

Proceedings from 2026 Vehicle Dynamics seminar **Future directions**

version modified 2026-08-18 07:57

editors:

Bengt Jacobson bengt.jacobson@chalmers.se;

Lars Drugge larsd@kth.se;

The contents of these proceedings include both **presentations and poster material** and are published at <https://www.sveafordon.com/>, <https://research.chalmers.se/en>, and <https://kth.diva-portal.org/>.

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

VDCA is a workgroup in:



SVERIGES FORDONSTEKNISKA FÖRENING

SVEA is a member of:



Contents

Contents

Announcement of the Seminar

Participations

Introduction to the seminar

Presentation 1: *Overview and introduction to Autoliv and the Vårgårda test track*, Filip Petersson, Autoliv

Presentation 2: *Sustainability in commercial transport: the eTrailer from Trailer Dynamics*, Abdullah Jaber, CEO and Dr.-Ing. René Henn, Head of Vehicle Performance, Validation & Testing, Trailer Dynamics GmbH

Presentation 3: *A path-following controller for reversing tractor-trailer and A-double*, Zhaohui Ge, Chalmers University of Technology, Göteborg

Presentation 4: *On the performance of heavy vehicle tyres on the winter roads* Miro-Tommi Tuutijärvi, University of Oulo, Uleåborg, Finland

Presentation 5: *Potential customer benefits of Torque Vectoring in Heavy Commercial Vehicles*, Jolle Ilkema, Scania

Presentation 6: *From Intent to Action: AI-Assisted Vehicle Dynamics Design Using Validated Modelica Libraries*, Johan Andreasson, Modelon

Presentation 7a: *KTH, Vehicle engineering*, Mikael Nybacka, KTH

Presentation 7b: *Chalmers, Mobility engineering & Systems, Control and Mechatronics*, Jonas Bärghman and Jonas Fredriksson, presented by Bengt Jacobson, Chalmers

Poster 1: *Development environments for route based functions in road vehicles*, Victor Andersson, Chalmers

Poster 2: *Turbulence signal approximation at unsimulated yaw angles*, William Kumlien, Chalmers & VCC

Poster 3: *Steer-by-wire with closed-loop yaw rate control*, Mohammad Faddawi and Elmer Janmark, VCC

Poster 4: *Experimental validation of road friction and slope estimation models for enhanced AEB performance in heavy trucks*, Malte Håkanson, KTH & Scania/Traton

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 2026 — Future directions

Registrations have closed.



Vehicle Dynamics 2026 — Future directions

👁 2109



Event registration closed.

Date And Time

2026-05-20 @ 09:00 to
2026-05-20 @ 16:30

Registration End Date

2026-05-21

The seminar has two pages, one with Swedish flag and one with English flag. The page you read now is the main page for information, registration and possible updates.

Link to proceedings: *Will come here*, some time after the seminar. We hope to be able to publish most of presentations and posters.

Fordonsdynamiksseminarium 2026 — Framtida inriktningar

Vehicle Dynamics 2026 — Future directions

This year, we have chosen a very open topic for the seminar. In engineering and vehicle development, we face significant challenges. These include energy and climate, sustainability and resilience, and the balance between global and local perspectives. At the same time, there are major opportunities. These include electric propulsion, AI in product development, AI embedded in products, and the use of big data and cloud technologies. The overall purpose of our products remains unchanged. They should provide efficient and safe road and ground transportation. However, these opportunities are likely to reshape many concepts that have evolved over decades of vehicle engineering. Many of these opportunities have existed for a long time. In recent years, global and local political developments have increased the urgency to act on them.

With this as background, the seminar will present a selection of studies/findings/proposals. Most presentations originating from Sweden, but we have a couple of international presentations also. The seminar invites engineers and technicians in and after work-life as well as young engineers under education. An important purpose with the seminar is to create and maintain networks between us.

Autoliv will present their test track but also their workplace. Hence the first presentation and the lunch demo tour on test track is also a *SVEA workplace meeting*, so we underline that also engineers outside the core vehicle dynamics are welcome.

Wednesday May 20

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

In-real-life:

Autoliv Sverige AB
Wallentinsvägen 22, 447 37 Vårgårda, Sweden

Map: <https://maps.app.goo.gl/RriKcRFQMRnkr5ucA>
(Note, the building is new and not yet visible at Google Maps)

Parking possibilities:

- <https://maps.app.goo.gl/S2Zc7SGcMHGSB3oP9>
- <https://maps.app.goo.gl/5BHVPUN42BgvBEX96>

Location

Autoliv, Vårgårda. Map:

<https://maps.app.goo.gl/RriKcRFQMRnkr5ucA>

On-line:

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

Registration

Registration is made on <https://www.sveafordon.com/en/event/vehicle-dynamics-2026/>

If you are SVEA member, it is easier to register for the seminar if you log in before registration.

You will get a confirmation that you are registered.

Initial seminar registration deadline is 2026-05-13, we will order light lunch and fika for those registered until then plus some in reserve.

We usually re-opens the registration after that deadline and for those who register then, we cannot promise light lunch and fika.

2026-05-14: Registration re-opened. Please continue to register. Number of seats is not yet limiting and we will try to light lunch and fika for new registrations, and send out link to on-line participation.

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!).

Presenters (incl. poster presenters) attend for free.

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). (<seminar fee!).

You will directly automatically become preliminary member.

Purpose with the seminar

- Present and discuss interesting issues on future directions 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

Poster exhibition

There will be an exhibition of posters. It can be, e.g., master theses or PhD theses, either concluded or 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 5 minute “micro presentation” with a few slides. Then the presenter should 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 SVEA web. It will include a list of seminar participants, unless you ask us to not list your name.

Agenda

09:00-09:30	Coffee and registration		
09:30-09:45	Welcome	Matthijs Klomp (Moderator), Bengt Jacobson (SVEA, VDCA), Filip Petersson (Autoliv)	
09:45-10:45	Session 1: Presentations (20+10 min each):		
	Pres1: <i>Overview and introduction to Autoliv and the Vårgårda test track</i>	Filip Petersson, Autoliv	
	Pres2: <i>Sustainability in commercial transport: the eTrailer from Trailer Dynamics</i>	Abdullah Jaber, CEO and Dr.-Ing. René Henn, Head of Vehicle Performance, Validation & Testing, Trailer Dynamics GmbH	
10:45-10:50	Short break		
10:50-11:50	Session 2:		
	Presentation (20+10 min):		
	Pres3: <i>A path-following controller for reversing tractor-trailer and A-double</i>	Zhaohui Ge, Chalmers University of Technology, Göteborg	
	Micro presentations of posters (5 min each):		
	Post1: <i>Development environments for route based functions in road vehicles</i>	Victor Andersson, Chalmers	
	Post2: <i>Turbulence signal approximation at unsimulated yaw angles</i>	William Kumlien, Chalmers & VCC	
	Post3: <i>Steer-by-wire with closed-loop yaw rate control</i>	Mohammad Faddawi and Elmer Janmark, VCC	
	Post4: <i>Experimental validation of road friction and slope estimation models for enhanced AEB performance in heavy trucks</i>	Malte Håkanson, KTH & Scania/Traton	
11:50-13:30	Light lunch with networking combined with demo tour on Autoliv's test track.		
13:30-14:30	Session 1: Presentations (20+10 min each):		
	Pres4: <i>On the performance of heavy vehicle tyres on the winter roads</i>	Miro-Tommi Tuutijärvi, University of Oulo, Uleåborg, Finland	
	Pres5: <i>Potential customer benefits</i>		

	Pres 5: <i>Potential customer benefits of Torque Vectoring in Heavy Commercial Vehicles</i>	Jolle Ikema, Scania	
14:30-15:00	Coffee with networking and manned posters		
15:00-16:00	Session 4: Presentations (20+10 min each):		
	Pres 6: <i>From Intent to Action: AI-Assisted Vehicle Dynamics Design Using Validated Modelica Libraries</i>	Johan Andreasson, Modelon	
	Pres 7: Swedish vehicle engineering education: * Pres 7a: <i>KTH, Vehicle engineering</i> * Pres 7b: <i>Chalmers, Mobility engineering & Systems, Control and Mechatronics</i> * Discussion	Mikael Nybacka, KTH Bengt Jacobson, Chalmers All	
16:00-16:15	Wrap-up • Overall technical questions from today's presentations and posters • Feedback on present years seminar. Proposals for next year's seminar. • Any other questions or proposals for VDCA or SVEA		
16:30	Seminar (latest end time)		

The seminar is hosted by Autoliv arranged by the Swedish Vehicle Dynamics Competence Area (VDCA) and Swedish Vehicular Engineering Association (SVEA, Sweden's society member of FISITA). The seminar is arranged with VDCA representatives from:

Autoliv

AFRY Automotive

AstaZero

Chalmers

KTH

Polestar

Scania

Volvo Cars

Volvo Trucks

VTI

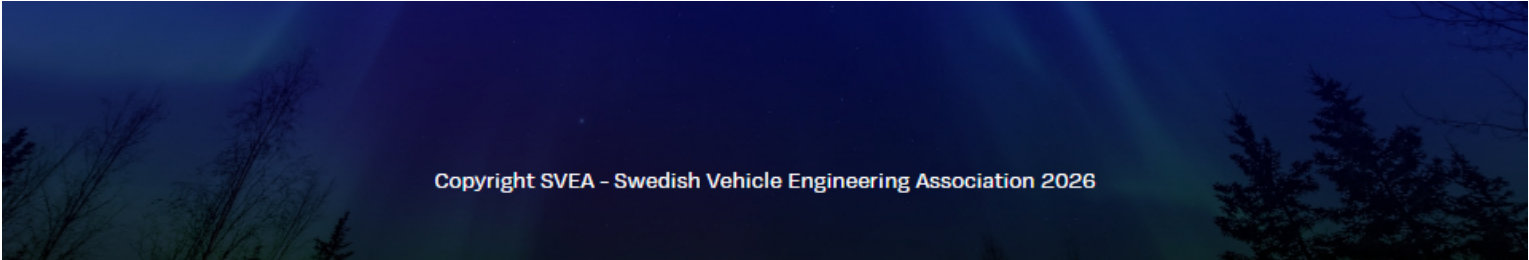
Zeekr Technology Europe

VDCA Swedish Vehicle Dynamics Competence Area



SVEA is the society member for Sweden in FISITA:





Copyright SVEA - Swedish Vehicle Engineering Association 2026

Participations

61 participants

Participant name	e-mail address	Affiliation
Abdullah Jaber	abdullah@trailerdynamics.de	Trailer Dynamics
Abhijeet Behera	abhijeet.behera@vti.se	VTI
Aniroodh Kumaraswamy	aniroodh.kumaraswamy@scania.com	Scania
Annika Carlsson	annika.k.carlsson@volvo.com	Volvo Trucks
Bengt J H Jacobson	bengt.jacobson@chalmers.se	Chalmers
Berk Varol	mustafa.berk.varol@volvo.com	Volvo Trucks
Carl Emvin	carl.emvin@chalmers.se	Chalmers
Christian Rylander	c_rylander@hotmail.com	
Dr. René Henn	rene.henn@trailerdynamics.de	Trailer Dynamics
Dragan	d.sekulic@sf.bg.ac.rs	University of Belgrade
Edgard Kfoury	edgard.kfoury@autoliv.com	Autoliv
Edo Drenth	edo@drenth.se	VAS
Egbert Bakker	ebakker@bahnhof.se	former Volvo Cars
Elias Palmkvist	elias.palmkvist@safholland.com	SAF Holland
Elmer Janmark	ejanmark@volvocars.com	Volvo Cars
Filip Petersson	filip.petersson@autoliv.com	Autoliv
Fredrik Bruzelius	fredrik.bruzelius@chalmers.se	Chalmers
Harshith Pidur Kuppusamy	harshith.pidur.kuppusamy@gmail.com	
Jan Tammperre	jan.tammperre@afry.com	AFRY
Jenny Jerrelind	jennyj@kth.se	KTH
Jiahao Sheng	jiahaosheng3327@gmail.com	
Johan Andreasson	johan.andreasson@modelon.com	Modelon
Johan Fritzen	johan.fritzen@autoliv.com	Autoliv
Jolle IJkema	jolle.ijkema@scania.com	Scania
Karl Redbrandt	karl.redbrandt@scania.com	Scania
Kenneth Ekström	kenneth.ekstrom@volvocars.com	Volvo Cars
Lars Drugge	larsd@kth.se	KTH
Leon Henderson	leon.henderson@volvo.com	KTH
Lidong Wang	wang.lidong@outlook.com	Chalmers
Lin Zhao	linzhao@kth.se	KTH
Malte Håkanson	malte.hakanson@hotmail.com	KTH & Traton
Martin Johansson	martin.johansson1@autoliv.com	Autoliv
Mathias Lidberg	mathias.lidberg@fcc.chalmers.se	Fraunhofer
Mats Jonasson	mats.jonasson@chalmers.se	Chalmers
Matthijs Klomp	matthijs.klomp@volvocars.com	Volvo Cars & Chalmers

Mattias Hjort	mattias.hjort@vti.se	VTI
Mikael Karlgren	mikael.karlgren@scania.com	Chalmers
Mikael Nybacka	mnybacka@kth.se	KTH
Miro-Tommi Tuutijärvi	miro-tommi.tuutijarvi@oulu.fi	Oulo University, Finland
Mohammad Faddawi	mfaddawi@volvocars.com	Volvo Cars
niccolo	niccole@chalmers.se	Volvo Trucks
Niklas Fröjd	niklas.frojd@volvo.com	
Per-Olov Fryk	1949pof@gmail.com	former Volvo Trucks
Radu Raznovan	raznovan.radu@gmail.com	
Ramkumar Munavalli	ramkumarhm32@yahoo.com	
Rebecka Eldh	rebecka.eldh@modelon.com	Modelon
Rohan Kumaar Vasudevan	rohankumaar15@gmail.com	
Sachin Janardhanan	sachin.janardhanan@volvo.com	Volvo Trucks & Chalmers
Sandeep Santhosh Nair	sandeep.nair@vti.se	VTI
Sogol Kharrazi	sogol.kharrazi@vti.se	VTI
Toheed Ghandriz	toheed.ghandriz@volvo.com	Volvo Trucks
Tommi Saarikoski	tommi.saarikoski@volvo.com	Volvo Trucks & Chalmers
Ulrika Ståhl	ulrika.stahl@autoliv.com	Autoliv
Umur Erdinc	umur.erdinc@volvo.com	Volvo Trucks & Chalmers
Umur Erdinc	umur.erdinc@volvo.com	Volvo Trucks
UTSAV KHAN	utsav.khan@gmail.com	Zeekr
Victor Andersson	victoand@chalmers.se	Chalmers
Wenliang Zhang	zhang.wenliang@outlook.com	
William Kumlien	william.kumlien@volvocars.com	Lund University & Volvo Cars
Xin Li	xin.li.11@volvocars.com	Volvo Cars
Zhaohui Ge	ZHAOHUI.GE@CHALMERS.SE	Chalmers

Introduction to the seminar



Vehicle Dynamics 2026 — — Future directions



VDCA *Swedish Vehicle Dynamics Competence Area*

VEA SWEDISH
VEHICULAR
ENGINEERING
ASSOCIATION
SVERIGES FORDONSTEKNISKA FÖRENING



FISITA

About present year's seminar topic

Vehicle Dynamics 2026 — — Future directions

- A very open topic!
- Challenges and opportunities:

Energy and climate	Electric propulsion, AI in development and/or in vehicles, Big data, Cloud technologies, and ...
Sustainability and resilience	
Global and local perspectives	

- Many of these opportunities have existed for decades. However, in present decade, global and local political developments have increased the urgency to act on them.



Our annual Vehicle Dynamics seminars

Year	Topic	Location
2013	Vehicle Dynamics Challenges	Lindholmen, Göteborg
2014	Vehicle Dynamics in a Cooperative Environment	Scania, Södertälje
2015	Vehicle Dynamics for Energy Efficient Mobility	Chalmers, Göteborg
2016	Functional Architectures and Virtual Methods for Efficient Vehicle Dynamics Development	NEVS, Trollhättan
2017	Vehicle Dynamics for Automated Driving	Scania, Södertälje
2018	Model Fidelity for Vehicle Motion Predictions	Chalmers, Göteborg
2019	<replaced by IAVSD international conference>	Göteborg
2020	<cancelled>	Cancelled, due to pandemic
2021	Future Mobility ...and not only Lateral	On-line, due to pandemic
2022	Connected and Electric	KTH, Stockholm and on-line
2023	Testing, development, and verification	AstaZero, Sandhult and on-line
2024	Virtual verification	Linköping and on-line
2025	Model exchange for virtual pre series	Göteborg, Chalmers and on-line
2026	Vehicle Dynamics -- Future Directions	Autoliv, Vårgårda and on-line
2027	(to be discussed at the wrap-up of 2026's seminar)	

Purpose with the seminar

- **Present and discuss** interesting issues within Vehicle Dynamics and within the topic which is selected each year
- Create **understanding and interest** for vehicle dynamics
- Develop, increase, and spread **competence**
- **Networking** between engineers, organisations, and students

SVEA was formed during 1989-1990.

SVEA's 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**

Enjoy the
seminar day!

