRY Automotive
Scania
Volvo Cars
Volvo GTT

VDCA Swedish Vehicle Dynamics Competence Area

SVEA SWEDISH VEHICULAR ENGINEERING ASSOCIATION
SVERIGES FORDONSTEKNISKA FÖRENING

Registered participations

57 registered

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Introduction to the seminar

VDCA Swedish Vehicle Dynamics Competence Area

SWEDISH VEHICULAR ENGINEERING ASSOCIATION
SVERIGES FORDONSTEKNISKA FÖRENING

Introduction

Vehicle Dynamics Seminar 2023

Testing, development and verification for Vehicle Dynamics

Wednesday 2023-05-24 at AstaZero

Issued by: Bengt Jacobson and Ingemar Johansson

Date: 2023-05-23

Introduction

- **Introduction Vehicle Dynamics Seminar– Testing, development and verification for Vehicle Dynamics (BJ)**
- **VDCA - Swedish Vehicle Dynamics Competence area (BJ)**
- **SVEA - Swedish Vehicular Engineering Association (IJ)**
- **Why Vehicle Dynamics (IJ)**
- **Practical details and agenda today (BJ)**

Purpose with the Seminar:

- Present and discuss interesting issues within and challenges for Testing, development, and verification for Vehicle Dynamics
- Create understanding and interest for Vehicle Dynamics
- Develop, increase and spread competence
- Networking between engineers, organisations and students

Introductions:

- **Bengt Jacobson**

Professor and group leader Vehicle Dynamics,
Division of Vehicle Engineering and Autonomous Systems,
Mechanics and Maritime sciences,
Chalmers University of Technology
Gothenburg Sweden
and
Leader of VDCA

- **Ingemar Johansson**

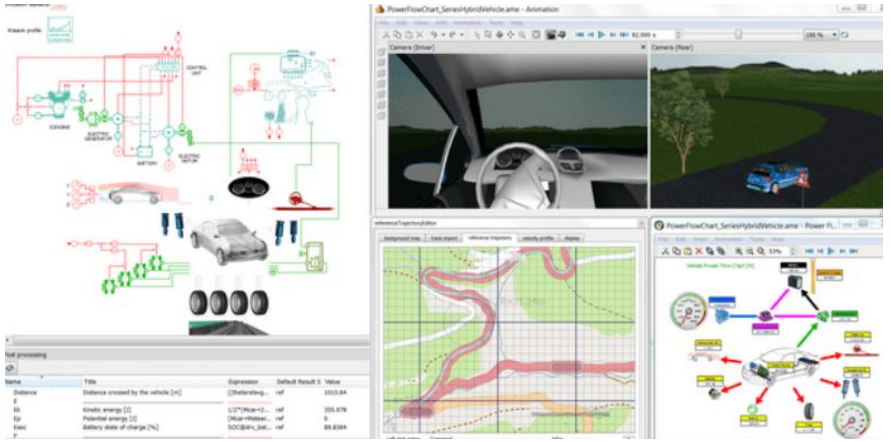
Chair of the Board SVEA

Thank you to AstaZero for hosting the seminar.

Special thank you to Håkan Andersson and Henrik Biswanger who have made this possible

Testing, development and verification for Vehicle Dynamics

- Vehicle Dynamics Seminar, an annual seminar, since 2013
- This year is the subject for the seminar is: “Testing, development and verification for Vehicle Dynamics”
- There is currently a lot of work ongoing to develop new analysis and simulation tools for the development process for vehicles
- Therefore is the development process for vehicles now more efficient where more alternatives can be tested in analysis tools, lead-times have been shortened and test and development in vehicles has been reduced
- However, test and development in vehicles will still be required to develop the attributes that are important for the driver and to subjectively assess how the complete vehicle works

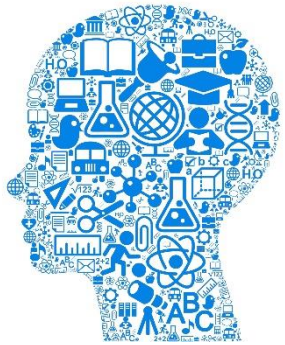


VDCA - Swedish Vehicle Dynamics Competence Area

To provide a **network** for vehicle dynamics

To **coordinate** research and thereby close gap and avoid double work

To know **state-of-the-art** globally



To secure **competence** by coordinated training

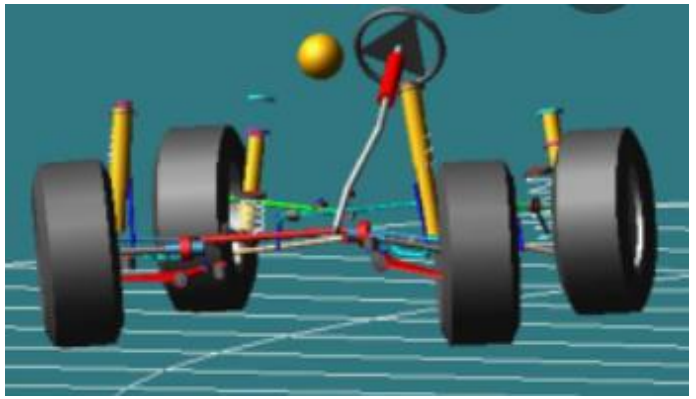
VDCA is since last year a working group within SVEA

SVEA - Swedish Vehicular Engineering Association

- SVEA, the Swedish Vehicular Engineering Association, is a society for people working in the Swedish Automotive industry and in the education and research within automotive engineering
- SVEA is a society that keeps itself updated about developments in the automotive industry and in research and informs its members and the public about any changes in e.g. technology and work processes
- SVEA arranges Seminars that can be of interest to its members. The purpose of the seminars is to present the current status and expected future solutions within selected technical areas
- SVEA is a member of FISITA, which gives us access to a world-wide organization for automotive engineers with a reach to over 200,000 engineers in 35 countries. FISITA provides a global platform for knowledge exchange between industry, societies and academia, helping to guide the future direction of the automotive mobility engineering profession
- SVEA has around 200 individual members and several corporative memberships. We are actively working to increase the membership numbers

Why Vehicle Dynamics

- **Vehicle Dynamics is a vehicle attribute that is critical for the vehicle performance, e.g. passive safety and how the vehicle is perceived by the driver**
- **Vehicle Dynamics is affected by e.g. the suspension systems, the steering system, wheel and tyres, brakes and the propulsion system**
- **The Vehicle Dynamics is developed from the mechanical systems and nowadays also by control systems and active systems**
- **Ride comfort is another vehicle attribute that is related to Vehicle Dynamics. Ride Comfort and Vehicle Dynamics need to be balanced and therefore must the Vehicle Dynamics be at a high level to allow for good Ride Comfort**
- **Automated driving systems need to have good Vehicle Dynamics when the controls systems are developed**
- **Therefore is Vehicle Dynamics a key attribute when a vehicle is developed**



Practical details and agenda today

Practical details:

- **The Seminar is a Hybrid meeting, i.e. in-real-life meeting and on-line meeting. This may create some difficulties that we need to resolve during the day**
- **On-line attendees should ask questions in the Comments, but if necessary you can also ask questions directly in the on-line meeting**
- **Every presentation is planned to take 20 minutes and there are 10 minutes for questions and discussion**
- **The Poster presentations are planned to take 3 minutes and questions and discussions are planned in breaks**

Agenda points:

- **09:40-09:50 Welcome and Introduction**
- **09:50-11:30 Session 1:** 3 presentations and 2 posters
- **11:30-12:30 Demo Tour AstaZero, presentation and bus tour**
- **12:30-13:30 Lunch, networking and poster discussions**
- **13:30-14:45 Session 2:** 2 presentations and 3 posters
- **14:45-15:15 Coffee, networking and poster discussion**
- **15:15-16:15 Session 3:** 1 presentation and 1 point about Vehicle Engineering Education
- **16:15-16:30 Wrap up**

Agenda

Start	End	No	What	Who	From
09:00	09:40		Coffee and registration		
09:40	09:50		Welcome	Ingemar Johansson Bengt Jacobson Håkan Andersson	SVEA VDCA & Chalmers AstaZero
09:50	**11:30**		**Session 1 Presentations (20+10 min each)**		
09:50	10:20	1	Development of frame test rig with MBS simulations	Joakim Eriksson	Scania
10:20	10:50	2	Vehicle dynamics testing in a moving-base driving simulator	Sogol Kharrazi	VTI
10:50	11:20	3	Cold Climate Testing: Why Arjeplog and Colmis in northern Sweden become a hub for the global automotive industry every winter	Per Gyllenberg Benjamin Minshaw	Colmis
			Session 1 Posters (3 min each)		
11:20	11:23		Quantify and mimic the feedback through the steering wheel at some driving conditions	Aron Dalemo	Polestar & Chalmers
11:23	11:26		Using torque vectoring to improve steering predictability while minimizing energy use in Heavy electric vehicles	Jonas Persson Jonathan Åkesson	Volvo Trucks & Chalmers
11:26	11:29				
11:30	**12:30**		**Demo Tour AstaZero test facility**		
		4	AstaZero tracks. Short presentation	Håkan Andersson	AstaZero
			Bus tour test facitility		
12:30	**13:30**		**Light lunch with networking and poster discussion**		

Agenda

13:30	**14:45**		**Session 2: Presentations (20+10 min each)**		
13:30	14:00	5	Suspension design as part of complete vehicle development	Yansong Huang	VCC and Chalmers
14:00	14:30	6	Tyre rolling resistance at various operational conditions and limitations in current tyre labelling	Jukka Hyttinen	Scania and KTH
			Session 2 Posters (3 min each)		
14:30	14:33		Continuously controlled damping tuning on four poster rig	Jesper Ramsberg	VCC & Chalmers
14:33	14:36		Optimised force distribution algorithm and model	Guglielmo Nappi Sanjay Banerjee	Scania & KTH
14:36	14:39		Modelling and measurements of singularity-induced vehicle motion during low-speed driving	Luca Mereu	Politecnico di Torino & Chalmers
14:45	**15:15**		**Coffee with networking and poster discussion**		
15:15	**16:15**		**Session 3: Presentations (20+10 min each)**		
15:15	15:45	7	Tyres and the purposes of models	Edo Drenth Niklas Fröjd	Volvo Trucks
15:45	16:15	8	Swedish vehicle engineering education		
			KTH, Vehicle engineering	Mikael Nybacka	KTH
			Chalmers, Mobility engineering	Dag Henrik Bergsjö	Chalmers
			Discussion		
16:15	**16:30**		**Wrap-up**		
			Feedback on this seminar	Ingemar, all	
			Proposals for next year	Ingemar, all	
			Discussion on smaller events beside annual seminar (“workshops”)	Ingemar, all	

Presentation 1:

Development of frame test rig with MBS simulations

Joakim Eriksson, Scania

JOAKIM ERIKSSON, SCANIA

Development of new frame test rig with MBS simulations

Agenda

- Introduction
- Background
- Simulations contribution
- Timeline
- Result
- Summary