VDCA “core group” has representatives and contributions from vehicle manufacturers, university groups in the subject Vehicle Dynamics, and VTI:

Autoliv

AFRY Automotive

AstaZero

Chalmers

KTH

Polestar

Scania

Volvo Cars

Volvo Trucks

VTI

Zeekr Technology Europe

Presentation 1:

***Overview and introduction to Autoliv and the
Vårgårda test track,***

Filip Petersson, Autoliv

Presentation 2:

***Sustainability in commercial transport: the
eTrailer from Trailer Dynamics,***

Abdullah Jaber, CEO and Dr.-Ing. René Henn,
Head of Vehicle Performance, Validation &
Testing, Trailer Dynamics GmbH

Sustainability in commercial transport: the eTrailer from Trailer Dynamics

Dr.-Ing. René Henn
Head of Vehicle Performance, Validation & Testing

Abdullah Jaber
CEO Trailer Dynamics GmbH

Göteborg, 2026



01

Package of the eTrailer





Our idea:
Electrification of semi-trailer



Our partners:
Krone, Jost & Thermo King



Our mission:
Contribute to decarbonization of
heavy duty transport



Our team:
90 employees



Our target:
Series-production readiness



Our location:
Eschweiler



The eTrailer

E-Kit: modular system for electrification of semi-trailer

E-Kit:

- Contains sensed king-pin, control box, electric axle and high voltage battery system
- 800V system voltage
- Modularer system approach



The eTrailer

Electric axle & motor-gearbox-unit

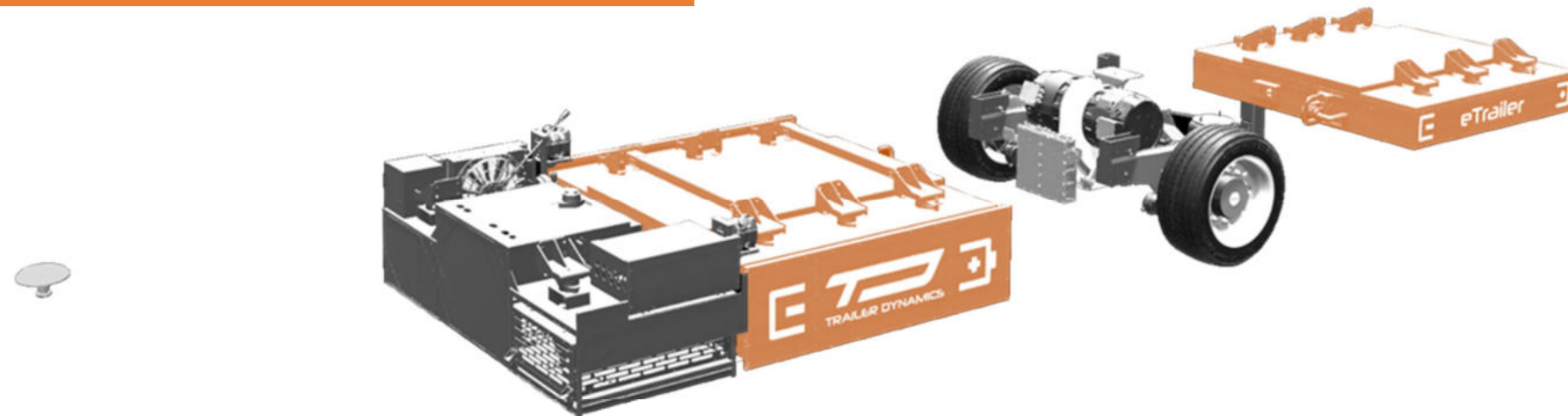
Electric axle & motor-gearbox-unit

- Two electric engines/inverter with central gearbox
- Transmission to wheel end by crank shafts
- Continuously power: 360 kW
- Peak power: 580 kW



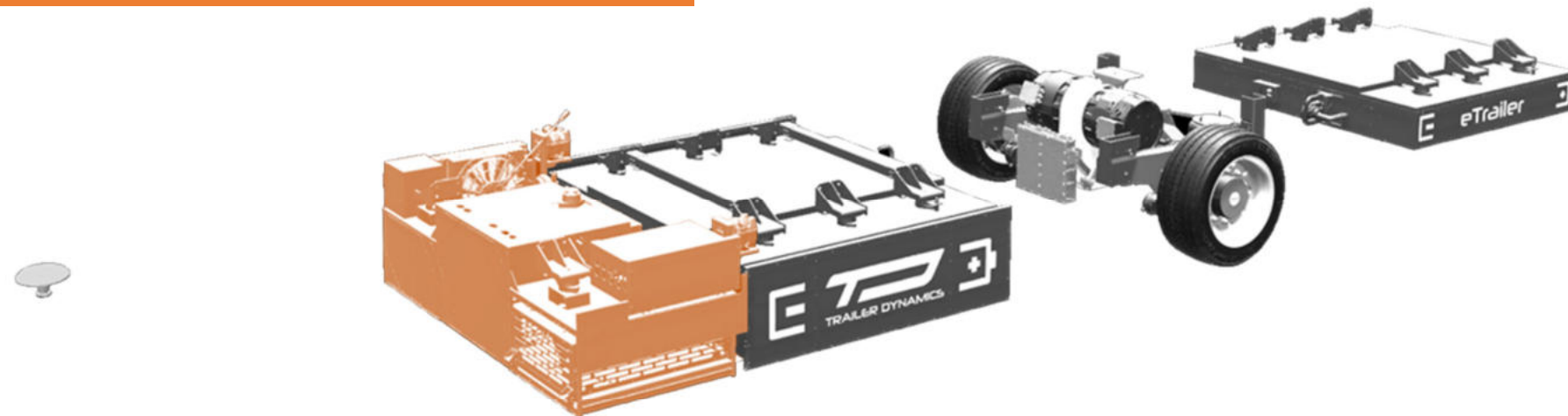
Battery system

- Charging power up to 350 kW DC
- Available in three capacity specifications:
 - 187 kWh
 - 367 kWh
 - 551 kWh
- Homologation according UN-ECE R 100



Control box

- Low voltage system & high voltage energy distribution
- Battery management system
- Vehicle control unit
- Thermal management



King-pin

- Regulation of the eTrailer by redundant sensing system
- Independent from the tractor unit
- Automatic recalibration



02

Testing of structural design



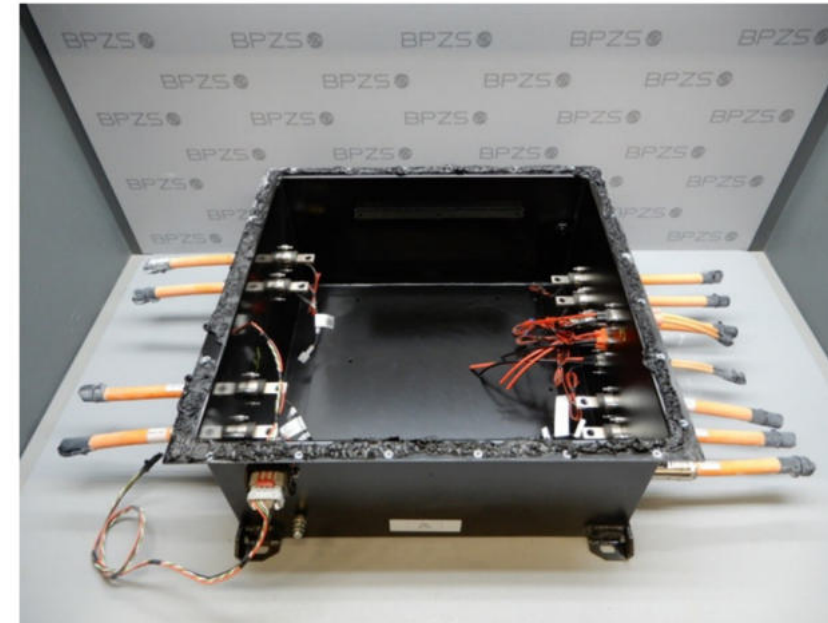
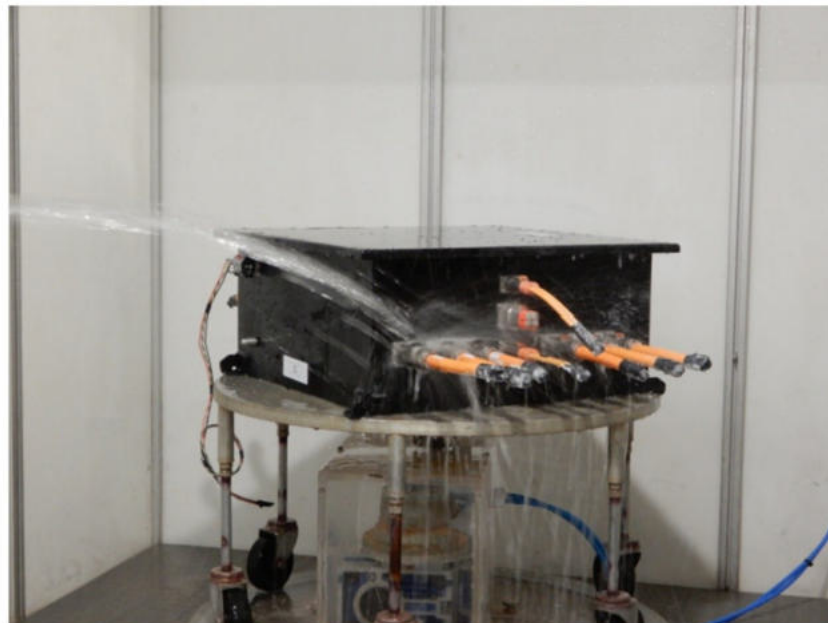
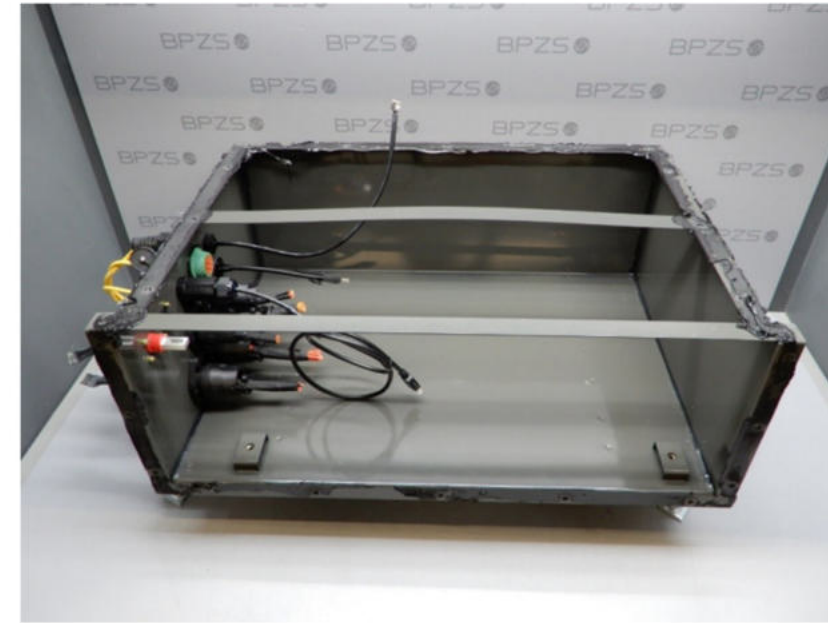
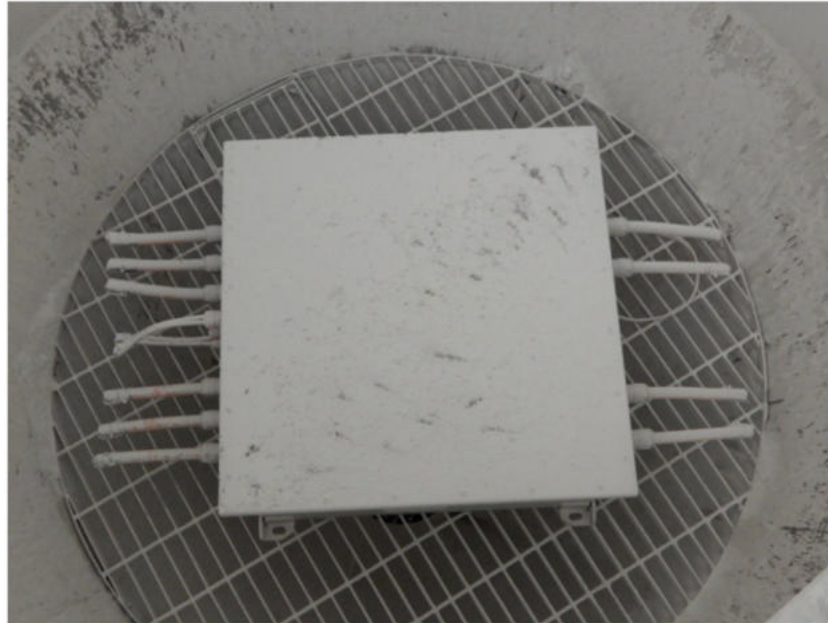
Testing for structural design

Test cases: shunting, sleeping police men, ramp crossing, square profile etc.



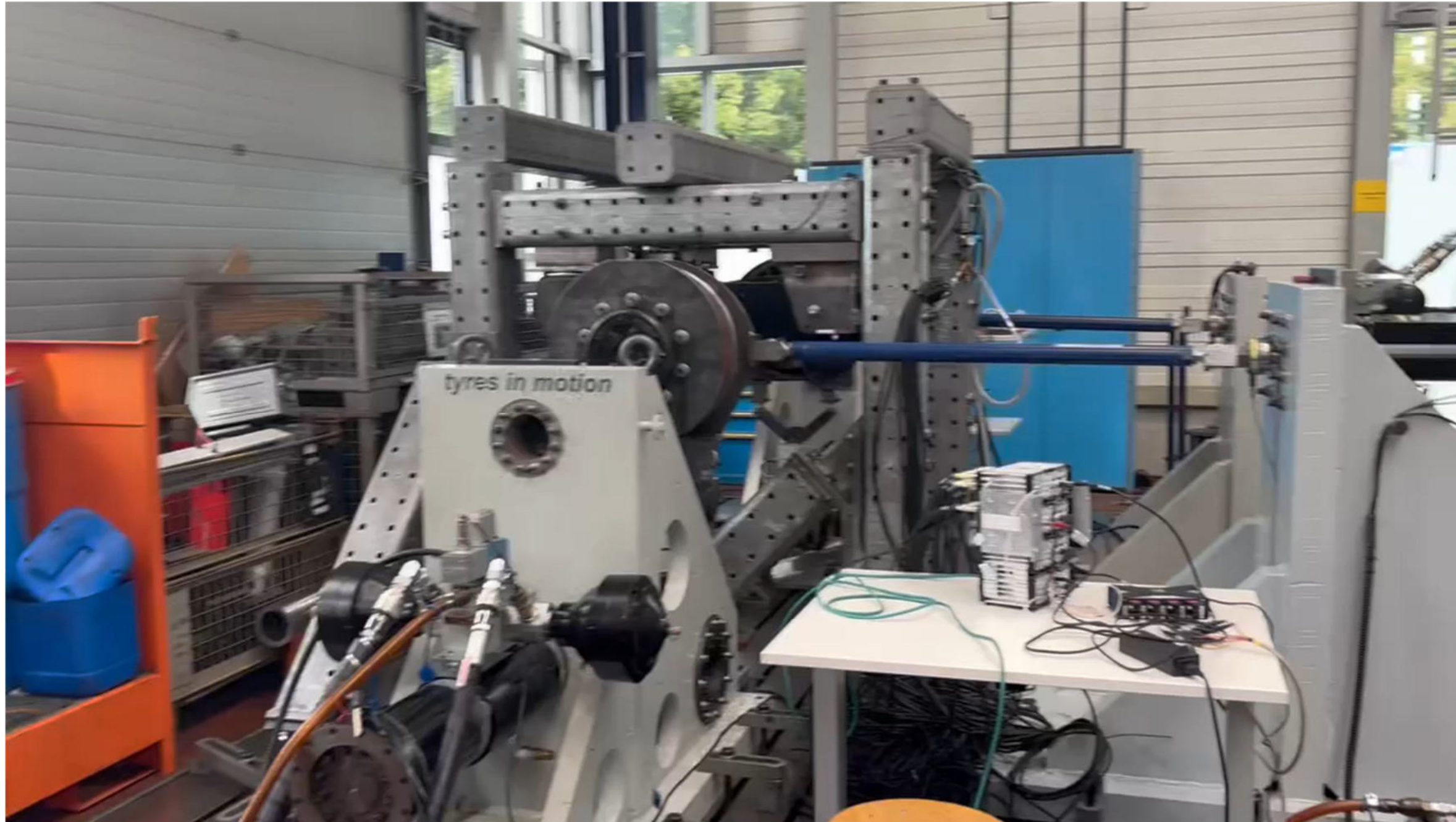
Component Tests

Dust and water intrusion at Power Distribution Unit



Component test

eAxle



Componenten Test

Control box



03

Integration tests



Homologation

UN ECE R 10 – Elektromagnetische Verträglichkeit

Setup, 30-1000 MHz, Pos-1



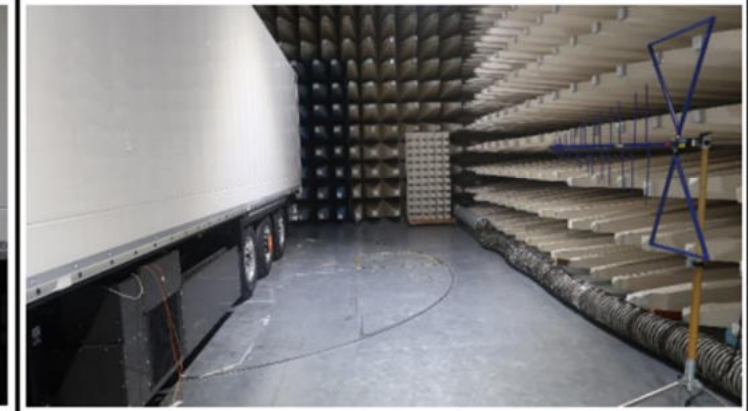
Setup, 30-1000 MHz, Pos-5



Setup, 30-1000 MHz, Pos-3



Setup, 30-1000 MHz, Pos-7



Setup, 30-1000 MHz, Pos-2



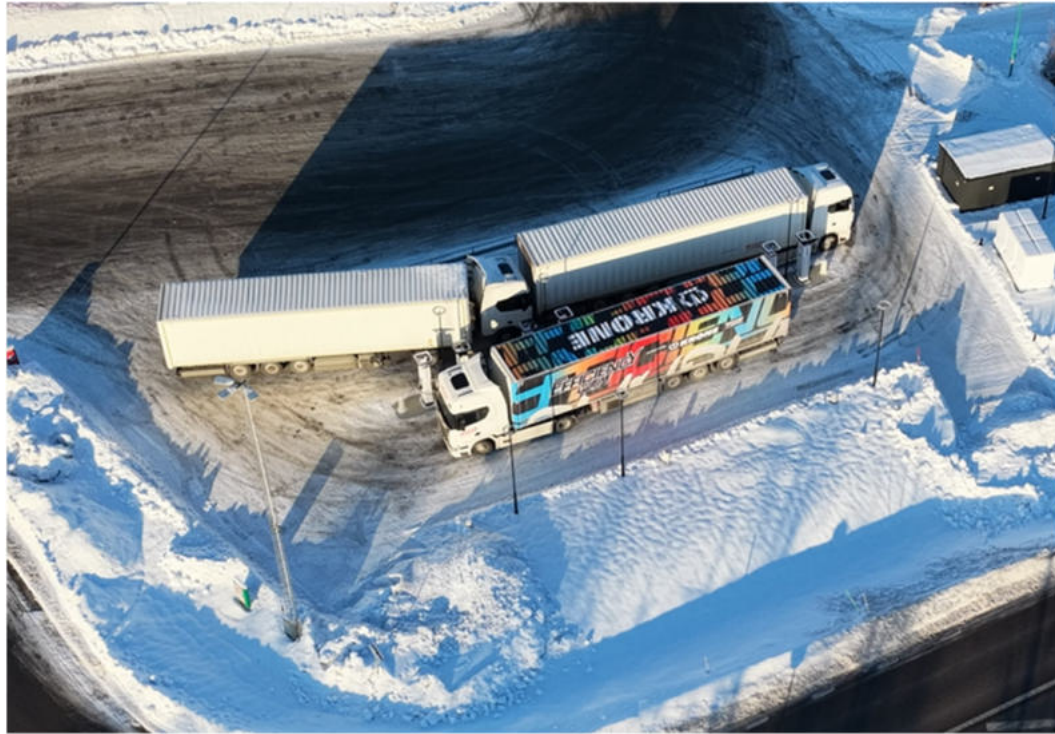
Setup, 30-1000 MHz, Pos-6



Testing on low- μ tracks

Development of Anti-Slip-Regulation (ASR)





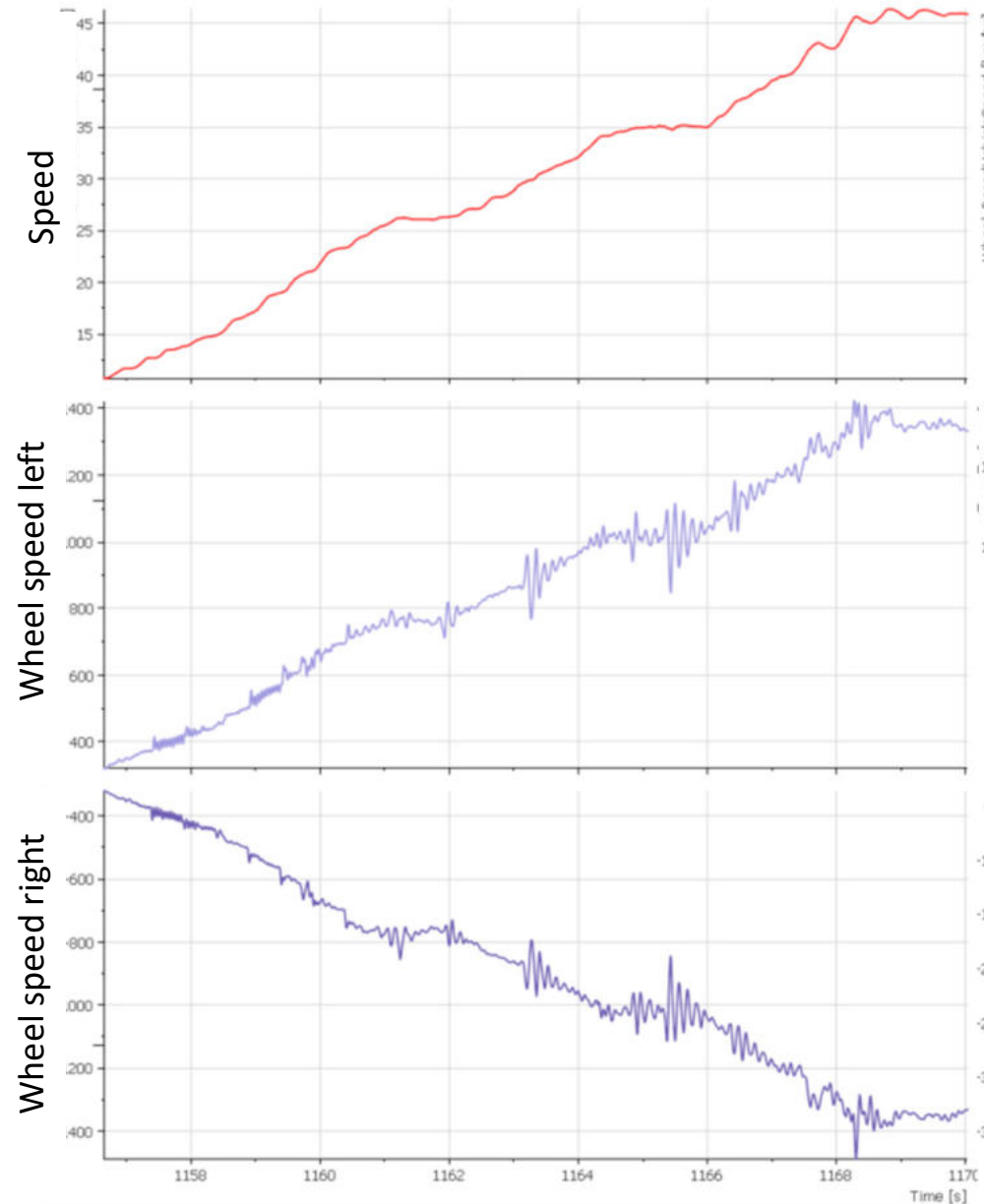
- Testing of eTrailer components during driving and charging at low temperatures (-30°C)
- Testing of Anti-Slip-Regulation (ASR) and king-pin regulation on snow and ice
- Brake testing on snow & ice
- Trip to Polar circle as long haul test on snow and ice
- Optimization of efficiency and thermal battery management for cold countries
- Testing with diesel and BEV tractor units



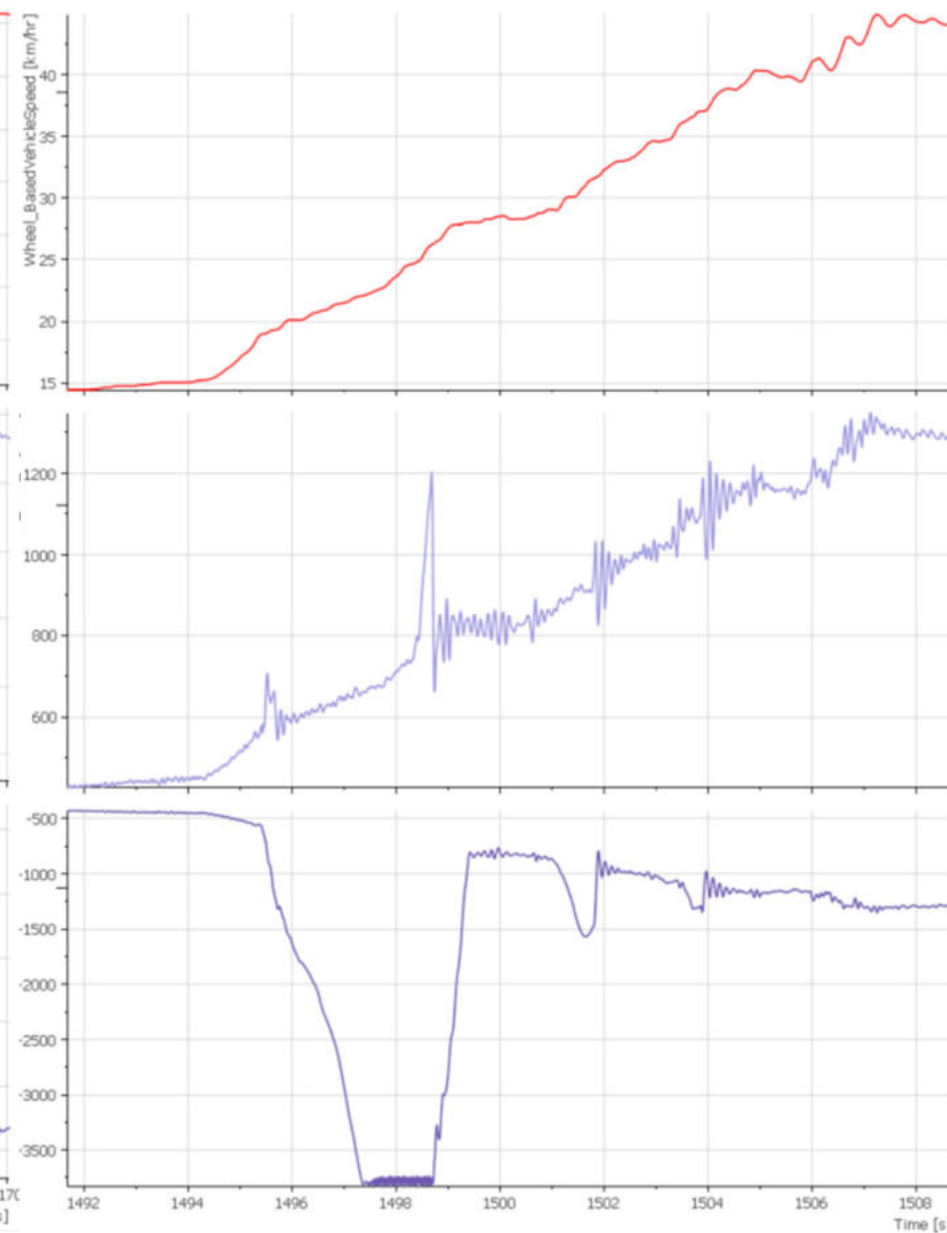
Acceleration on ice

Testing on ice patches

With usage of ASR



Without usage of ASR



- Test track contains irregular patches of ice and dry asphalt
- Control system of eTrailer needs to interact with ASR
- Result:
 - Very stable driving behavior with ASR
 - More rough behavior without ASR

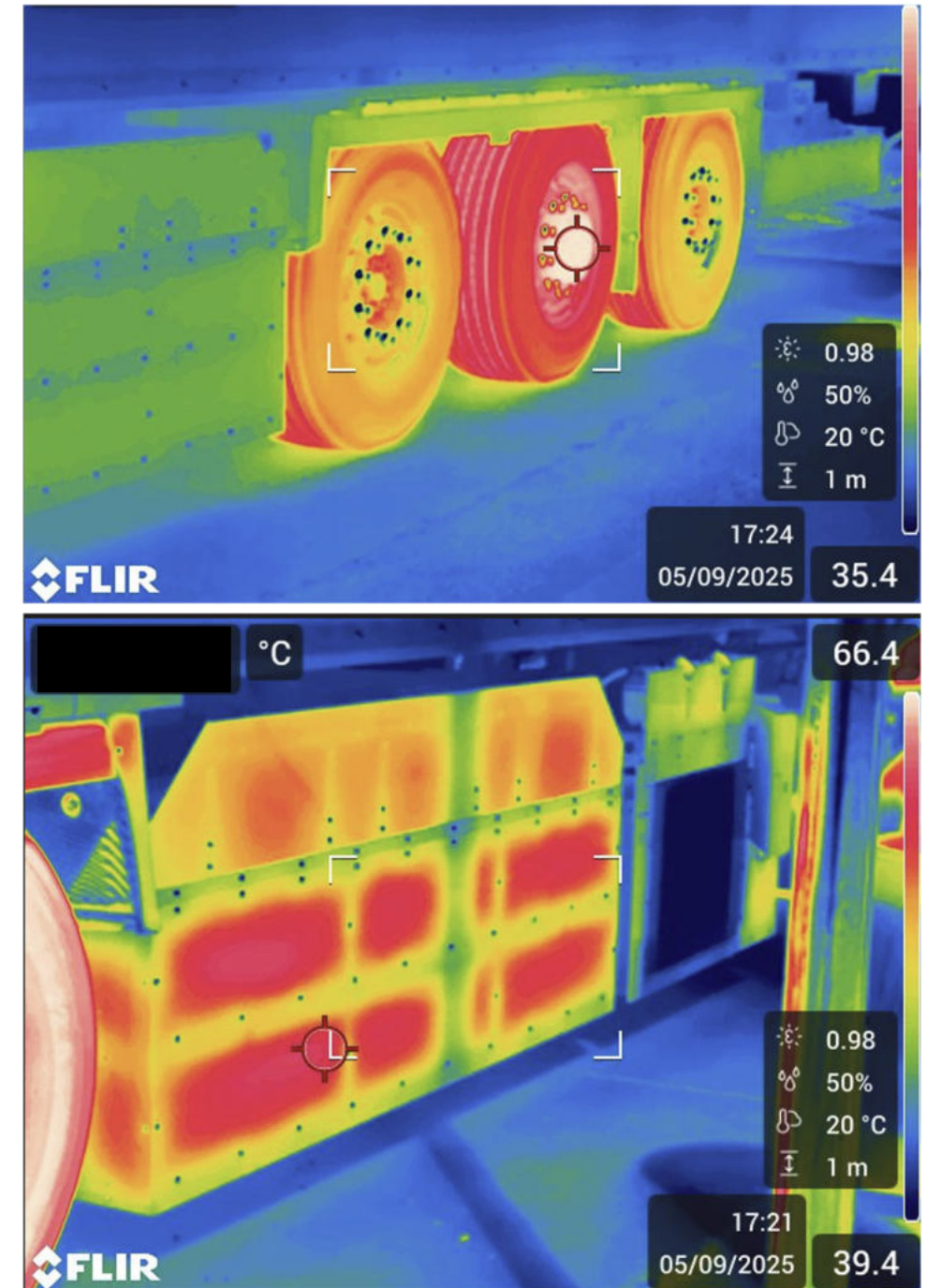


Summer Test 2025

Optimization of cooling system



- Testing of warming and cooling of eTrailer components during driving and charging at hot temperatures up to 40°C
- Up- and downhill testing in Sierra Nevada at high outside air temperatures



Development of eTrailer tires with Continental



- Tire profile and rubber specification optimized for usage in an eTrailer
- Legal for usage on public roads
- Tested in cold and hot countries (Sweden / Spain)



04

Testing with different
tractor units



Testing with different tractor units



Testing on public roads

Comparison of eTrailer with conventional trailer on reference tracks



Regulation

Vehicle classes:

Die Fahrzeuge werden in nachfolgende vier (4) Motoren-Klassen eingeteilt:

Klasse 1: Normale Verbrennungsmotoren mit Diesel oder 100 % nachhaltigem Diesel

Klasse 2: Elektrofahrzeuge mit Batterie

- B.E.V. oder reine oder vollelektrische Fahrzeuge
- Elektrofahrzeuge mit Brennstoffzellen

Klasse 3: Verbrennungsmotor mit H2

Klasse 4: Verbrennungsmotor mit (Bio-)LNG



Class 1: 10 trucks

Class 2: 3 trucks (all BEV)

Class 3: 0 trucks

Class 4: 1 truck

+ Trailer dynamics eTrailer with diesel tractor unit

Scoring:

Die Rangfolge wird in jeder Motorenklasse (Ziffer 5) anhand des Performance Index (PI) ermittelt, der sich aus dem Energieverbrauchsindex (ECI) und dem Regelmäßigkeitsindex (RI) zusammensetzt:

- a) Regelmäßigkeitsindex (RI) = Strafpunkte für jede Minute oder Bruchteil einer Minute, die das Fahrzeug zu früh ankommt (max. Geschwindigkeit = Unterschreiten der Mindestfahrzeit) und Strafpunkte für jede Minute oder Bruchteil einer Minute, die das Fahrzeug zu spät ankommt (min. Geschwindigkeit = Überschreiten der maximalen Fahrzeit).
- b) Energieverbrauchsindex (ECI) = Tatsächlicher Energieverbrauch, ermittelt mit einem FIA-Messgerät, im Verhältnis zu den offiziellen und Fahrzeug-spezifischen Werten, die von jedem Hersteller für das jeweilige Modell gem. Zulassungsunterlagen angegeben werden.

Max. vehicle mass:

Das Gewicht von Zugmaschine mit Auflieger muss mindestens 16 Tonnen betragen und darf ein Gewicht von 18 Tonnen nicht überschreiten.

TRAILER HEADS



Truck Efficiency Run

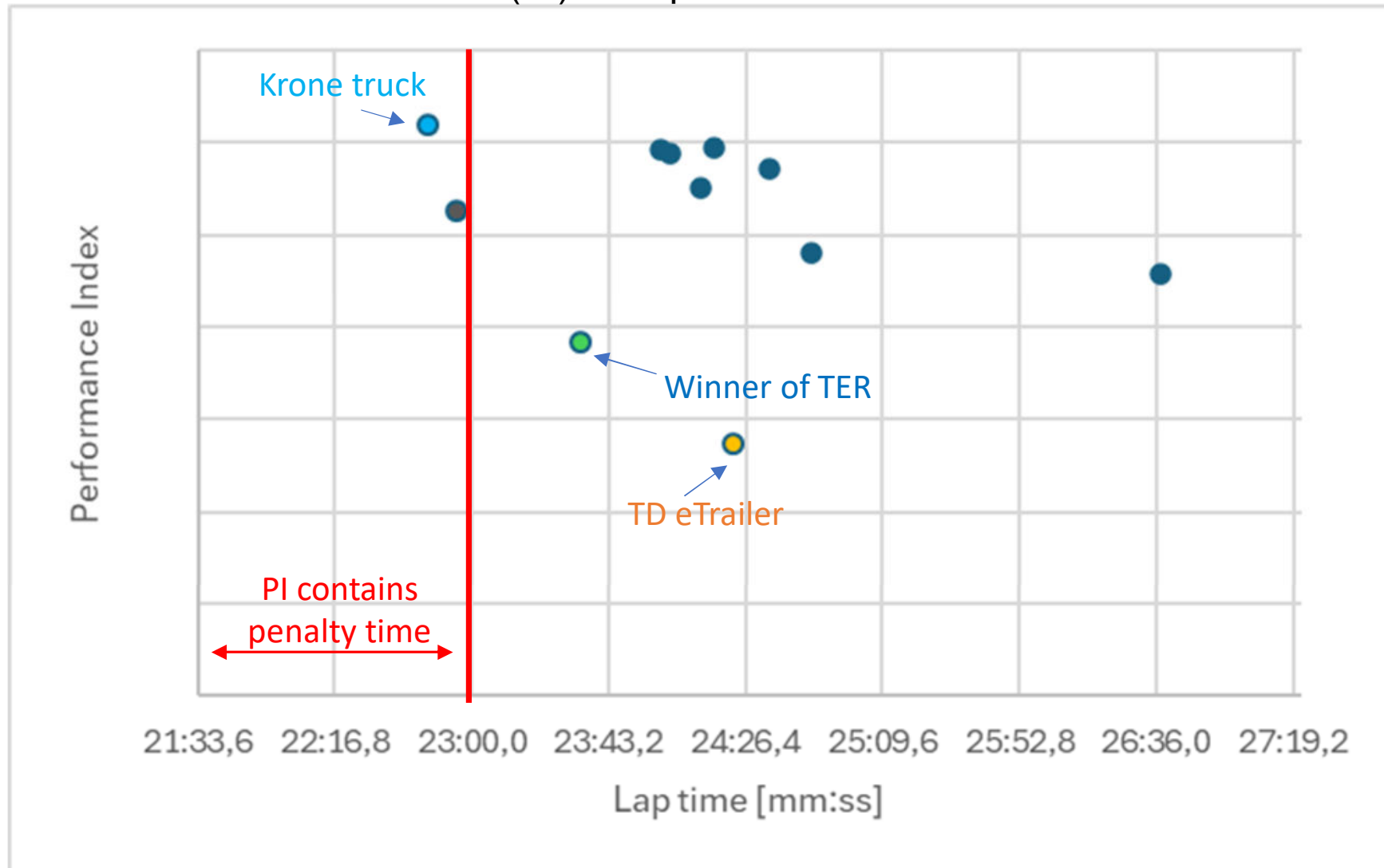
10.07.2025 Nürburgring GP-track (short) + Nordschleife