Introduction

Name: Joakim Eriksson

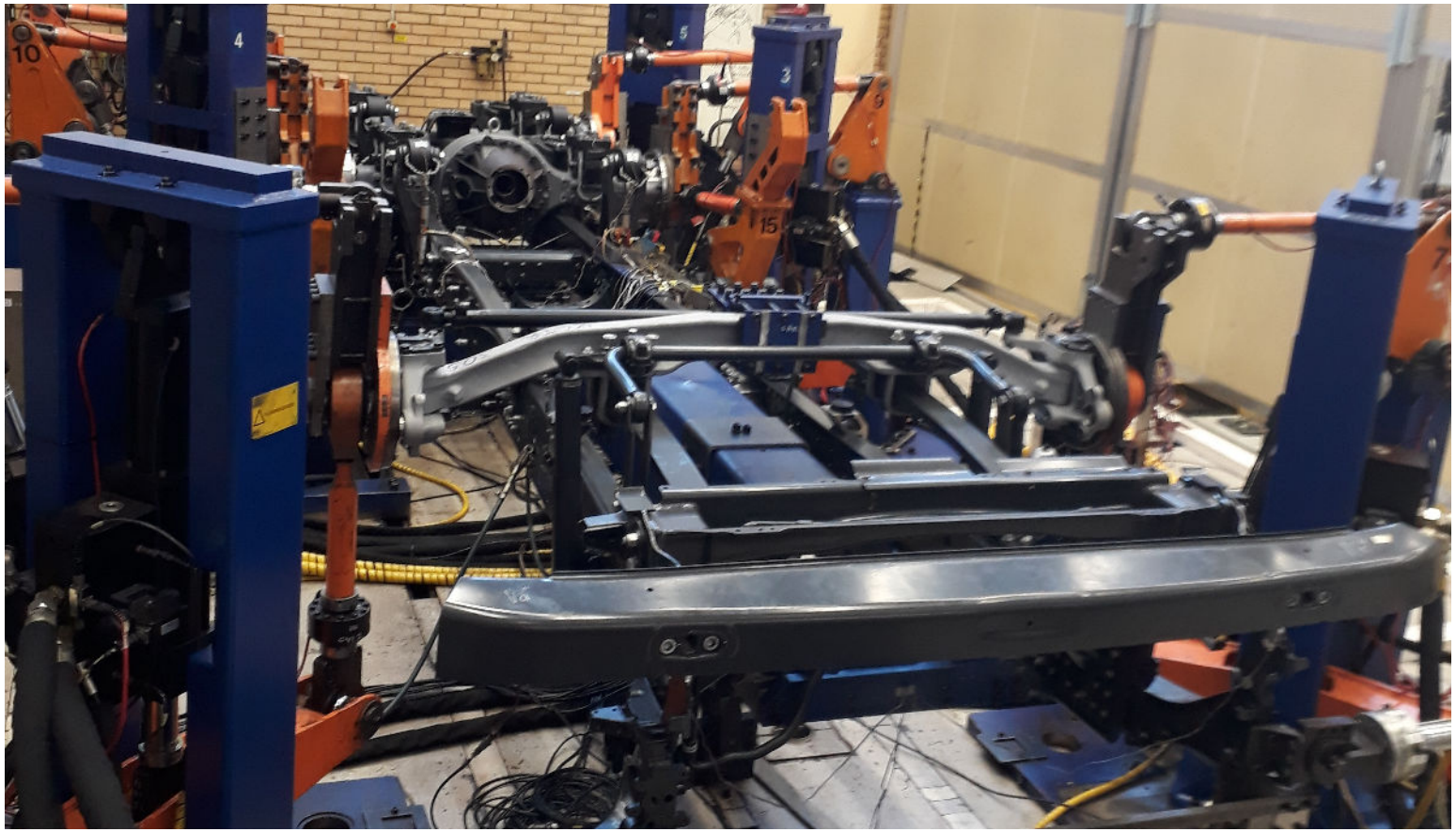
Working experience: 10 years at Scania

Position: Calculation engineer at truck chassis department

Background: Engineering Physics at Umeå University

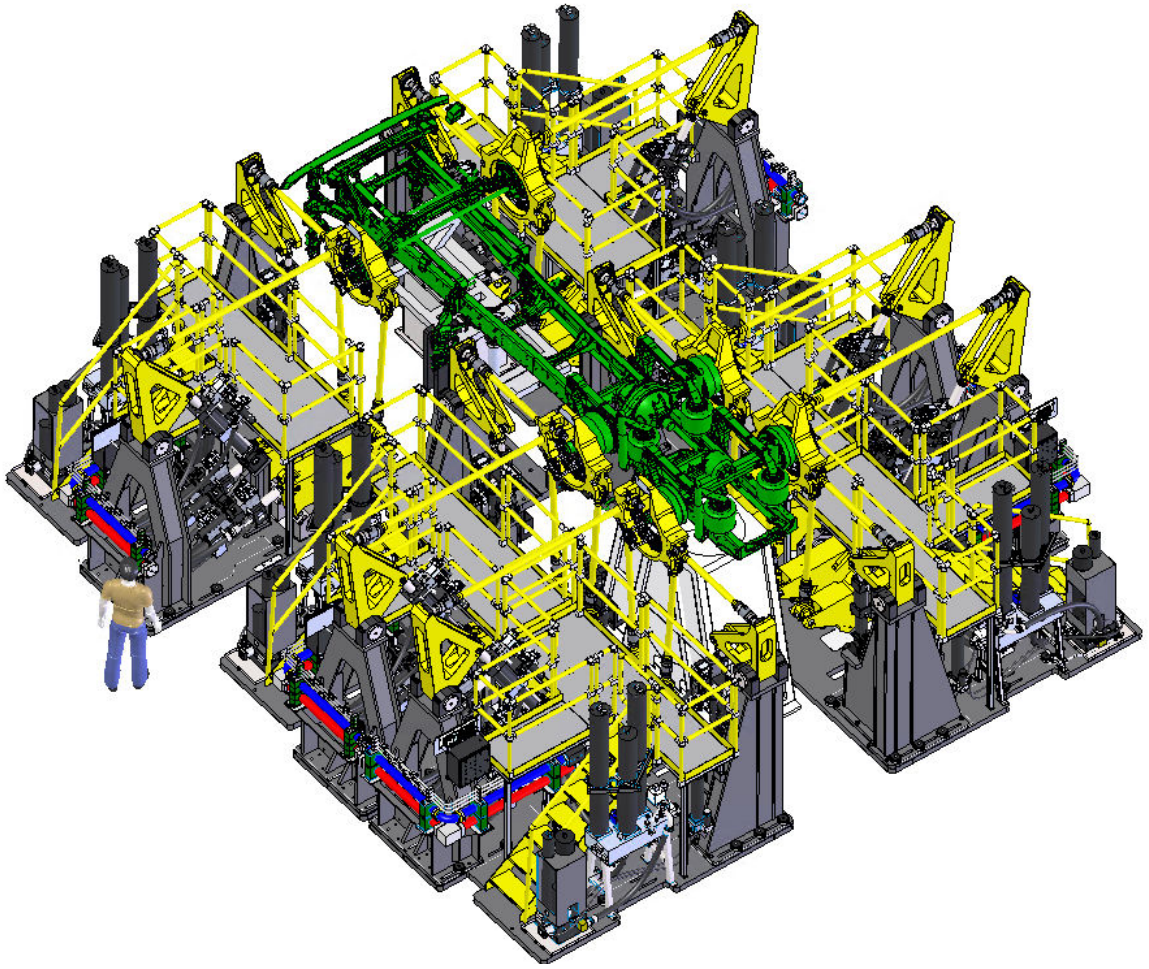
Background

- Existing frame rig was old
- Boundary conditions
- Improved capacity & speed
- More drive channels
- Input channels specific for BEV components



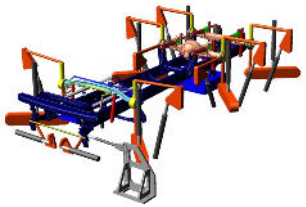
MBS contribution to frame rig development

- Obtain loads from full vehicle simulations
- Evaluate and rank different concepts for boundary conditions
- Loads & durability of rig components
- Dimensioning of struts & cylinders
- Geometry assurance
- Strategies for obtaining drive signals & editing test track measurements

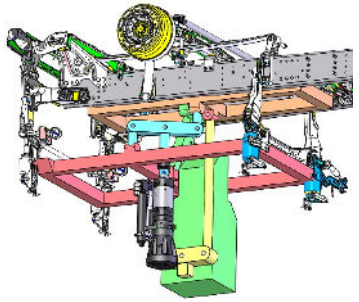


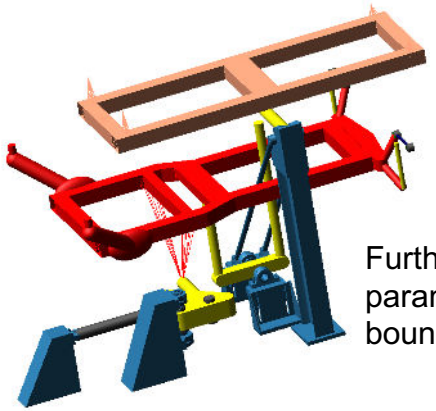
Timeline

Virtual frame rig R25 – verification and method development



Simulation of initial concept from MTS

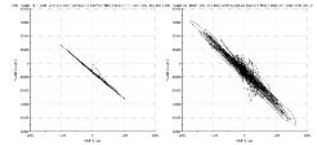




Further development & parameter study of front boundary conditions

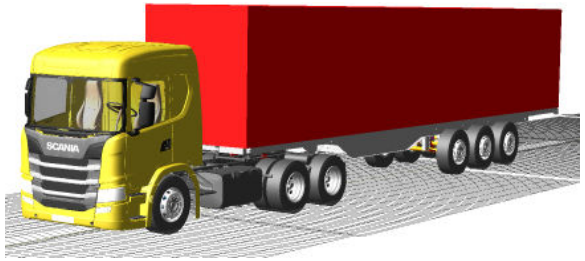
Full vehicle simulations with BEV tractor

Virtual strain gauge measurements on BEV components



2018

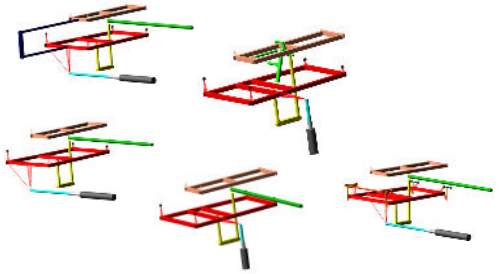
Full vehicle simulations of long haulage test schedule with 6x2 tractor



2019

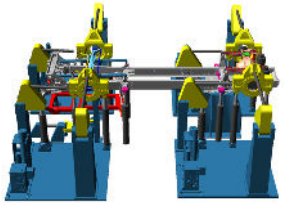
Full vehicle simulations of construction test schedule with 8x4 tipper

8 different concepts for front boundary conditions



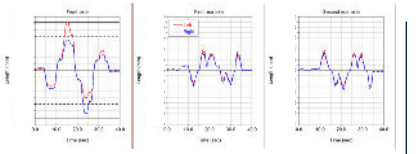
2020

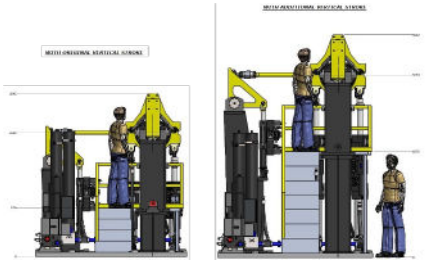
Different concepts for BEV boundary conditions



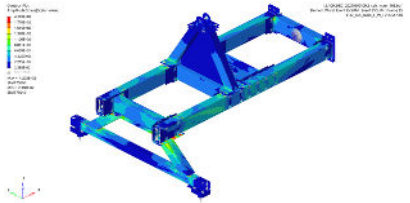
Timeline

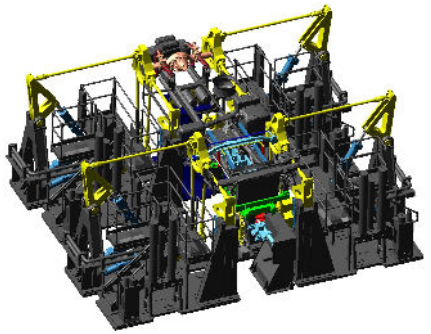
Investigation of increased motion and force demands for construction obstacles

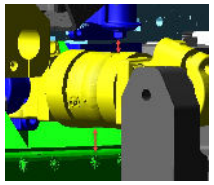




Validation of the boundary conditions together with rig design







Clearance calculations

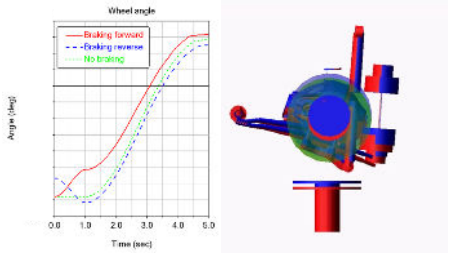
First simulation with measured BEV signals in CH2 ahead of first physical test