Distance	24.1 km
Average diesel consumption tractor unit	20.6 ltr. / 100 km
Total energy consumption eTrailer	24 kWh
Average energy consumption eTrailer	103,7 kWh / 100 km
SOC start	83,6 %
SOC end	79,2 %



Truck Efficiency Run (TER)

Results – Performance Index (PI) vs. lap time



Average diesel consumption (Krone truck)

33.4 ltr. / 100 km

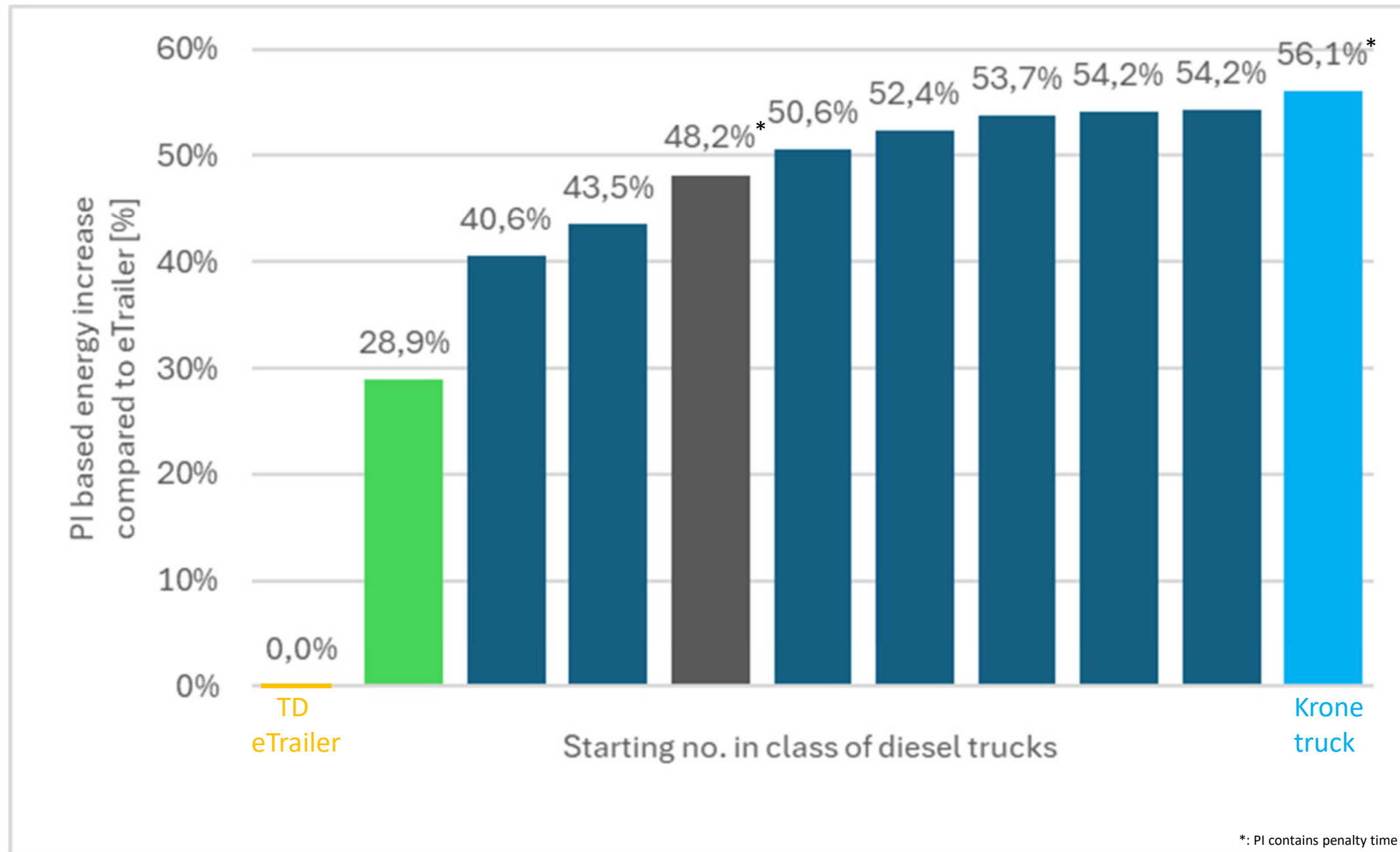
Average diesel consumption (TD eTrailer)

20.6 ltr. / 100 km
(38,3% saving)



Truck Efficiency Run

Results



Testing with electric tractor units

Field tests – customer targets

Field test „Black Forrest“

- Use electric tractor unit on a daily trip of 475 km in Black Forrest region without recharging the tractor unit during the trip
- Result: 40% SOC remaining in tractor unit at the end of the test

Field test „Long Haul“

- Elongate range of electric tractor unit
- Test charging infrastructure between the Netherlands and Hungary

Trailer Dynamics internal tests

- Winter test with electric tractor unit: testing usability in Swedish winter
 - Long haul test with testing of charging infrastructure
- Depending on usage profile very clear extension of range and reduction of travel time because tractor unit might not be charged during the trip



Many thanks for you attention!



Presentation 3:

***A path-following controller for reversing
tractor-trailer and A-double,***

Zhaohui Ge, Chalmers University of Technology,
Göteborg

A path-following controller for reversing tractor-trailer and A-double

Zhaohui Ge, Vehicle Dynamics group, Chalmers

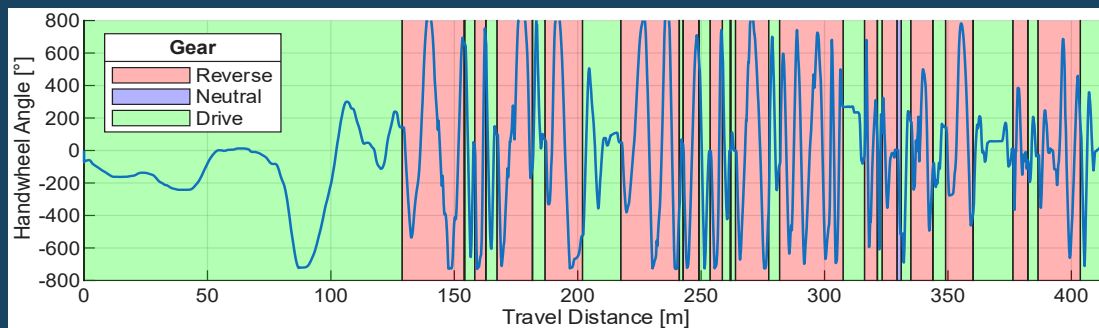
Content

1. Background
2. Test vehicle
3. Control design
4. Test results
5. Future work

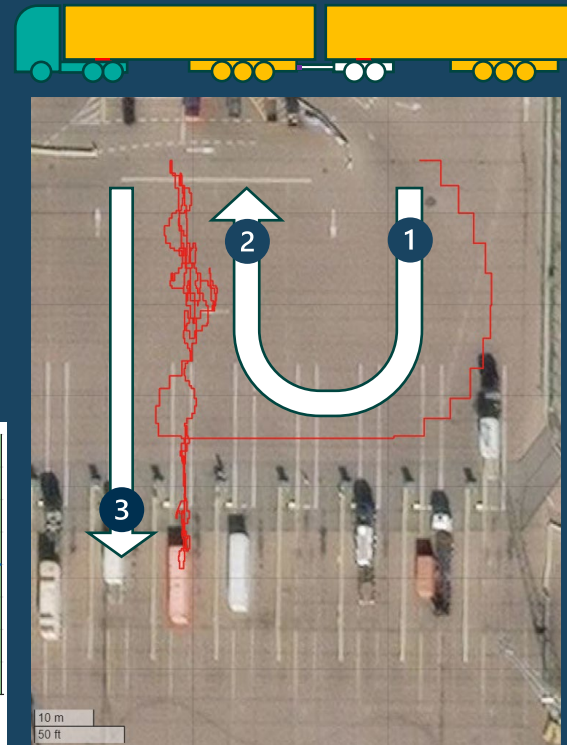
1. Background

Parking an A-double at Port of Gothenburg

- Time: ≈ 8 minutes
- Gear change: 32 times
- Handwheel travel: 8572 degrees ≈ 24 circles



Gear and handwheel steering angle



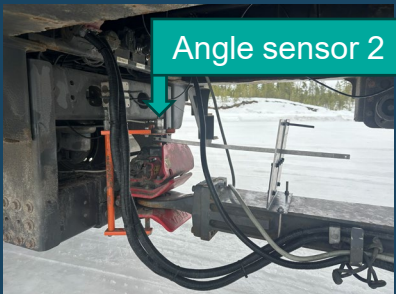
Tractor's path

2. Test vehicle

Sensing

All signals transmitted via CAN

- Articulation angle sensors
- GNSS & IMU on the last trailer
- Tractor speed



2. Test vehicle

Actuating

External steering interface via CAN

- Steering (-100~100%)
- Acceleration pedal position (0~100%)

Manual

- Parking brake
- Service brake
- Gear

VOLVO

FACT SHEET

EXTERNAL STEERING INTERFACE

EXSTER Support for external steering control via body builder module



PRODUCTIVITY

- The body builder can connect a wireless remote control.
- The vehicle can be controlled and driven from the outside.

Requirements for EXSTER:

- Body builder module (ECBB-HIG or ECBB-HI2).
- Volvo Dynamic Steering (ACTST-TO)

Note! Local homologation needs to be fulfilled. The remote control is not included in the variant.

Example of how the external steering can be used.