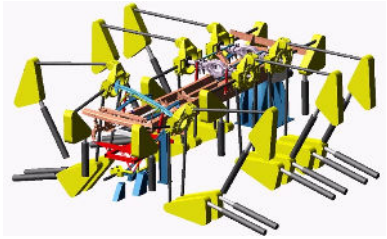
2020

2021

2022

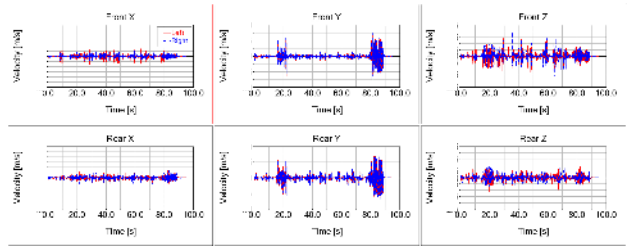
Wheel angle requirements investigation



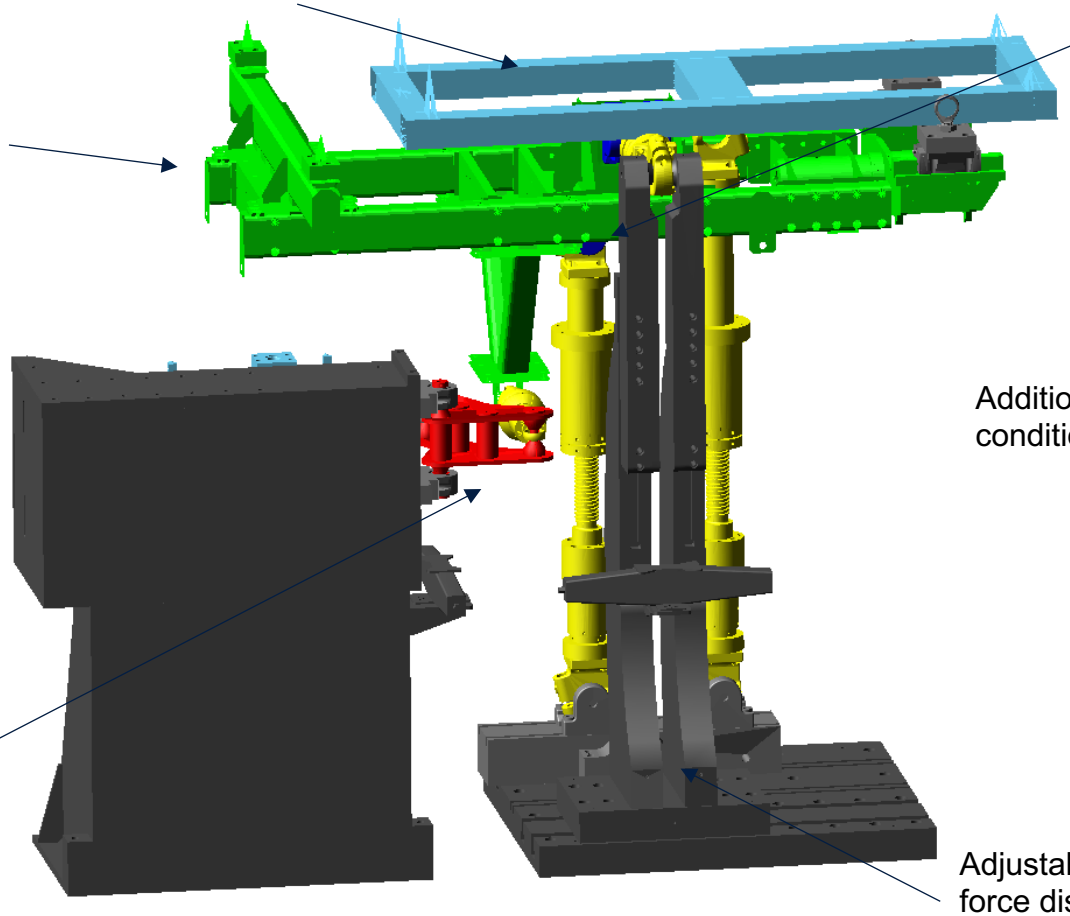


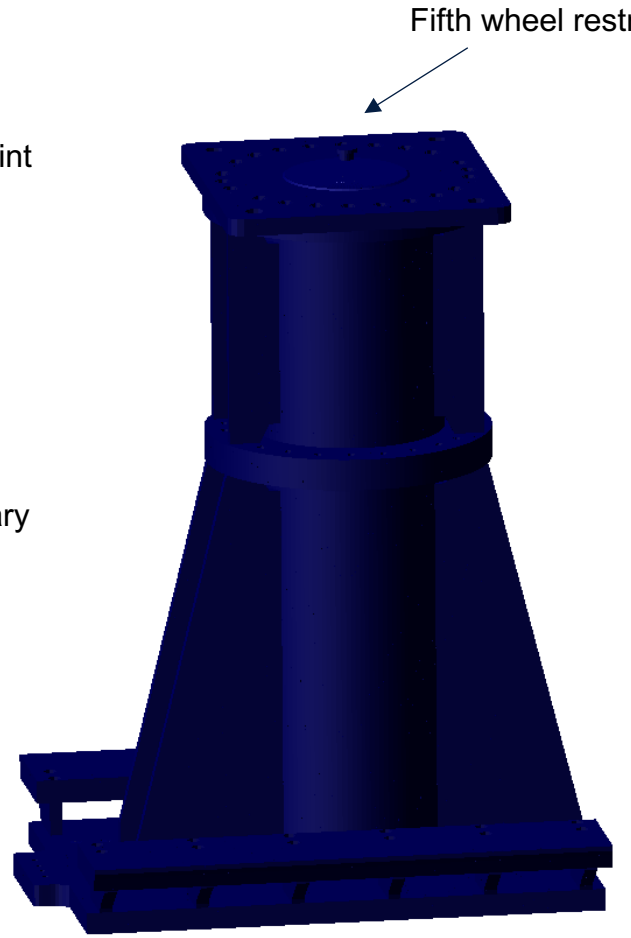
Validation of new corner module concept with increased displacement capabilities

Optimisation of target signal for the physical test



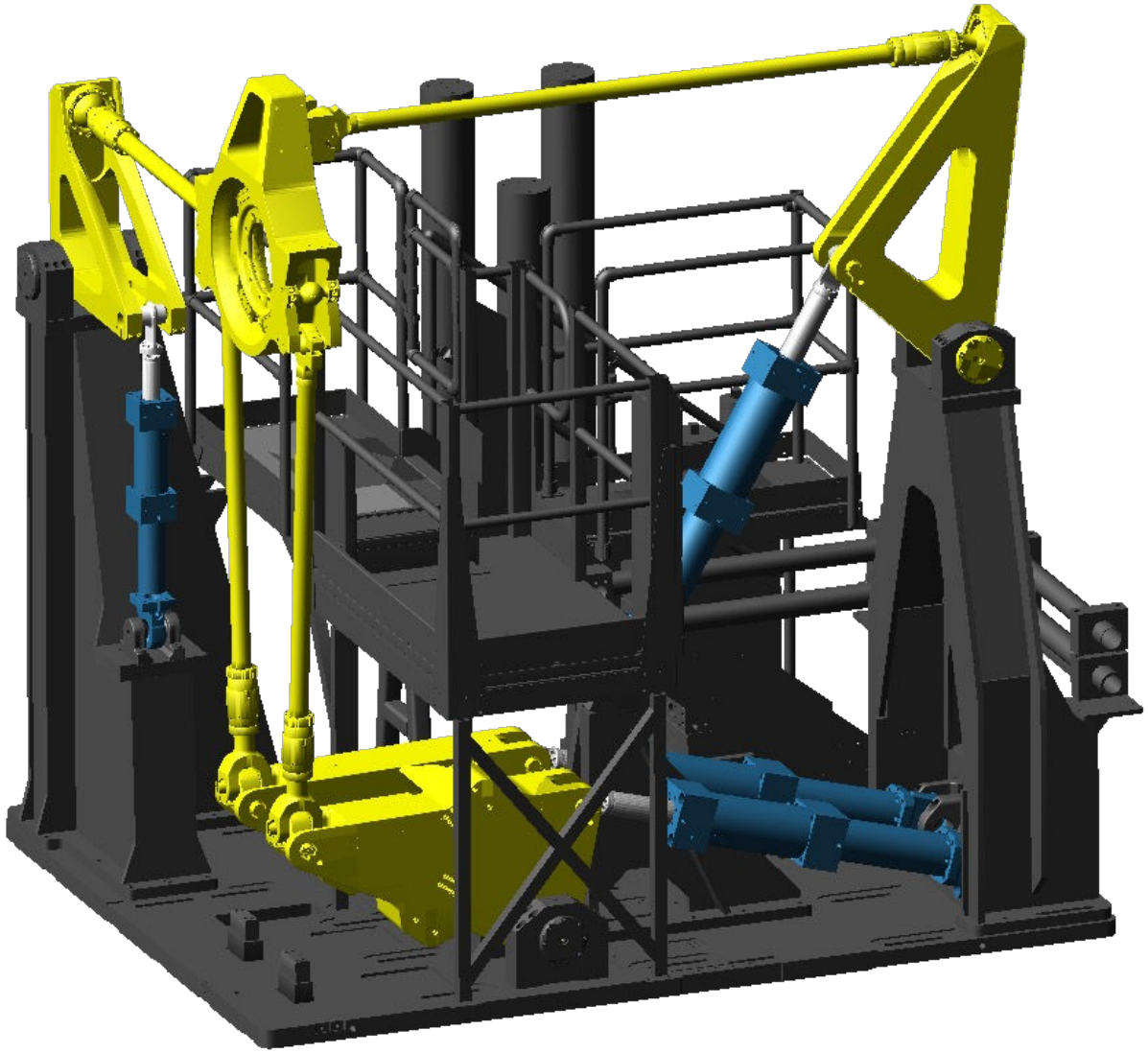
Boundary conditions





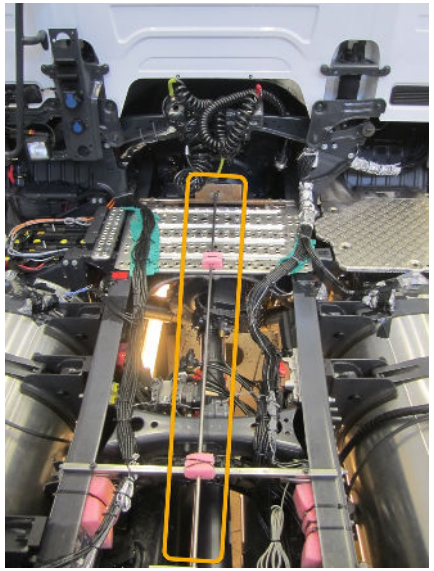
Corner module

- Four cylinders
- Four degrees of freedom
  - Vertical
  - Lateral
  - Longitudinal
  - Brake torque
- Attaches to the hub
- Available for three axles