3. Control design

Layout

Predefined inputs

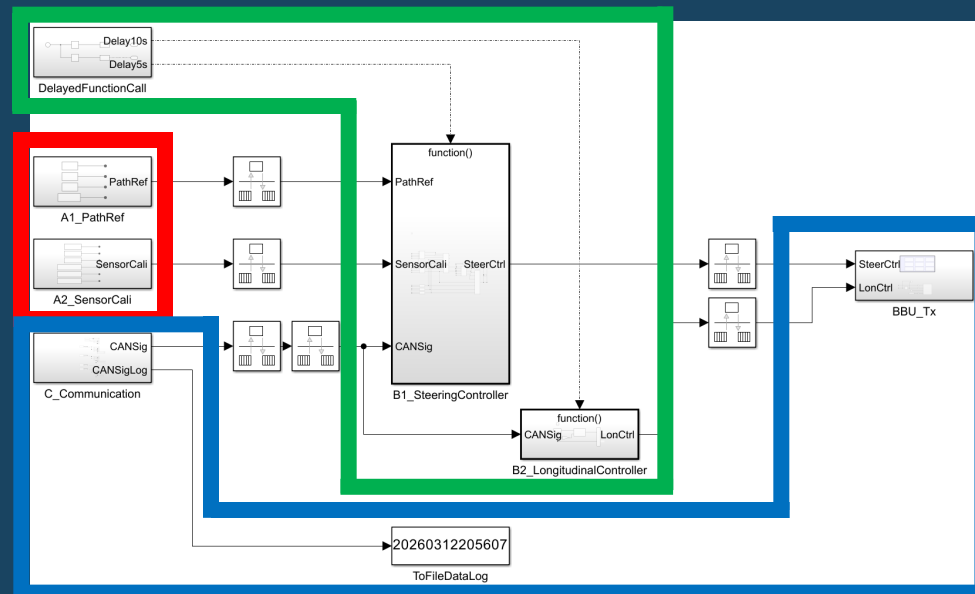
- Reference path
- Sensor offsets

Control

- Lateral control
- Longitudinal control

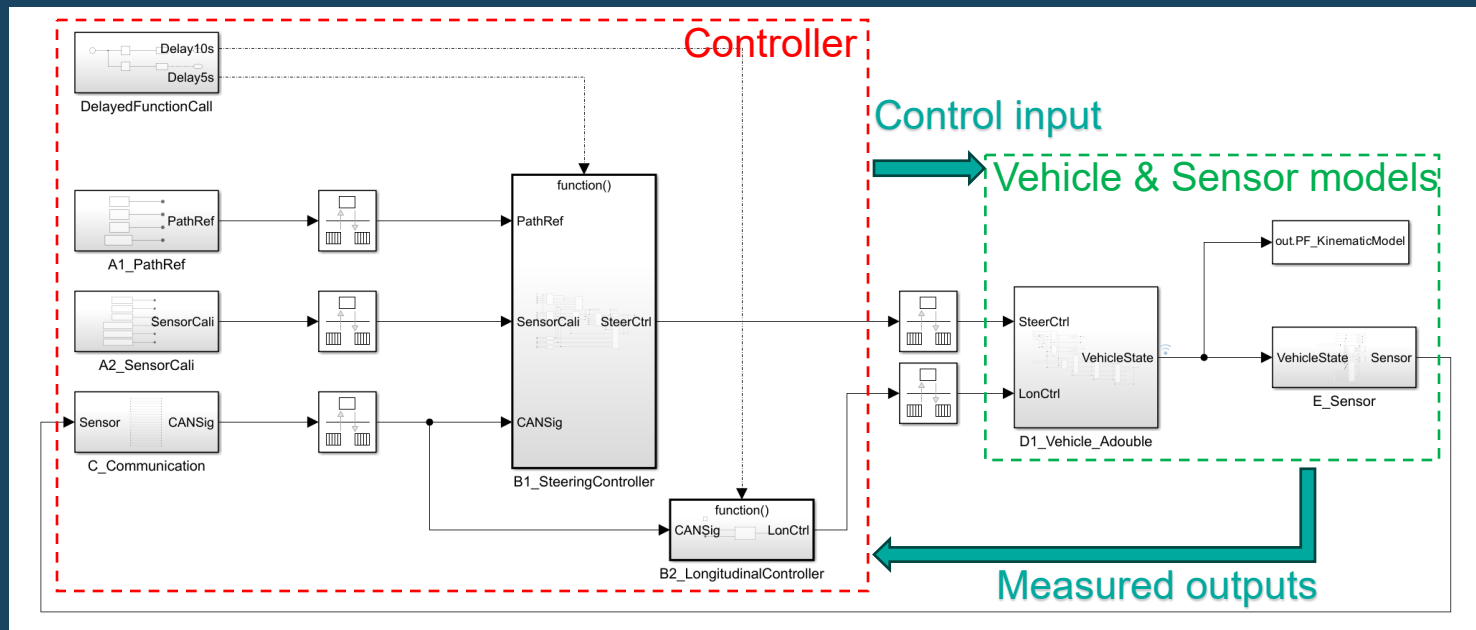
Communication

- CAN inputs (Vehicle, Articulation, GNSS)
- CAN outputs (Vehicle)
- Logger



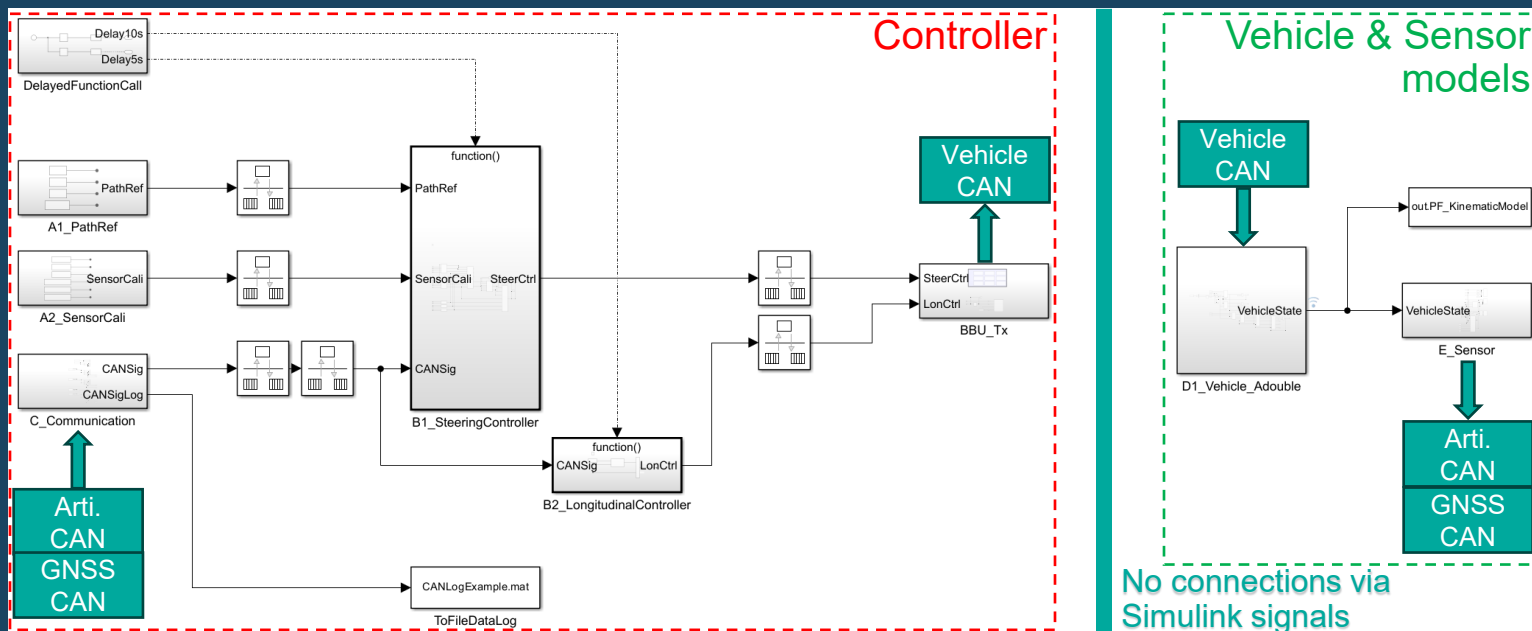
3. Control design

Simulation environment, Communicate via Simulink signal



3. Control design

Simulation environment, Communicate via virtual CAN

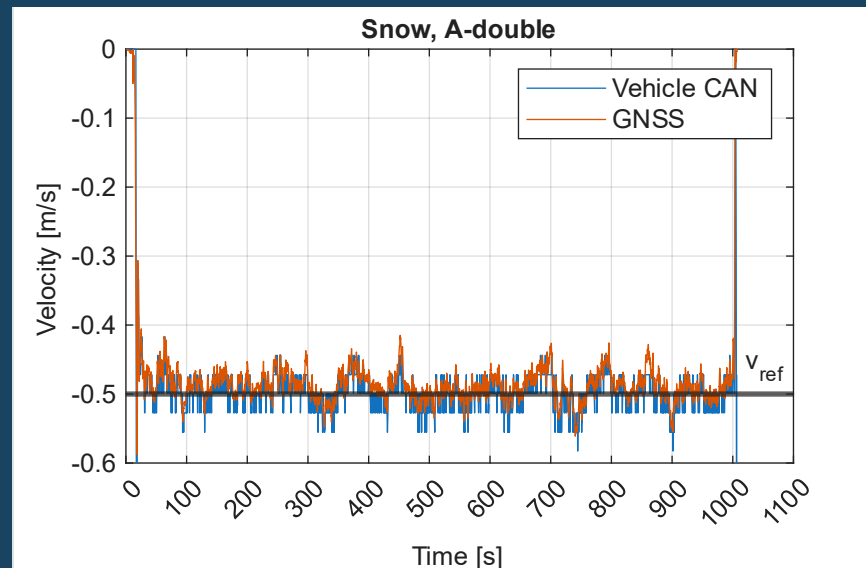


3. Control design

Longitudinal control

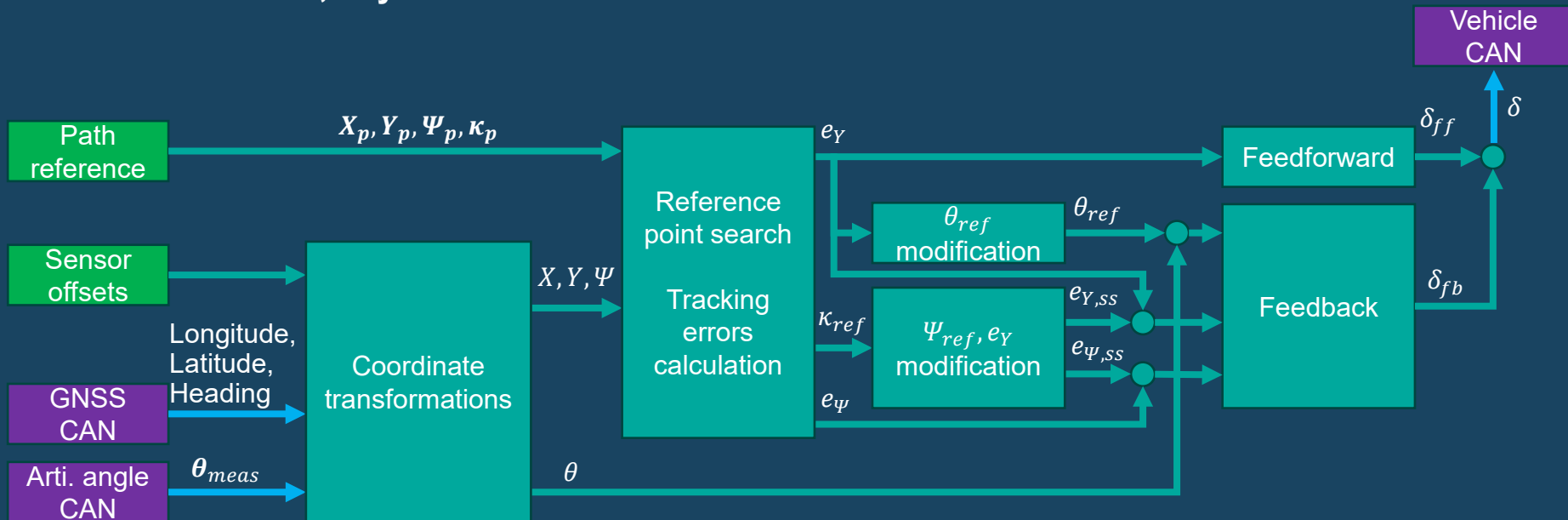
PI controller

- Output saturation applied
- Different K_p and K_I applied to different vehicles



3. Control design

Lateral control, Layout



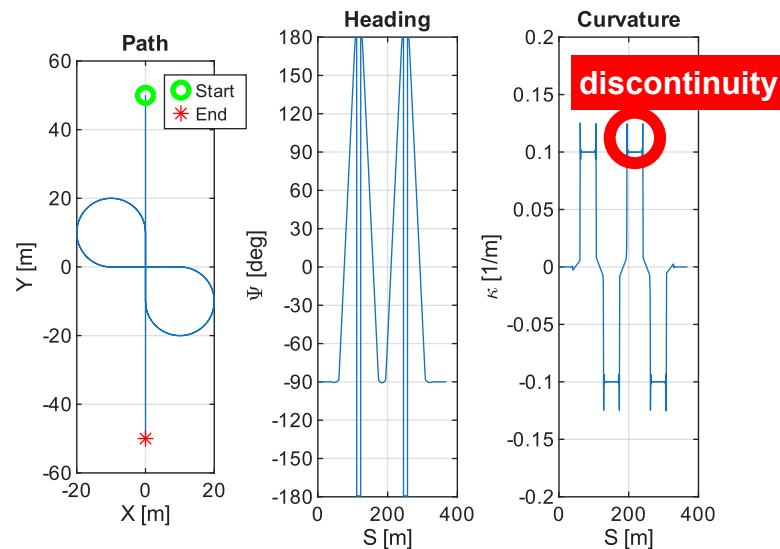
3. Control design

Lateral control, Path reference

Step 1. Define waypoints (X, Y) with a large distance (>1 m) in between.

Step 2. Reduce the distance between waypoints to a small distance (0.1 m) with spline interpolation.

Step 3. Calculate path heading and curvature based on waypoints.



3. Control design

Lateral control, Path reference with smooth curvature

Approach 1. Pseudo-continuous curvature

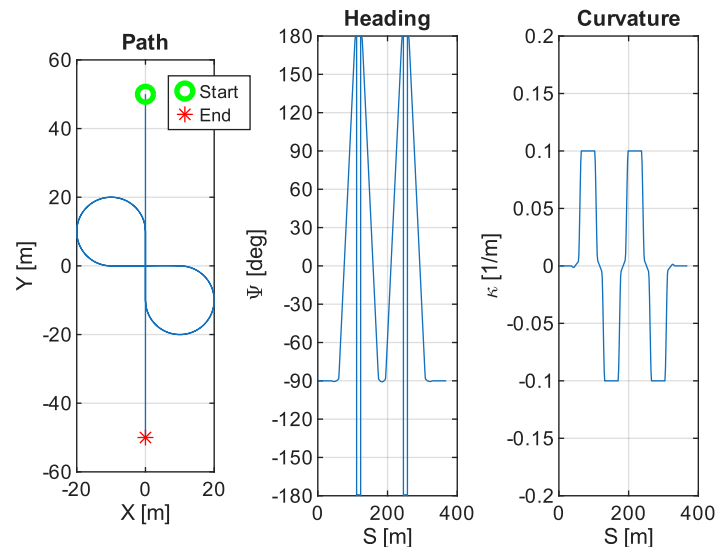
Same waypoints with smoothed curvature

Approach 2. Replan with decimated waypoints

- Decimate waypoints and heading with a large interval (20 m)
- Use existing smooth planning functions (smoothPathSpline)

Future approach, higher order continuity in curvature (for continuous steering angle)

- Tractor-trailer, continuous κ'
- A-double, continuous κ'''

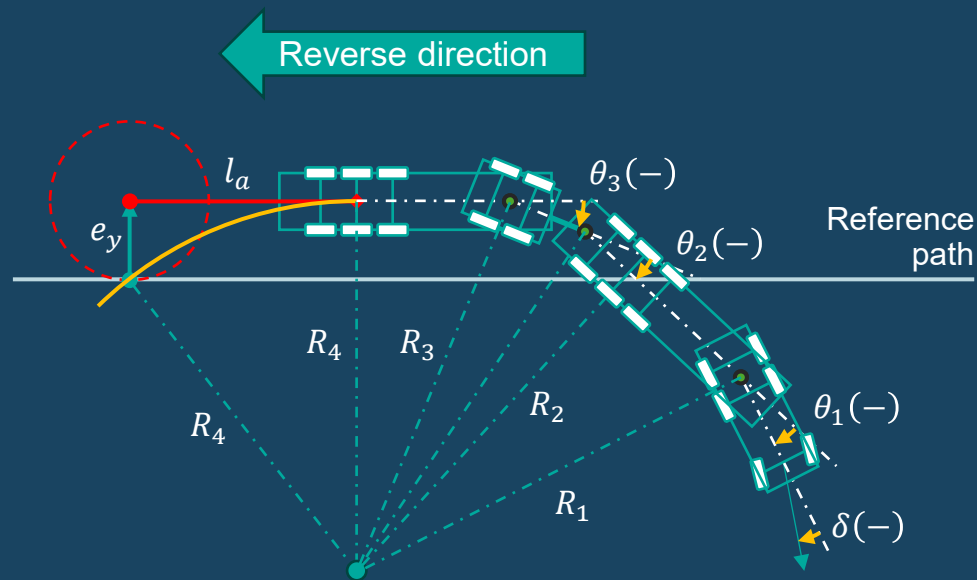


3. Control design

Lateral control, Straight line tracking

Modified pure pursuit

- Desired path radius for the last trailer
- From R_4 to the corresponding steady state based on the kinematic model
- Precompute lookup tables from e_Y to $[\theta_1, \theta_2, \theta_3]_{SS}$ and δ_{ss}



3. Control design

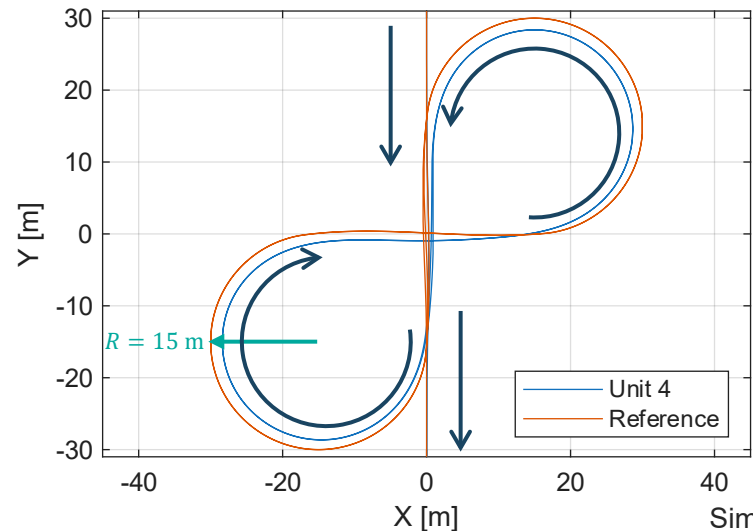
Lateral control, Straight line tracking

- Low tracking error for straight sections

$$e_y = 0.06 \text{ m at } Y = -30 \text{ m}$$

- High steady-state error for circular sections

$$e_y = 1.62 \text{ m when } R = 15 \text{ m}$$

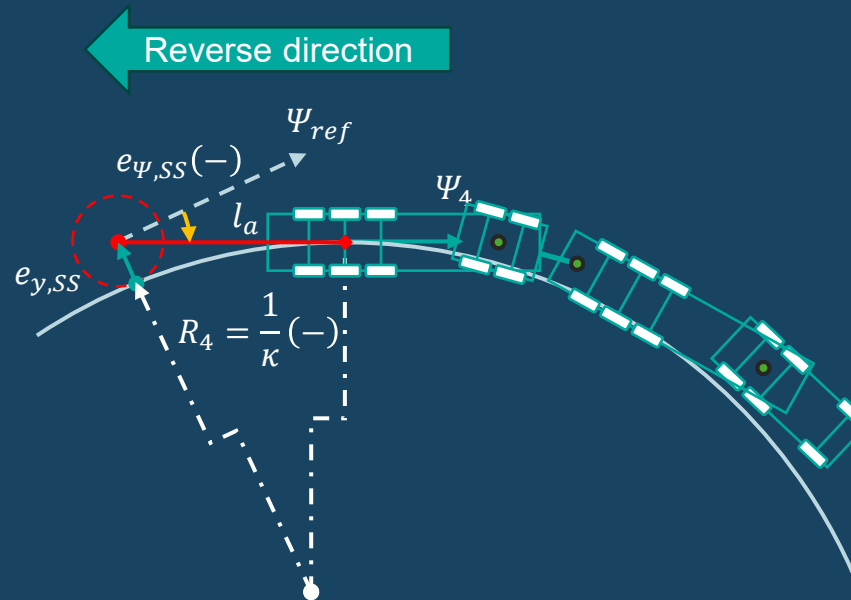


Simulation

3. Control design

Lateral control, Circular arc tracking

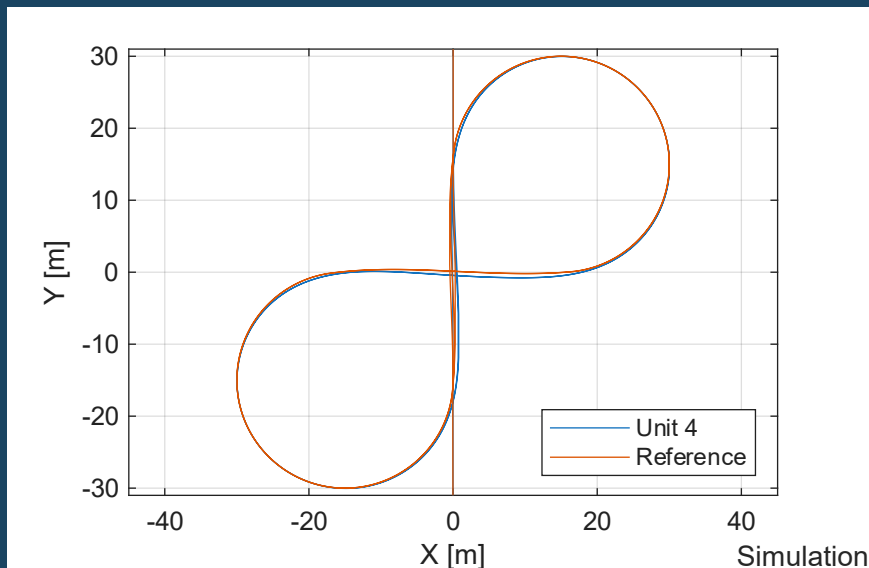
Eliminate steady-state offset by reference modification



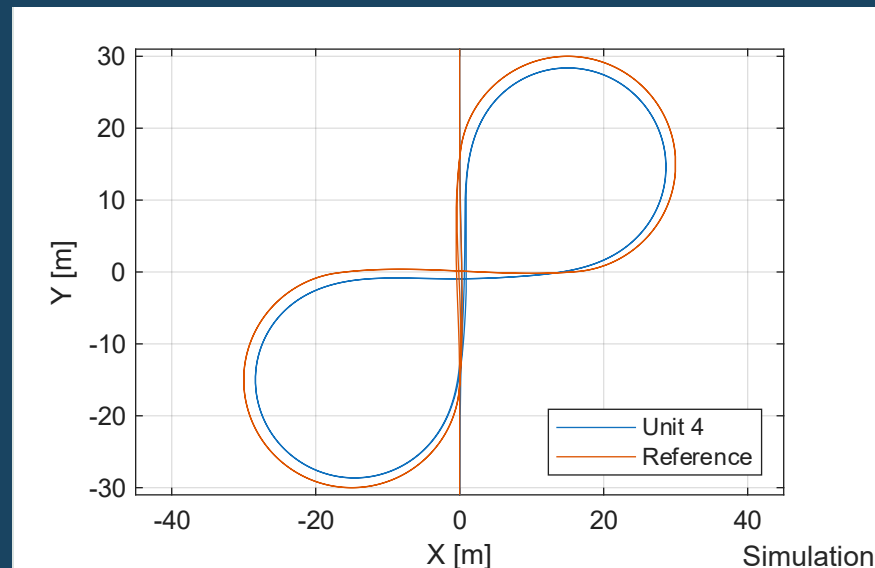
3. Control design

Lateral control, Circular arc tracking

- With reference modification



- Without reference modification

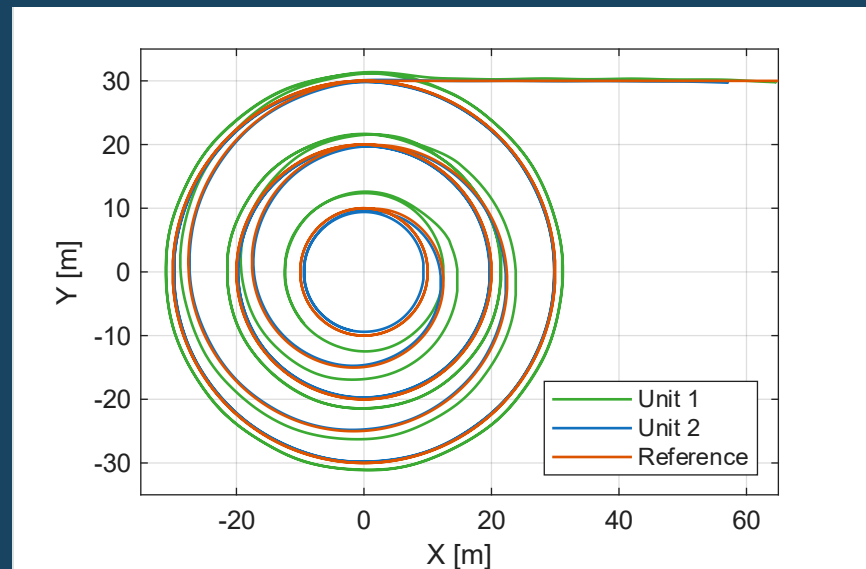
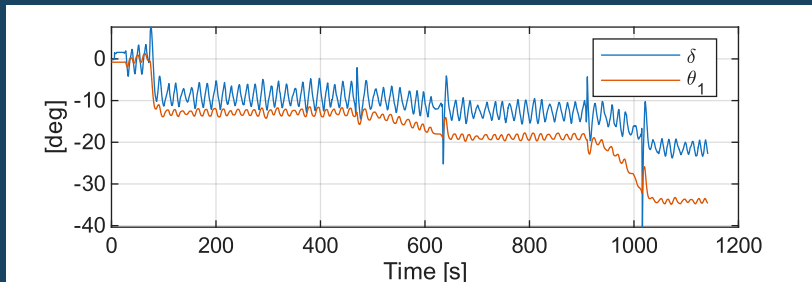


4. Test results

Tractor Trailer, Constant radii (30, 20, 10 m), 1 m/s

- Stable tracking
- Steady-state error $\uparrow$ when Radius $\downarrow$

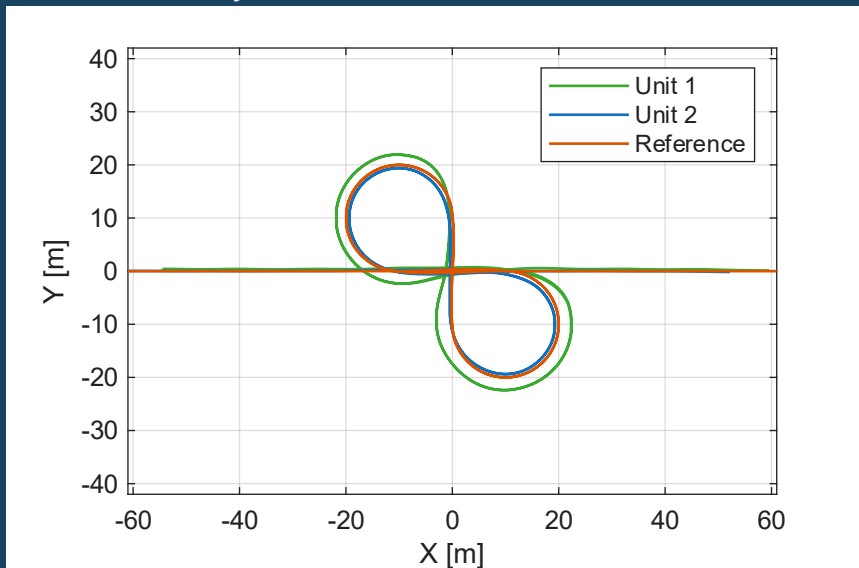
R [m]	30	20	10
e_y [m]	0.15	0.26	0.59



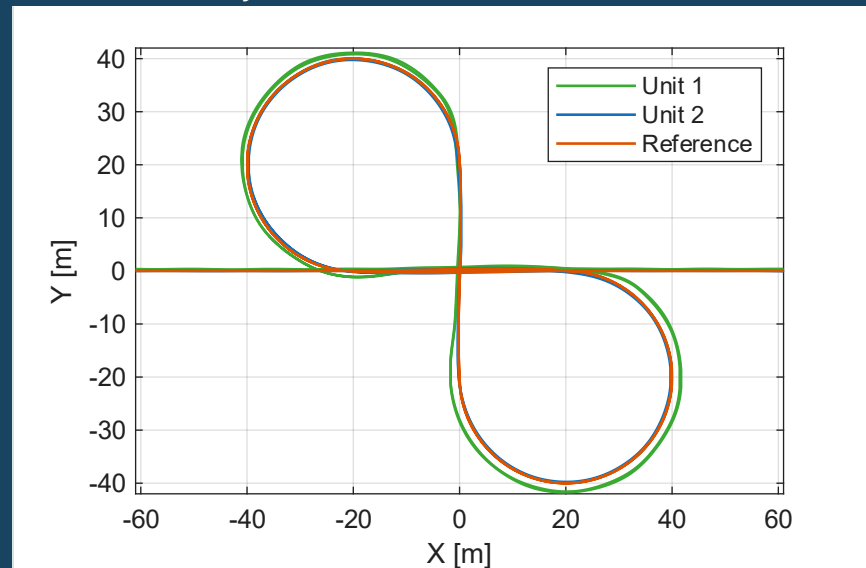
4. Test results

Tractor Trailer, Figure 8 (10, 20 m), 1 m/s

- $R = 10$ m, $e_{y,ss} \approx 0.7$ m

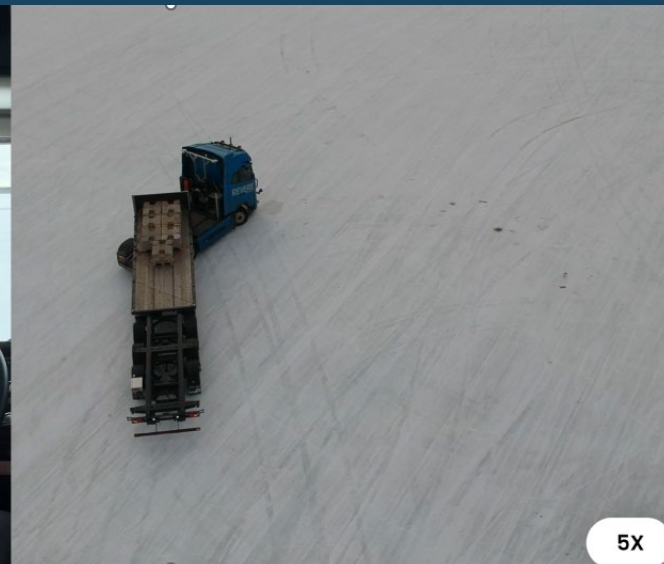
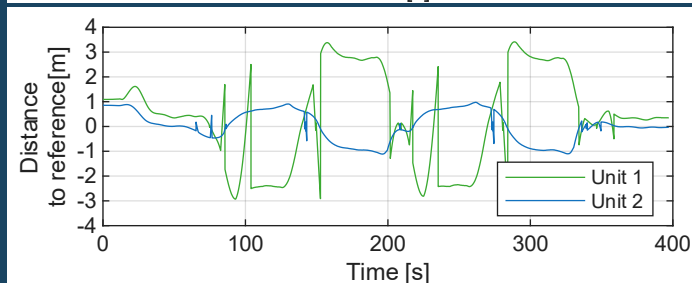
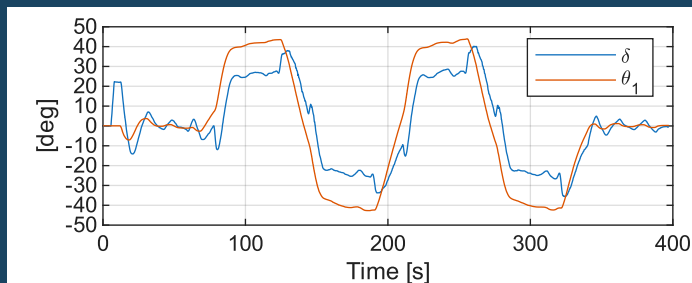
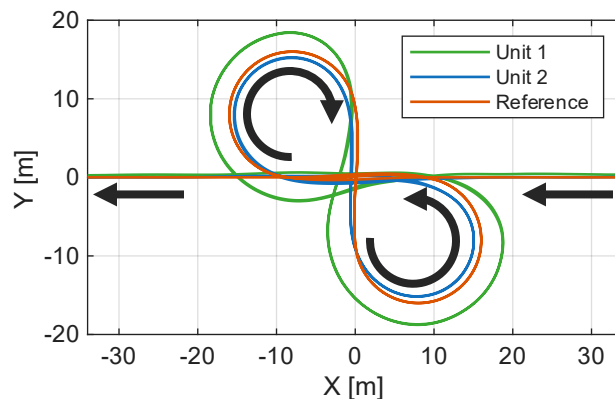


- $R = 20$ m, $e_{y,ss} \approx 0.2$ m



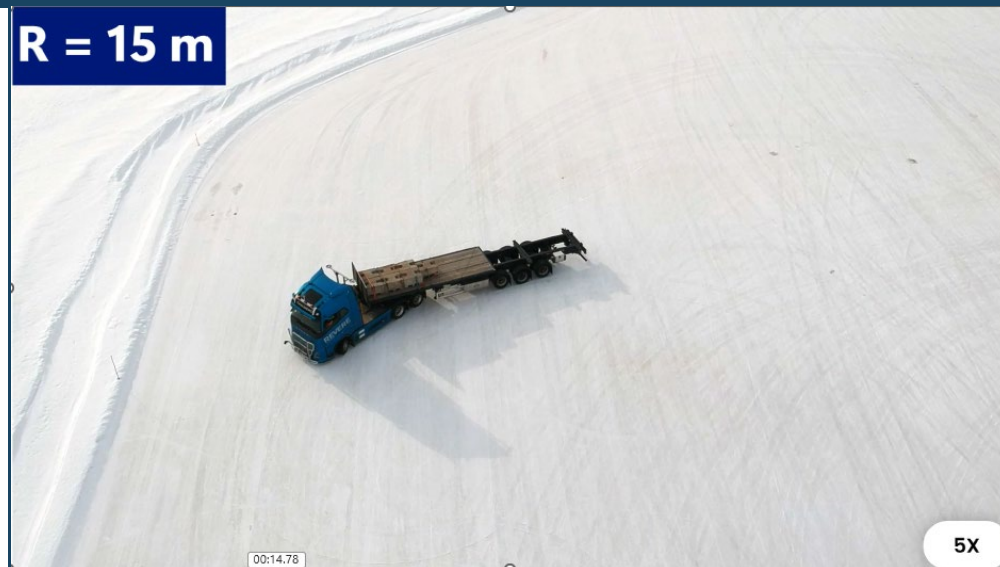
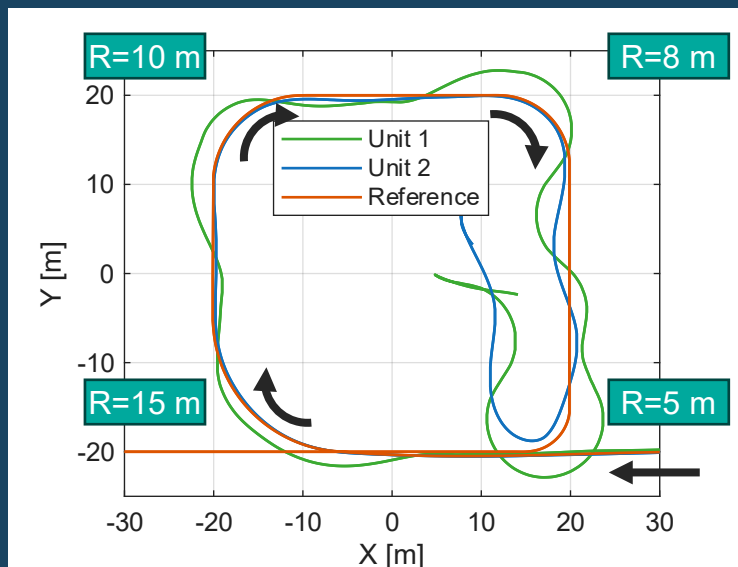
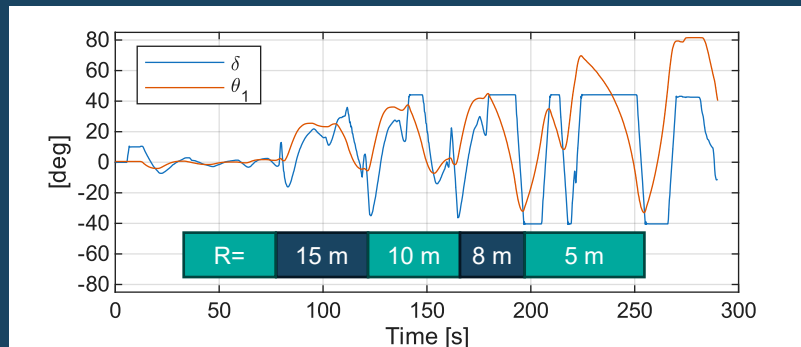
4. Test results

Tractor Trailer, Figure 8 (8 m), 1 m/s



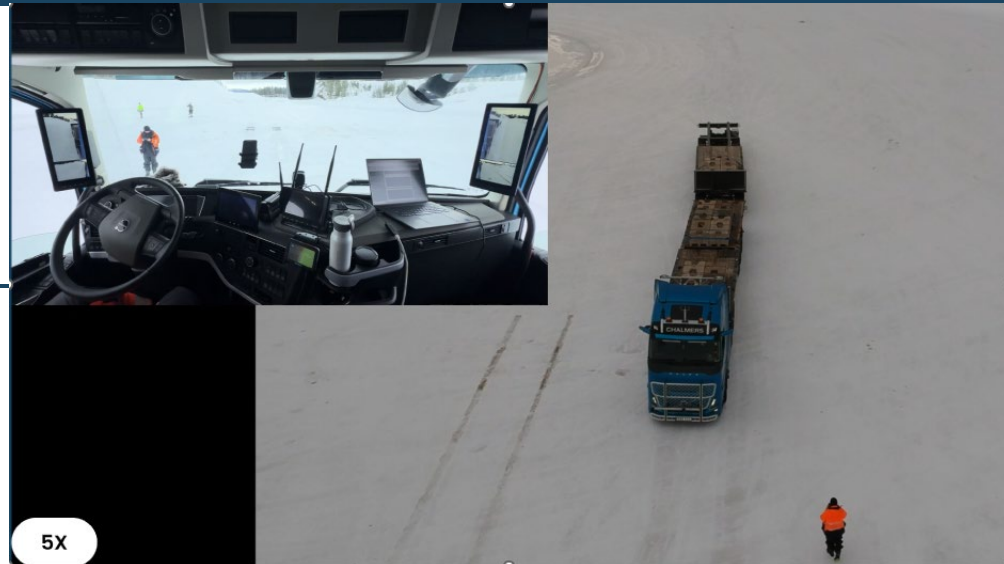
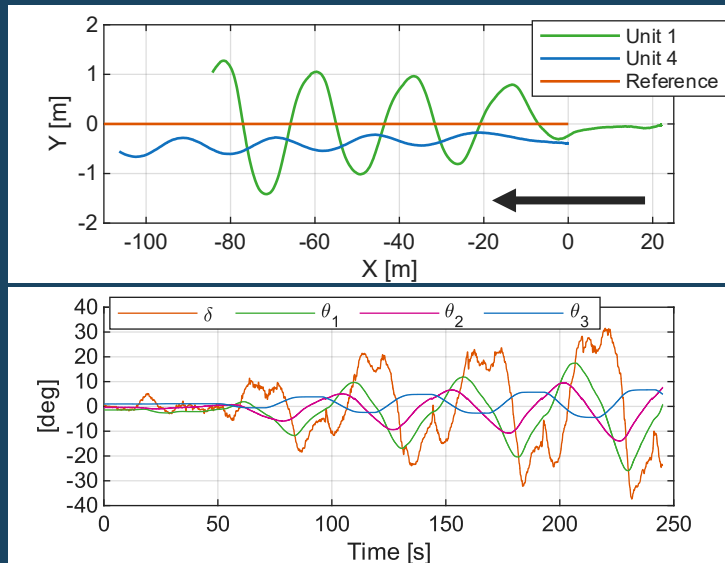
4. Test results

Tractor Trailer,
90-degree turn (15, 10, 8, 5 m), 1 m/s



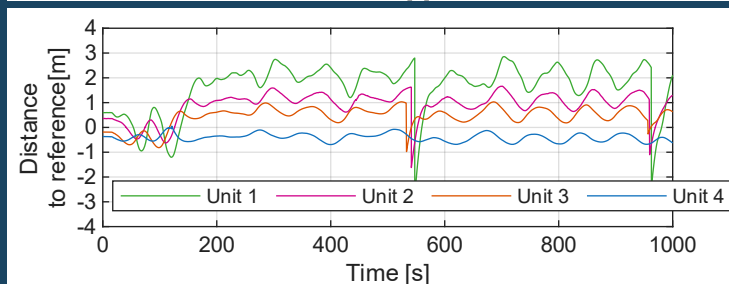
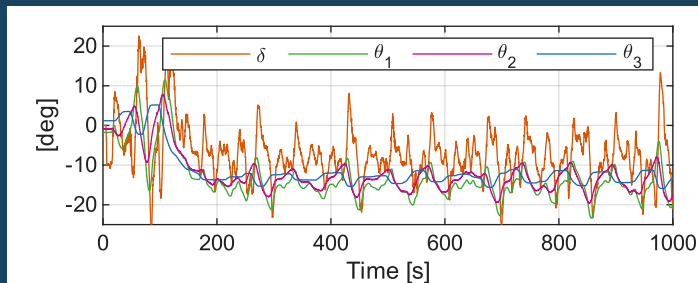
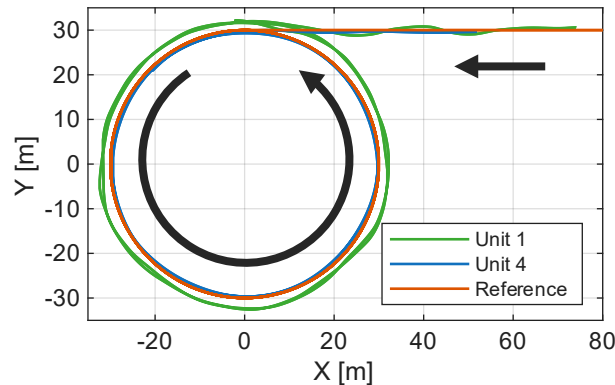
4. Test results