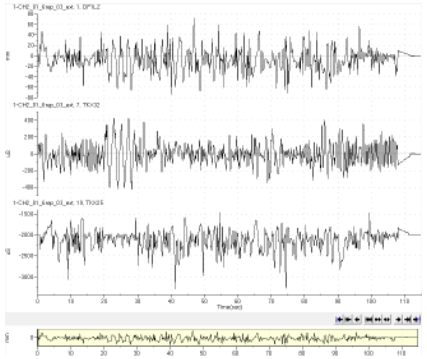
Required measurement channels for controlling the rig

- Wheel force transducers
  - Longitudinal and lateral wheel actuators
  - Braking torque
- Distance axle – frame
  - Vertical wheel actuators (leaf suspension)
- Air spring force (calibrated strain gauges)
  - Vertical wheel actuators (air suspension)
- Frame twist angle
  - Twist input actuator
- Bending strain gauge on rod
  - BEV boundary condition actuators



Rig control method

Test vehicle

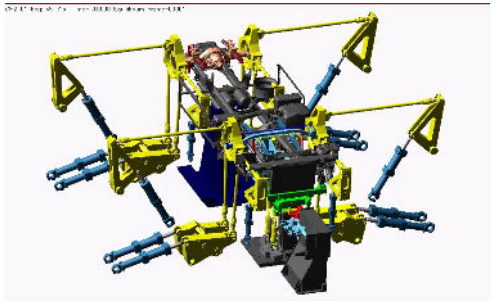


Measured data

Iterate
How?
until

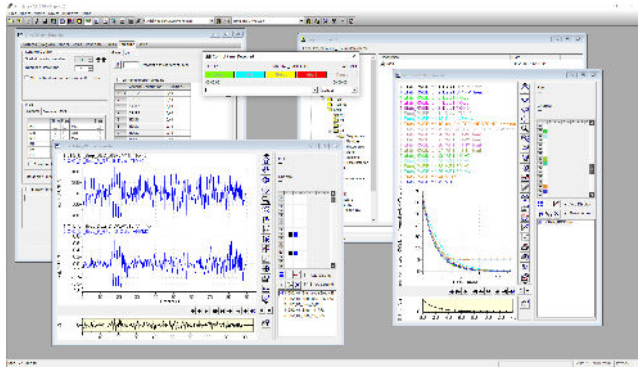
Desired

Virtual model



Response

Drive



RPC Pro

Summary

- The rig is now operational
- Large increase in test speed
- Ability to test BEV vehicles
- The rig design will be able to handle any obstacle we have at Scania test track


SCANIA

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Presentation 2:

Vehicle dynamics testing in a moving-base driving simulator

Sogol Kharrazi, VTI

Vehicle Dynamics testing in a moving-based driving simulator

Sogol Kharrazi

SVEA Vehicle Dynamics Seminar, 2023

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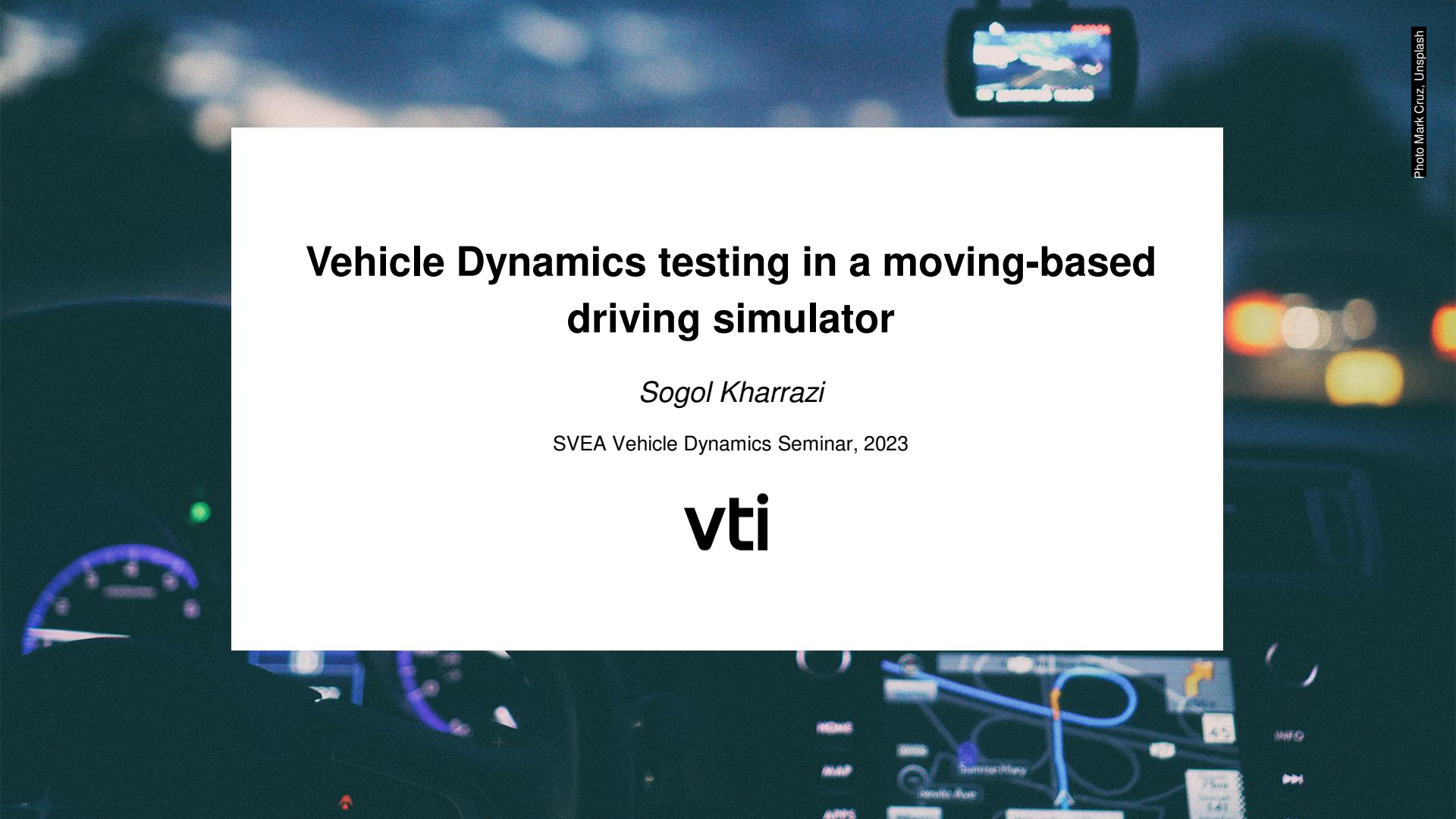

Photo Mark Cruz, Unsplash

Short information about me

Senior researcher

VTI, Vehicle systems and driving simulation unit

Adjunct associate professor

Linköping University, Vehicular systems division

I got my PhD from Chalmers in 2012.

Introduction

Driving simulators are used in a broad spectrum of applications. However, using driving simulators as a tool for vehicle dynamics testing has not been so common.

Driving simulators can be a valuable addition to the tool chain for vehicle dynamics development.

- Flexible: vehicle design, driving scenario and surroundings can be changed
- Repeatable
- Safe
- Immediate changes possible: a fresher recollection of previous experiences

VTI moving-base driving simulators

SIM III, Linköping

SIM IV, Gothenburg

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Vehicle dynamics in Sim IV

Sim IV has been used to assess and compare the dynamics of different heavy vehicles.

More specifically, to compare driver's perception of performance of High Capacity Transport (HCT) vehicles vs. conventional vehicle combinations.

First step was to tune the motion cueing algorithm for lateral dynamics assessment of heavy vehicles.