A-Double, Straight line, 0.5 m/s



4. Test results

A-Double, Constant radius (30 m),
0.5 m/s

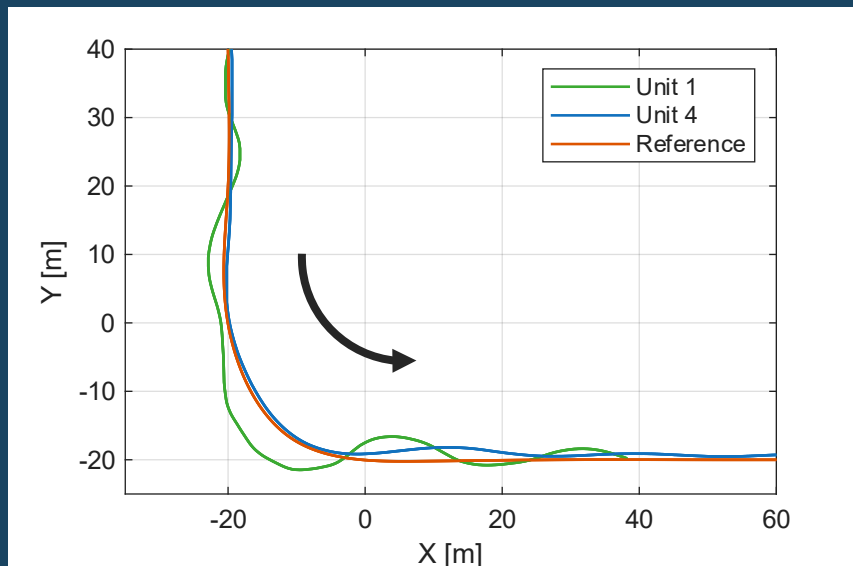


5X

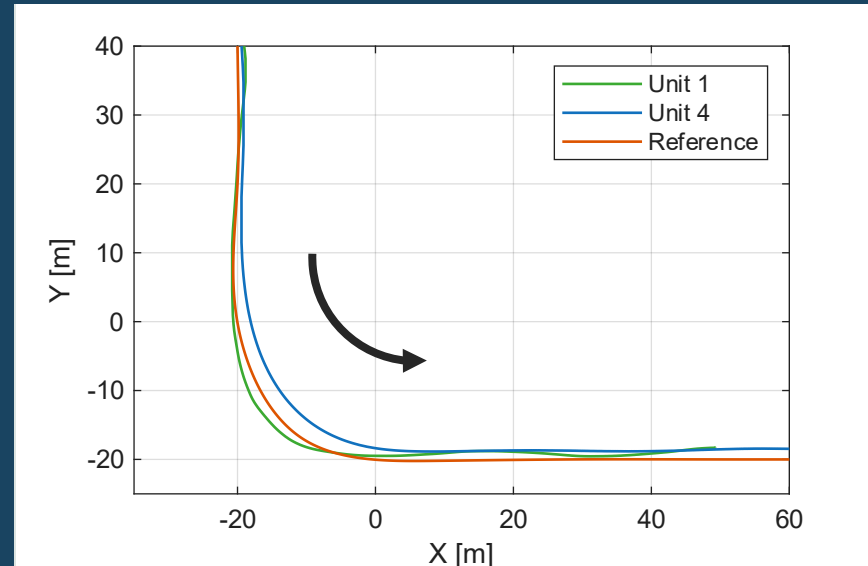
4. Test results

A-Double, 90-degree turn (20 m), 0.5 m/s

• $l_a = 11.55$ m



• $l_a = 15.40$ m

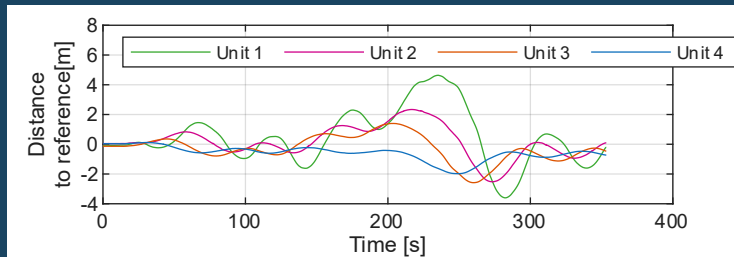


4. Test results

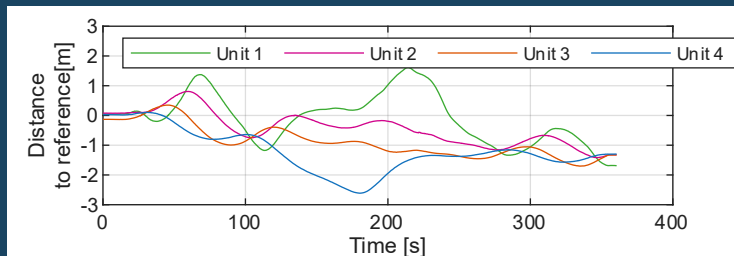
A-Double, 90-degree turn (20 m), 0.5 m/s

• $l_a = 11.55$ m

• $l_a = 15.40$ m



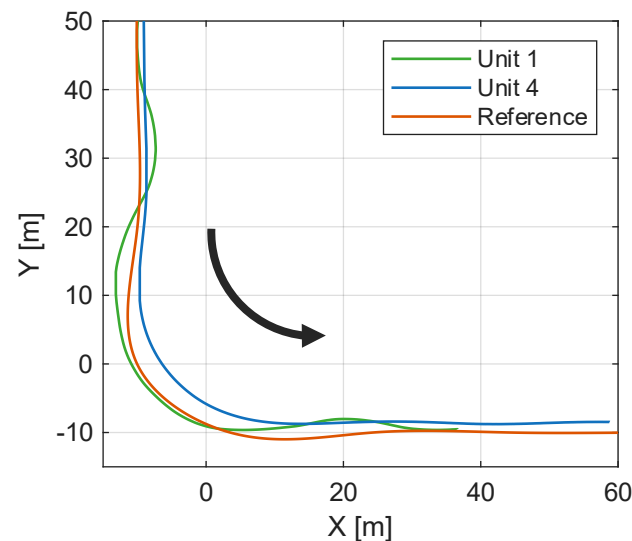
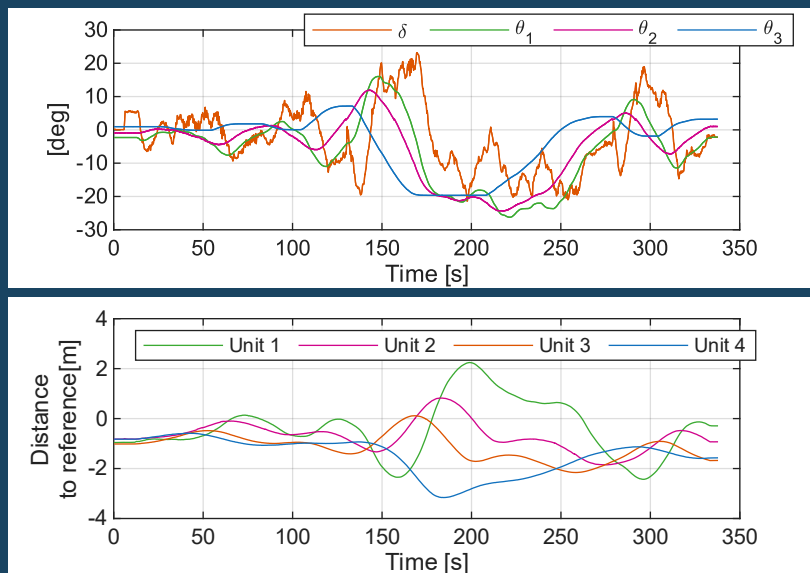
• $l_a = 15.40$ m



5X

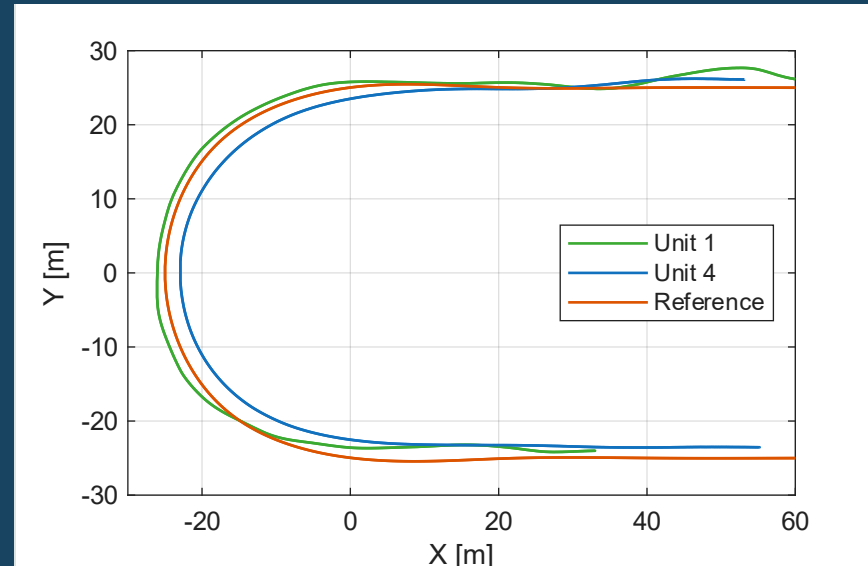
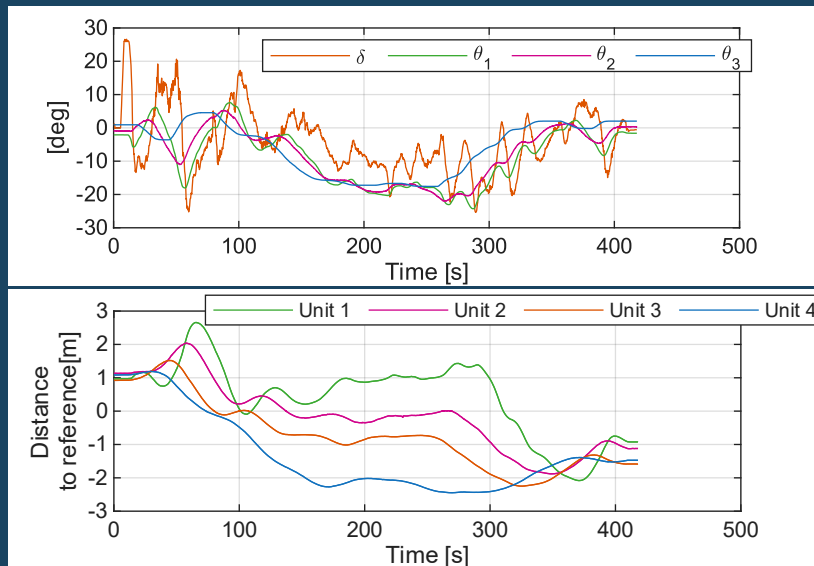
4. Test results

A-Double, 90-degree turn (10 m), 0.5 m/s



4. Test results

A-Double, U-turn (25 m), 0.5 m/s

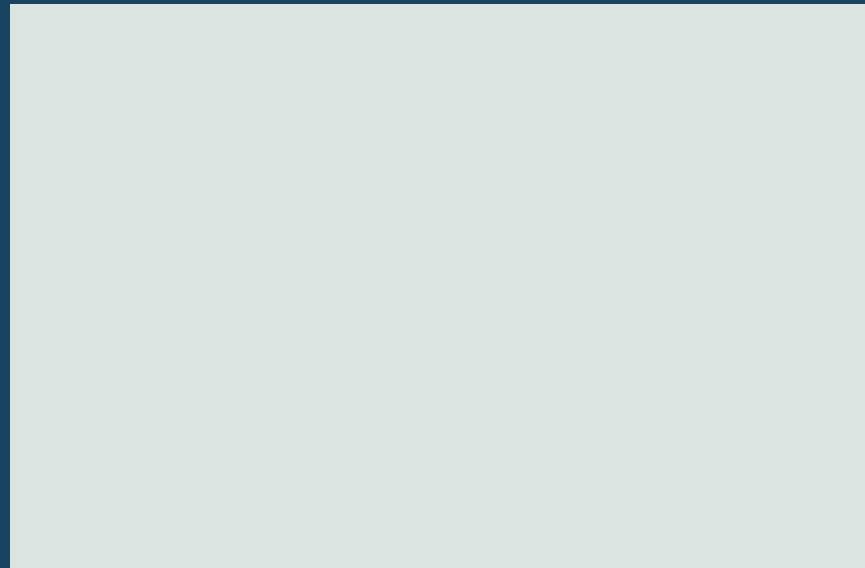


5. Future work

To be tested in June

Bi-directional controller

Performance under different conditions



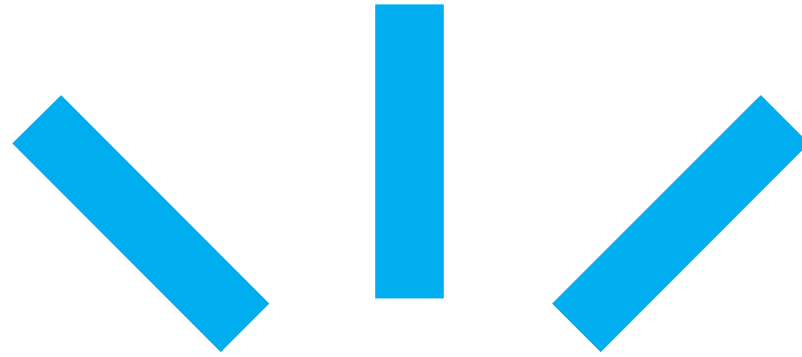


CHALMERS
UNIVERSITY OF TECHNOLOGY

Presentation 4:

***On the performance of heavy vehicle tyres on
the winter roads***

Miro-Tommi Tuutijärvi, University of Oulo,
Uleåborg, Finland



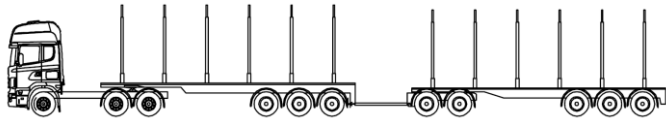
On the performance of heavy vehicle tyres on the winter roads - E! SafeTrucks tyre measurements 2024-2026

20.5.2026 – Miro-Tommi Tuutijärvi

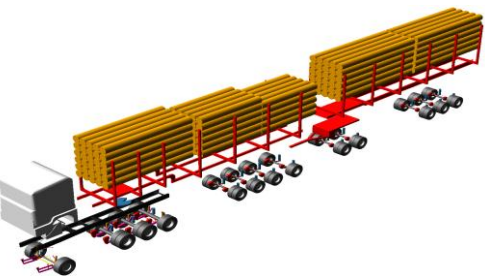
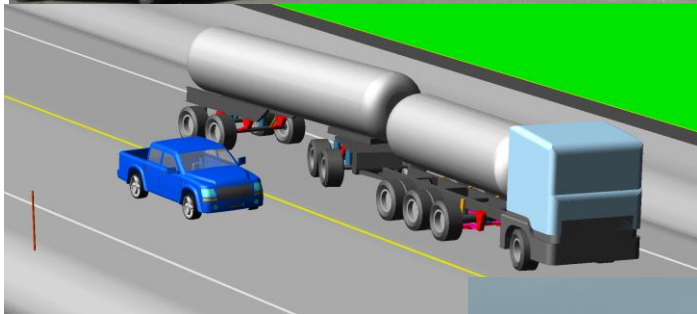
Machine and Vehicle Design (MVD) – University of Oulu



Background



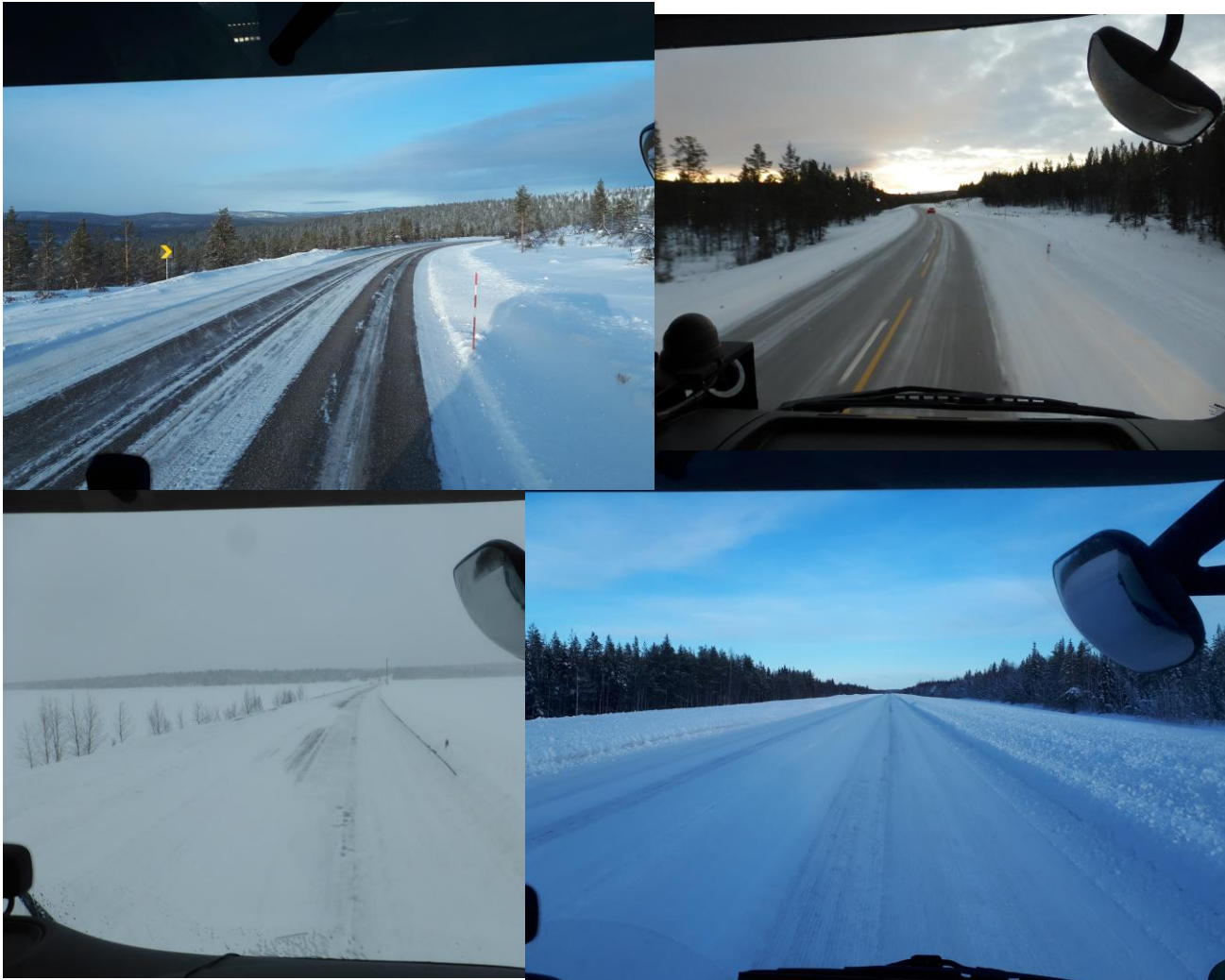
First Finnish HCT full-scale vehicle tests in Lappeenranta (2013)!