Tuning was performed subjectively, with help from a small group of professional test truck drivers

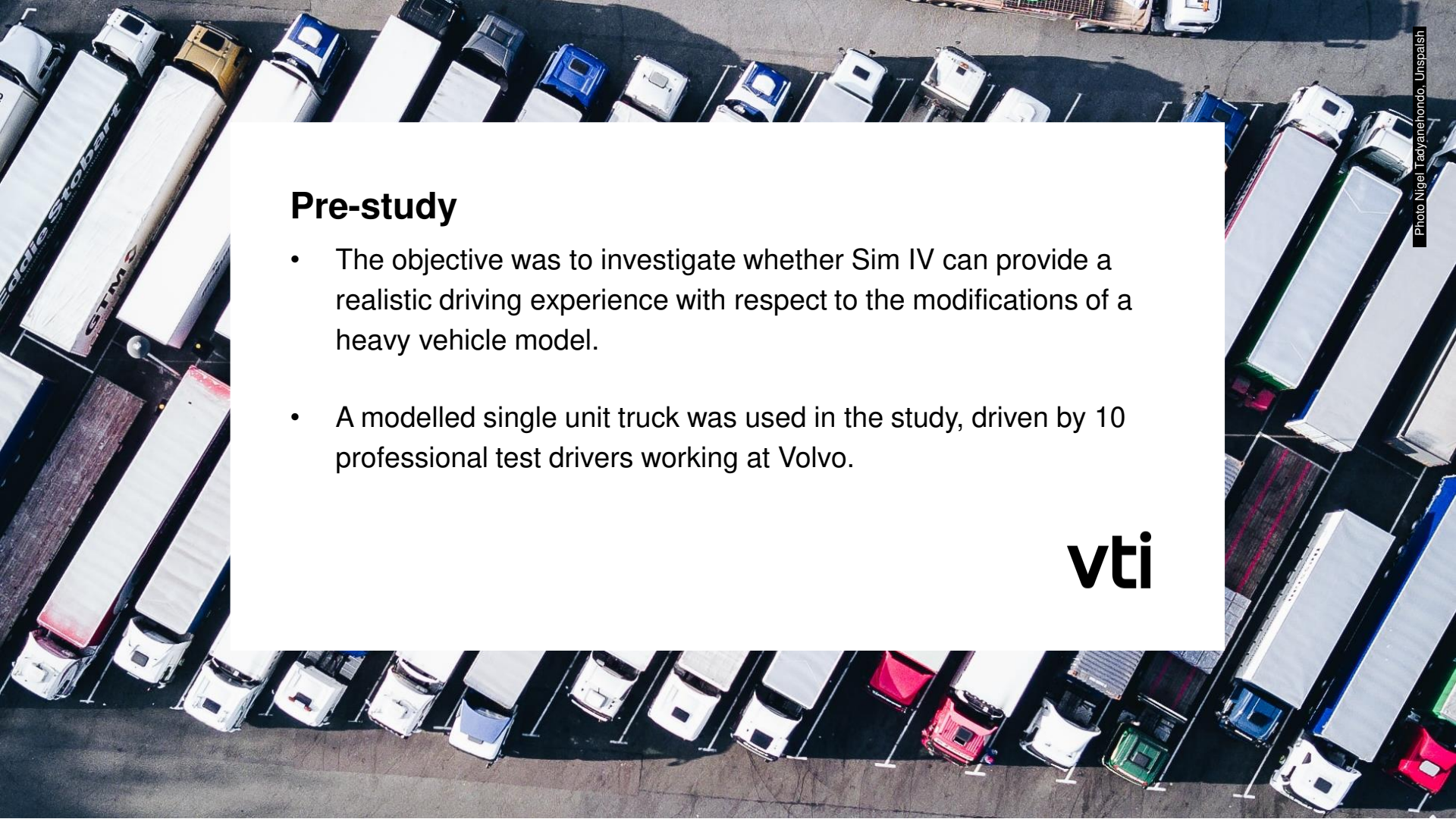

Photo Nigel Tadyanehondo, Unspalsh

Pre-study

- The objective was to investigate whether Sim IV can provide a realistic driving experience with respect to the modifications of a heavy vehicle model.

- A modelled single unit truck was used in the study, driven by 10 professional test drivers working at Volvo.

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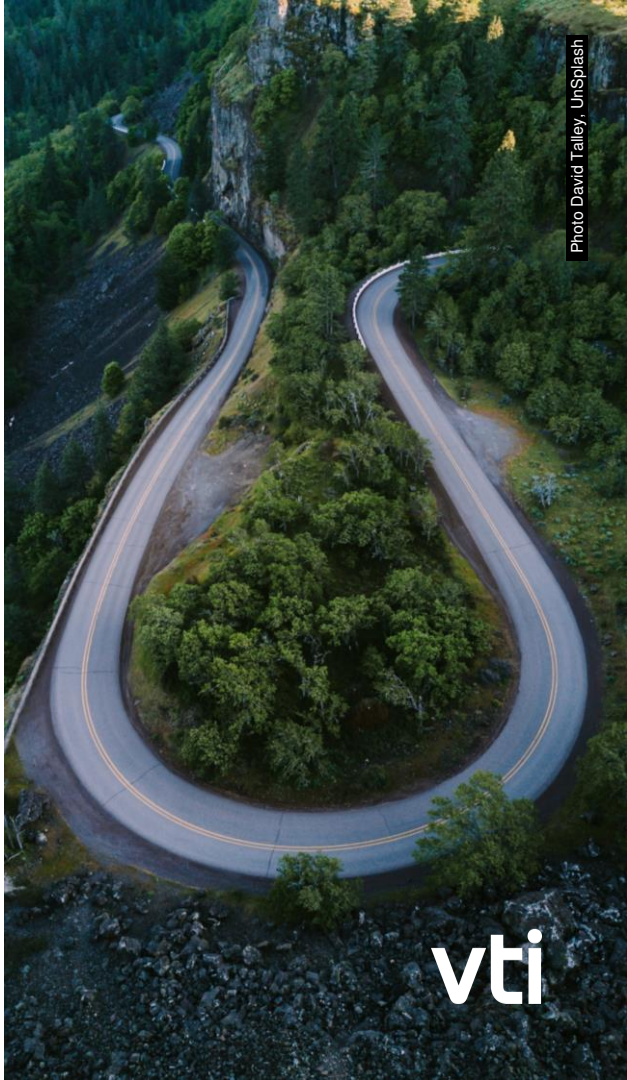
Pre-study

The drivers drove and compared the baseline truck with 4 modified versions of it with different parameter sets.

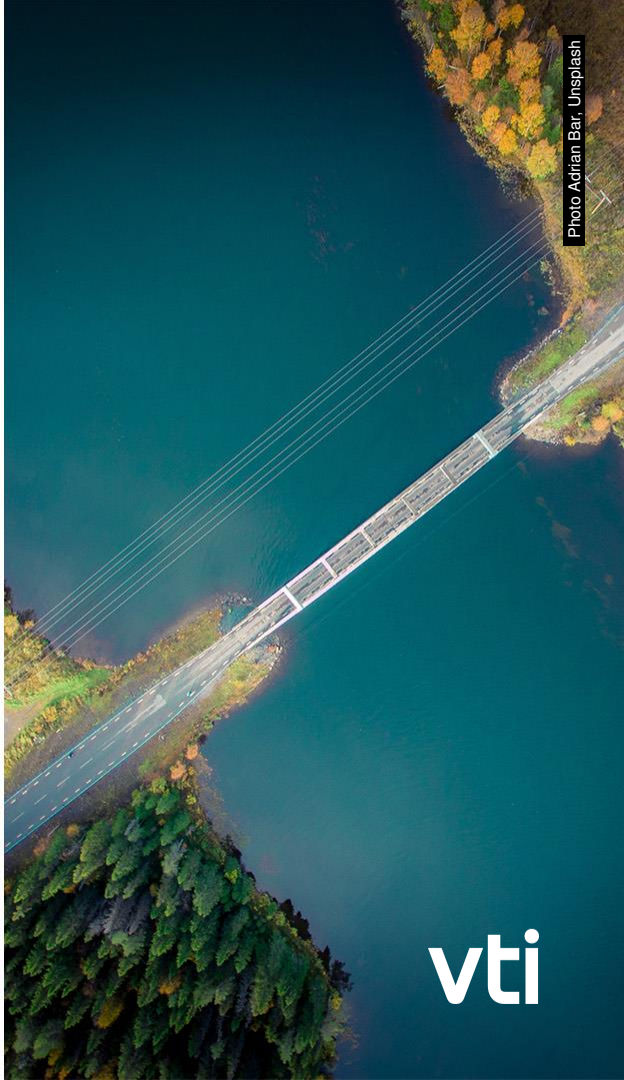
- **Parameter set 1:** Increased roll stiffness: a 100 % and 50% increase of the roll stiffness of the rear and front axles of the truck
- **Parameter set 2:** Decreased roll stiffness: a 40% decrease on the rear axles roll stiffness
- **Parameter set 3:** Softer rear tires: a 25% decrease on the cornering stiffness of the tires at rear axles
- **Parameter set 4:** Increased roll understeer: a roll steer coefficient of -0.45 is considered to model roll understeering, in contrast to a zero roll-steer coefficient for the baseline vehicle



Results of the pre-study

The drivers' deduction of the applied changes on the truck were categorized as **correct**, **quite correct**, or **incorrect**

- For parameter set 3 (softer rear tires), 75% of the drivers guessed the parameter change completely **correct** while the remaining drivers also had a **quite correct** deduction.
- The results for the other three parameter sets were also very promising.
- There were **only 2 incorrect** answers, out of a total of 32



Main simulator study

55 truck drivers participated in the study, and each driver drove a pair of vehicles, a conventional heavy vehicle and an HCT vehicle, in SIM IV.

	Heavy Vehicle Combination		
1	Tractor-Semitrailer		40T/16.5m
2	Tractor-Semitrailer-Dolly-Semitrailer (Adouble)		80T/30m
3	Truck-Centre Axle Trailer		40T/19m
4	Truck-Centre Axle Trailer-Centre Axle Trailer		74T/28m
5	Truck-Dolly-Semitrailer (Nordic)		64T/25m
6	Truck-Dolly-Link Trailer-Semitrailer (Truck-Bdouble)		83T/32m

Main simulator study

After each drive, the drivers were asked to rate different aspects of the vehicle performance, in a 7-grade scale, with questions such as:

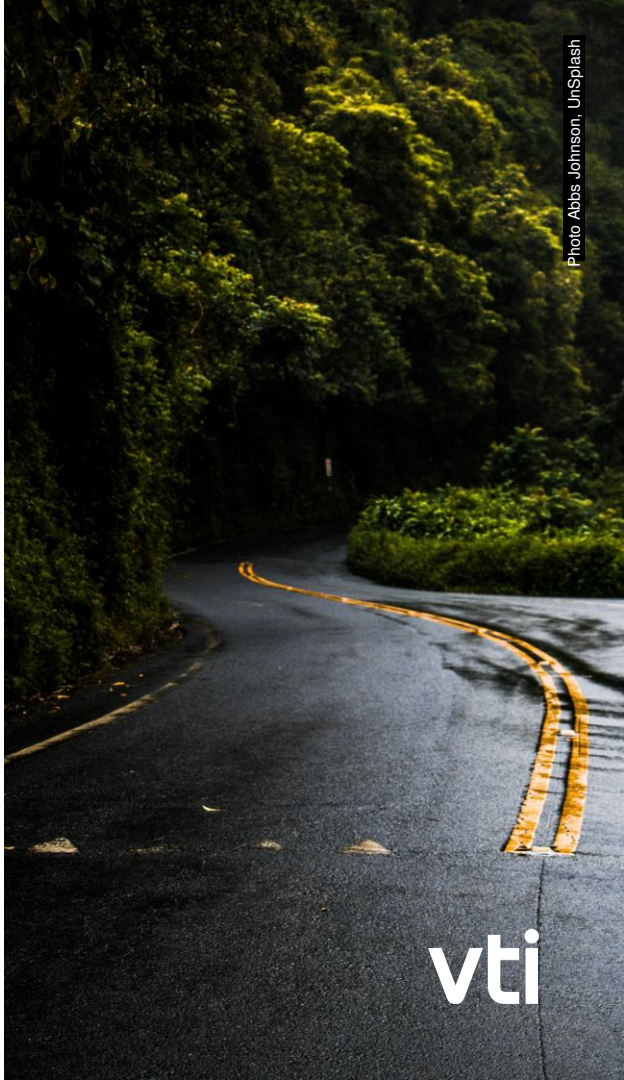
- How easy it is to keep the vehicle on the desired path on the curvy roads
- How they perceive the roll stability of the vehicle on the curvy roads
- How they perceive the trailers, stable or oscillatory, during overtaking and lane changes.
- How easy it is to control the vehicle.

There was also one concluding question, asking the drivers to compare the controllability of the two vehicles they drove.

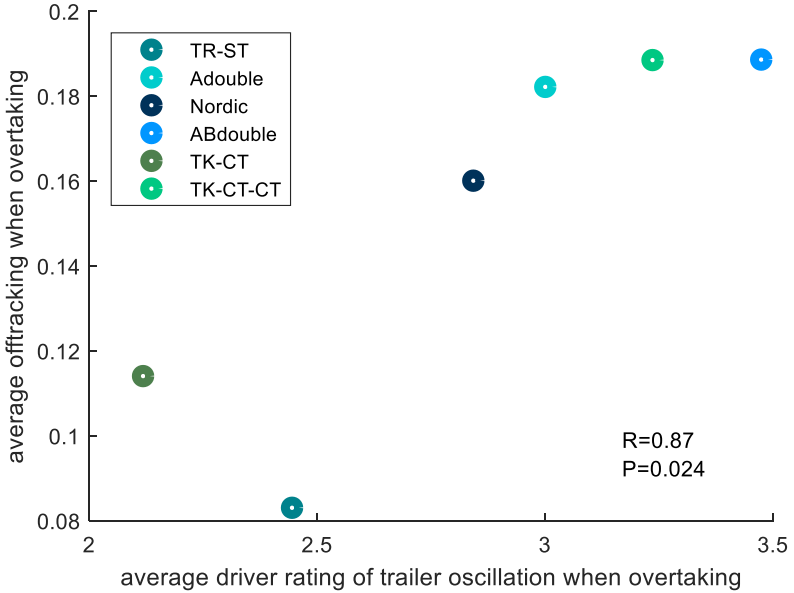
Results, driving experience

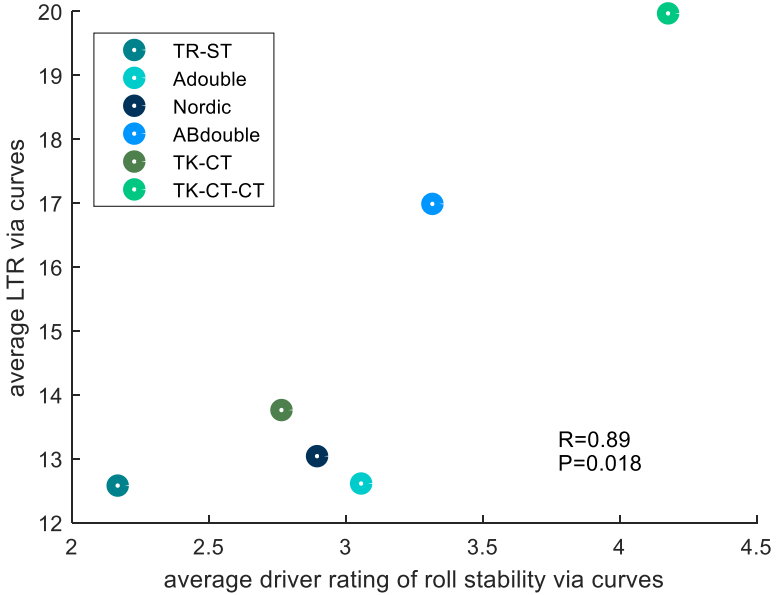
Average ranking of the total driving experience realism was 5.2 out of 7.

	Average rating (?/ 7)	Standard deviation
Roads	5.0	1.23
Surrounding	4.6	1.35
Braking	4.7	1.44
Accelerations	4.8	1.44
Sound	4.7	1.55
Suspensions	4.8	1.52
Cabin vibrations	4.9	1.37
Steering feel	4.7	1.56
Manoeuvrability	4.7	1.33
Speed perception	4.7	1.55



Results, subjective vs objective evaluation





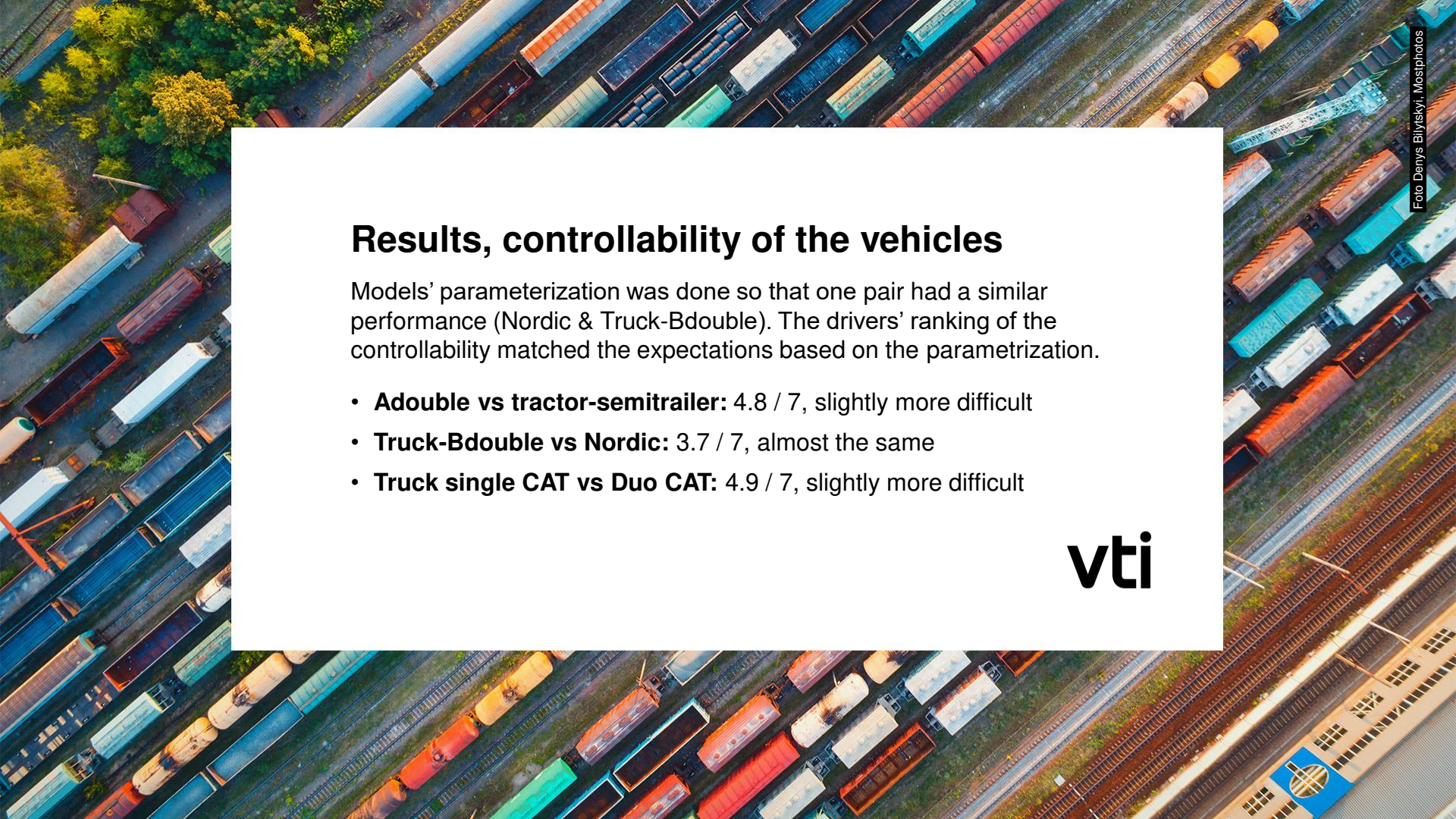


Foto Denys Bilytskyi, Mostphotos

Results, controllability of the vehicles

Models' parameterization was done so that one pair had a similar performance (Nordic & Truck-Bdouble). The drivers' ranking of the controllability matched the expectations based on the parametrization.

- **Adouble vs tractor-semitrailer:** 4.8 / 7, slightly more difficult
- **Truck-Bdouble vs Nordic:** 3.7 / 7, almost the same
- **Truck single CAT vs Duo CAT:** 4.9 / 7, slightly more difficult

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Conclusions

- The tested simulator has the capability of providing satisfactory feedback to the drivers so that they could correctly deduce the vehicle changes and perceive the differences in performance of various vehicles.
- There was a strong correlation between drivers' perceived performance of the vehicles and the objective performance measures.
- Moving base driving simulators can benefit the field of vehicle dynamics testing, not as a replacement but rather a complementing tool in the existing test chain.

For more information refer to the following publications

- S. Kharrazi, B. Augusto and N. Fröjd, “Vehicle dynamics testing in motion based driving simulators,” Vehicle System Dynamics, 2019.
- S. Kharrazi, B. Augusto and N. Fröjd, “Assessing dynamics of heavy vehicles in a driving simulator,” Journal of Transportation Research Part F: Traffic Psychology and Behaviour, vol. 65, pp. 306-315, 2019.
- B. Augusto, S. Kharrazi and N. Fröjd, “Vehicle Dynamics Testing in Driving Simulators - A Case Study for Heavy Vehicles,” ViP Publication, report 2017-3, 2019.
- S. Kharrazi, F. Bruzelius and U. Sandberg, “Performance based standards for high capacity transports in Sweden-FIFFI project 2013-03881-Final report,” VTI, report 948A, 2017.

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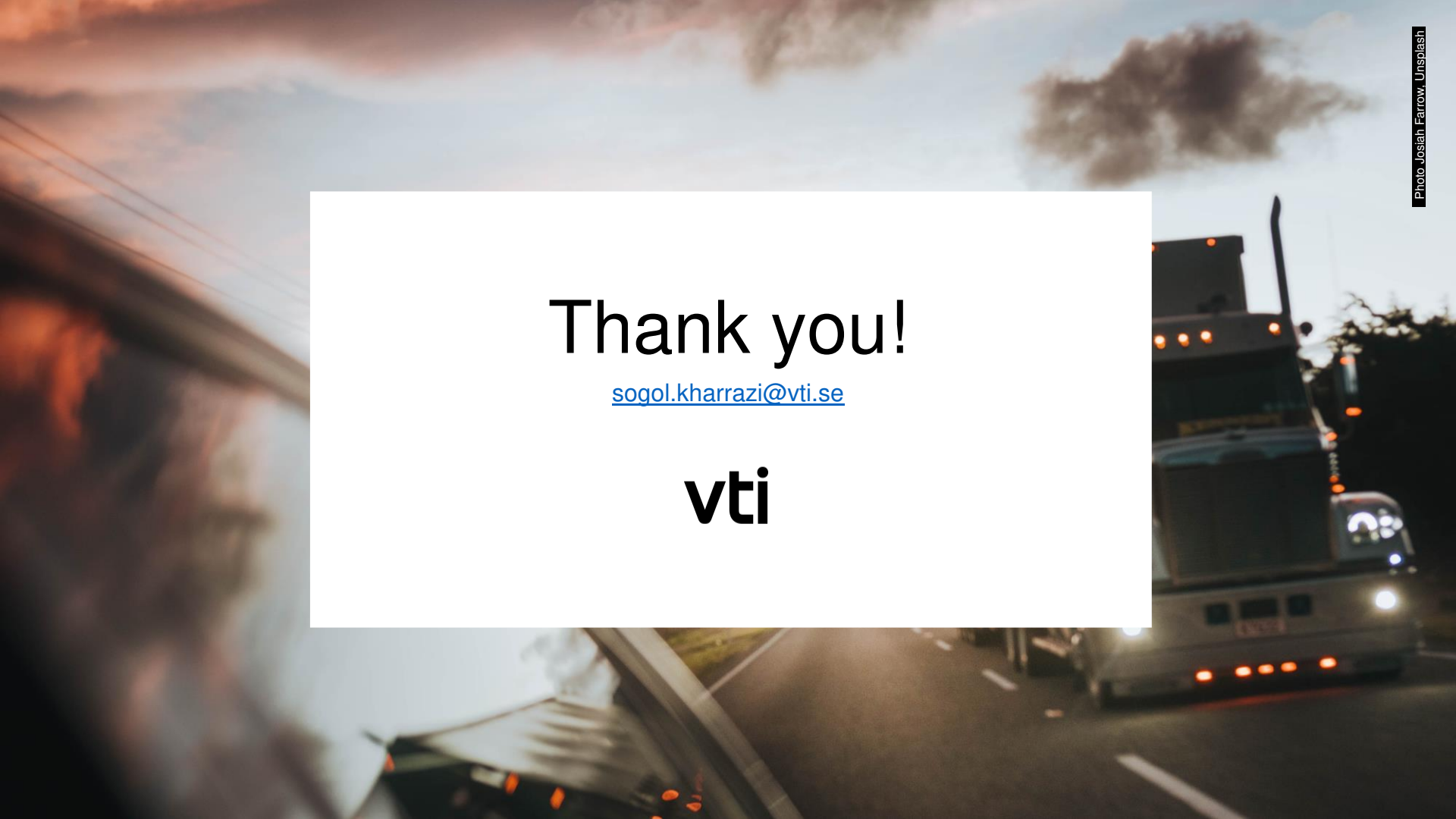
Future plans

Driveability assessment in Sim III

PREDICTing and evaluating driveability and performance of zero emission heavy duty vehicles

Scania, VTI, LiU, KTH



Thank you!

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