- Driving dynamics simulations started in larger scale with lateral and roll stability studies of heavy commercial vehicle (HCV) combinations with Finland's HCT trials in 2013
- First full-scale vehicle tests were followed by simulation studies when transport companies started to apply for HCT trial permits which then led to vehicle combination dimensioning studies
- Tire models were required for simulations and following first measurements done by 3rd parties and model fits, interest towards tires and their performance increased
- This resulted in the desire to develop own testing equipment capable of measuring heavy vehicle tyre forces in their typical usage



Introduction



- In northern countries, winter season brings significantly varying driving conditions
- The effect of tyre performance is emphasized with long heavy vehicle combinations due to interaction of several units with multiple axles.
- Quantifying tyre performance on various winter road conditions is not an easy task, as both are complex systems
- Considering these points, mobile approach to tyre force measurement equipment was selected and resulted in the Tyre Testing Trailer (TTT)
- In the E! SafeTrucks project, TTT has been utilized to gather tyre performance data on wide variety of road conditions



Tested Tyre set

No	Size and LI	Position	Type	Name	Rim	Inflation (bar)	Load 1 (kg)	Load 2 (kg)	Load 3 (kg)	Load 4 (kg)	Speed (km/h)	Slip [%]	Slip angle	“Nominal load [kg]”	2024	2025	2026
1	315/70R22.5 156/150L	S	Winter	S1	9.00	9.0	2000	3250	4500		15	0...-100	± 15°	4000	X	X	X
2	315/70R22.5 156/150L	S	Allseason	S2	9.00	9.0	2000	3250	4500		15	0...-100	± 15°	4000		X	X
3	315/70R22.5 154/150L	D	Winter	D1	9.00	8.0	1000	2000	3000	4000	15	0...-100	± 15°	2500	X	X	X
4	315/70R22.5 152/148M	D	Allseason	D2	9.00	8.0	1000	2000	3000	4000	15	0...-100	± 15°	2500	X	X	X
5	275/70R22.5 148/145L	T	Allseason	T1	8.25	9.0	1000	2000	3000	4000	15	0...-100	± 15°	2500		X	X
6	385/55R22.5 160K	ST	Winter	ST1	11.75	9.0	1000	2500	4000	5000	15	0...-100	± 15°	4500	X	X	X
7	385/55R22.5 160K	ST	Winter studded	ST1 S	11.75	9.0	1000	2500	4000	5000	15	0...-100	± 15°	4500	X	X	
8	385/55R22.5 160K	ST	Winter	ST2	11.75	9.0	1000	2500	4000	5000	15	0...-100	± 15°	4500		X	X
9	385/55R22.5 160K	ST	Allseason	ST3	11.75	9.0	1000	2500	4000	5000	15	0...-100	± 15°	4500			X
10	385/55R22.5 160K	ST	Allseason	ST4	11.75	9.0	1000	2500	4000	5000	15	0...-100	± 15°	4500		X	X
11	385/55R22.5 160K Worn	ST	Winter	ST1W	11.75	9.0	1000	2500	4000	5000	15	0...-100	± 15°	4500			X
12	385/55R22.5 160K Worn	ST	Allseason	ST3W	11.75	9.0	1000	2500	4000	5000	15	0...-100	± 15°	4500			X



Test location and conditions



- Tests done at Pudasjärvi airport (EFPU)
 - Full runway length 2,12 km, width 50 m
- Between weeks 6 and 10 from 2024 to 2026
- Temperature ranges from -31°C to $+3^{\circ}\text{C}$



Tyre Testing Trailer (TTT)

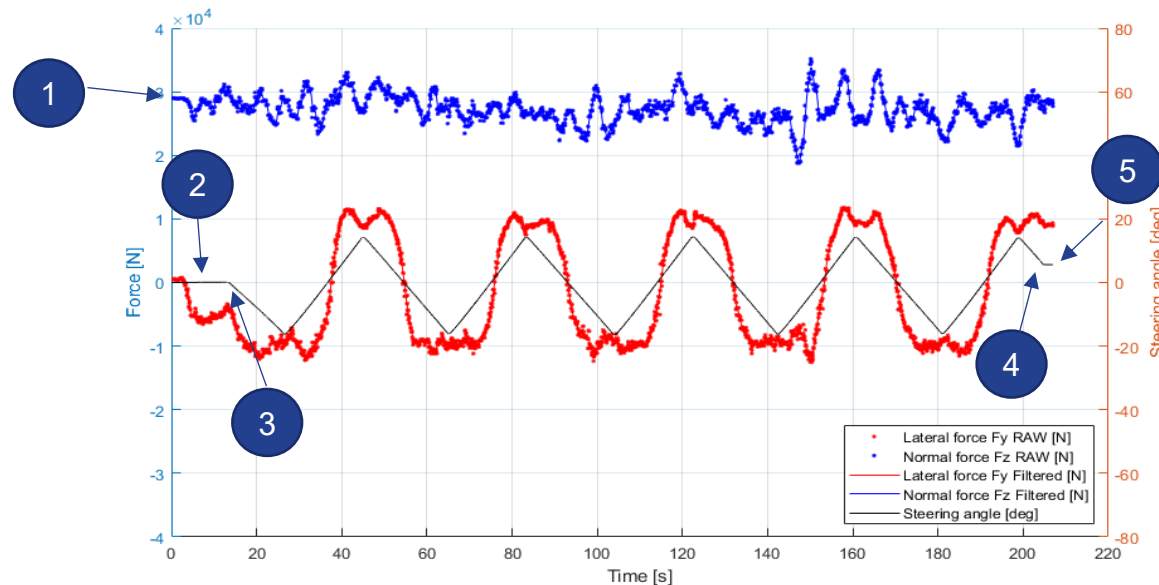
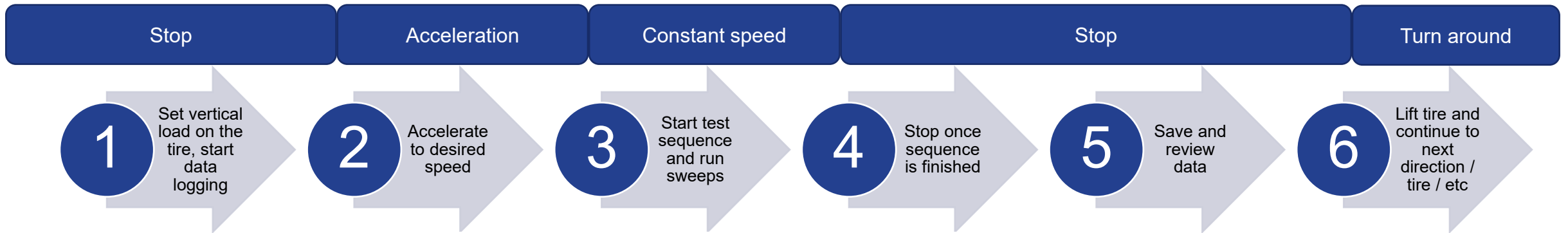


- Specifications:
 - Rim sizes 19,5" ja 22,5"
 - Wheel diameter 800-1300 mm
 - Tire width up to 455 mm
 - Wheel load up to 60 kN
 - Steering angle ± 45 degrees
 - Camber angle ± 10 degrees
 - Maximum braking moment 25 kNm
- Tire forces and moments calculated from strain gage measurements from rods holding the measuring hub
- Other measurements, including but not limited to:
 - Wheel speeds
 - Measured tire steering angle and height
 - RTK GPS for improved slip angle and trailer speed estimation
 - Sisu equipped with optical friction meter for friction estimation, surface and ambient temperature



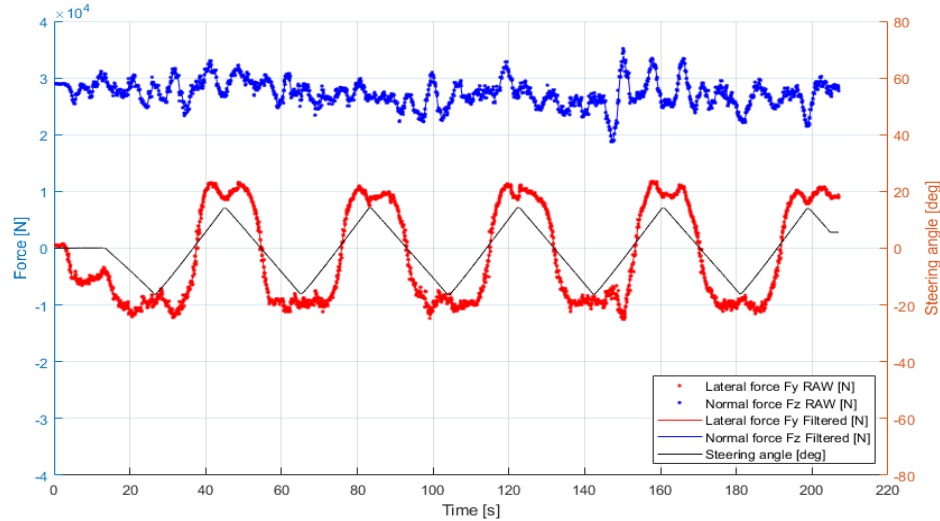
Measurement procedure (Pure lateral slip, F_y)

*Tests are usually run on two directions to use time efficiently

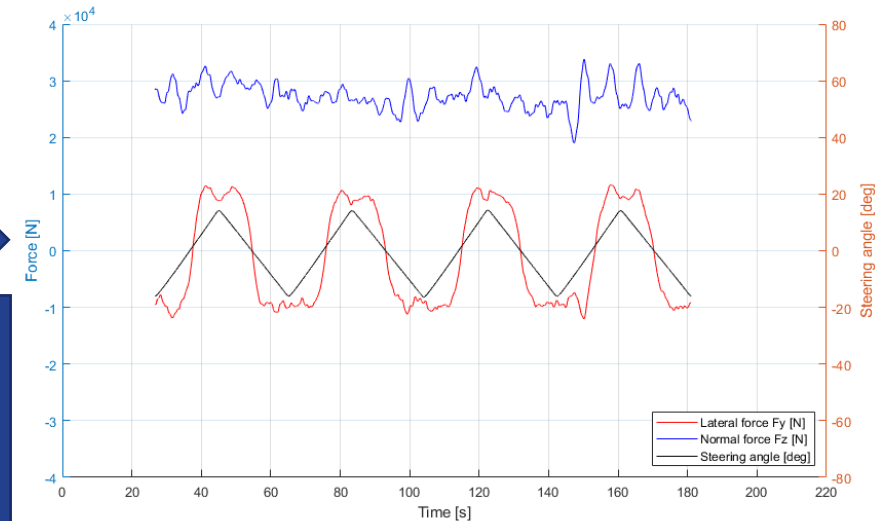




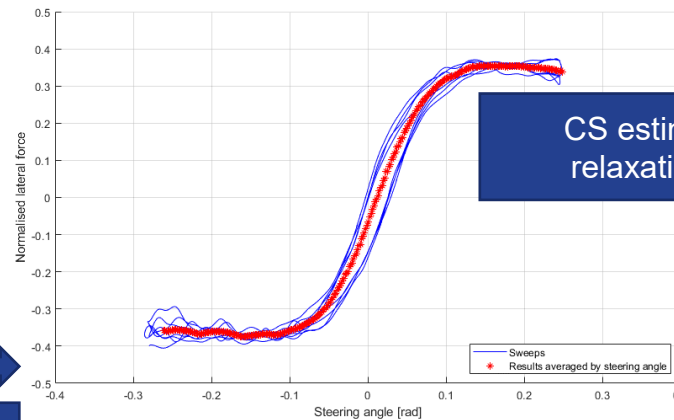
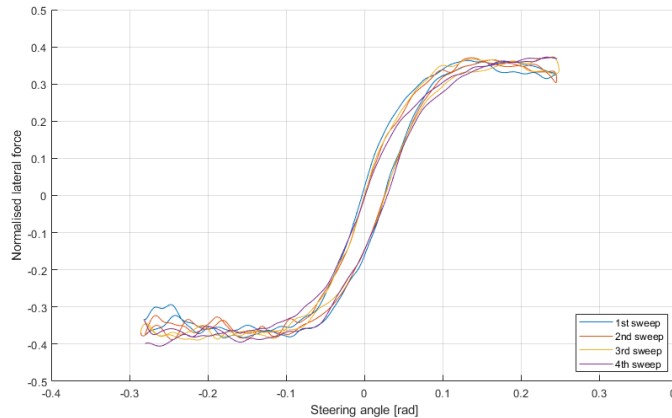
Processing F_y measurement data



- Filter raw data
- Snip filtered data from first minimum to last minimum

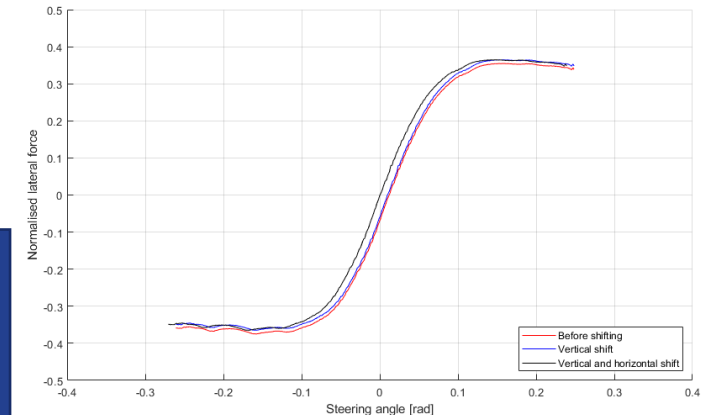


- Separate test cycle to individual sweeps
- Normalized lateral force (F_y/F_z) against steering angle



CS estimate after relaxation comp.

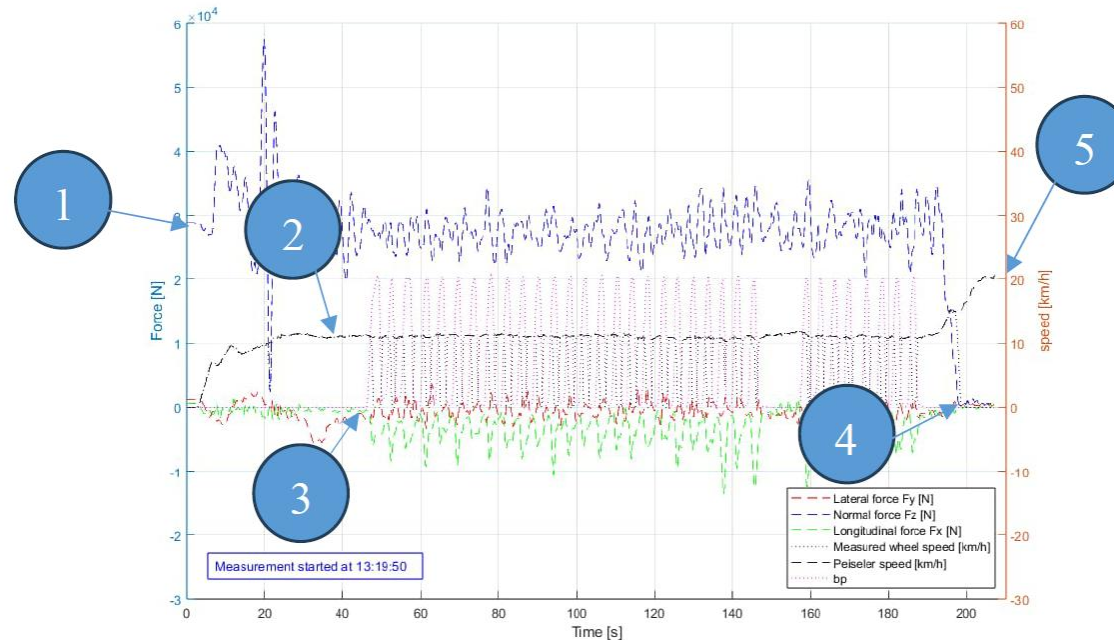
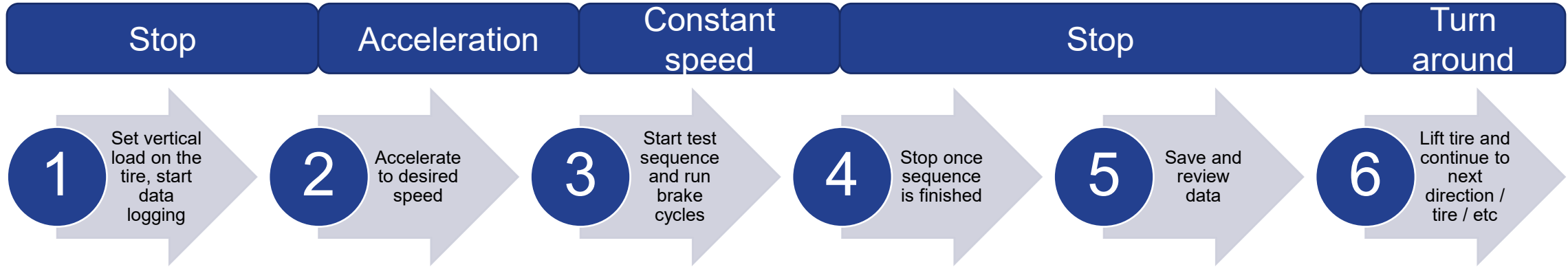
Horizontal and vertical shifts if needed



Average by steering angle to compensate the relaxation length

Measurement procedure (Pure longitudinal slip, F_x)

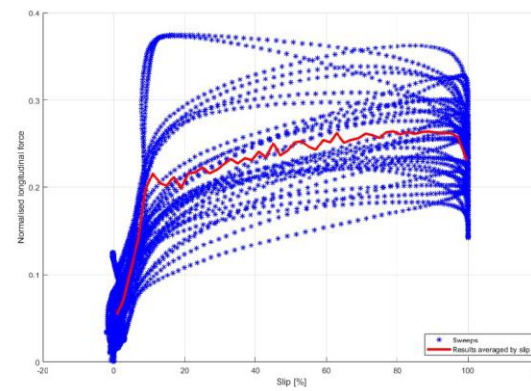
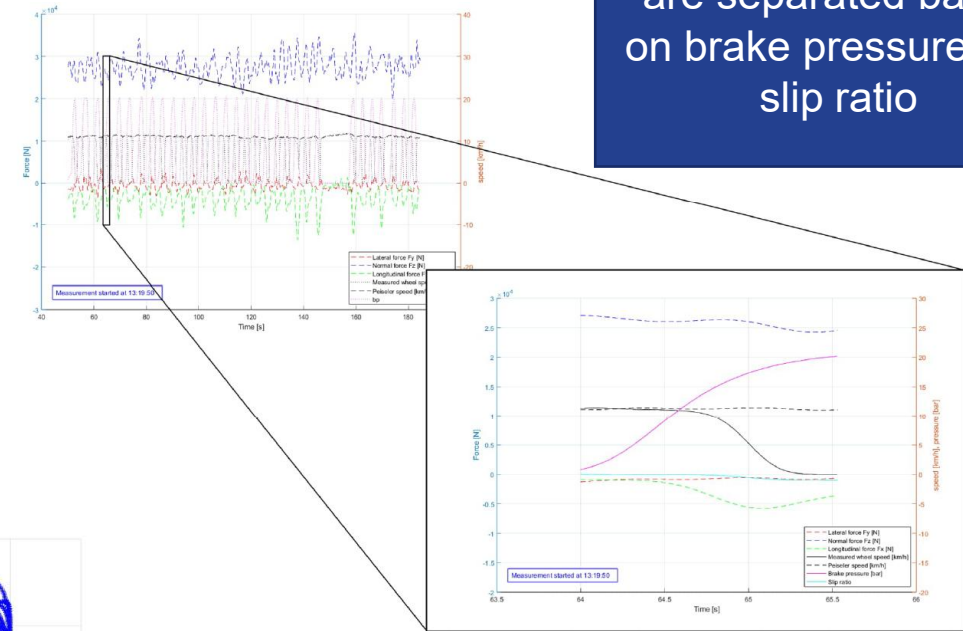
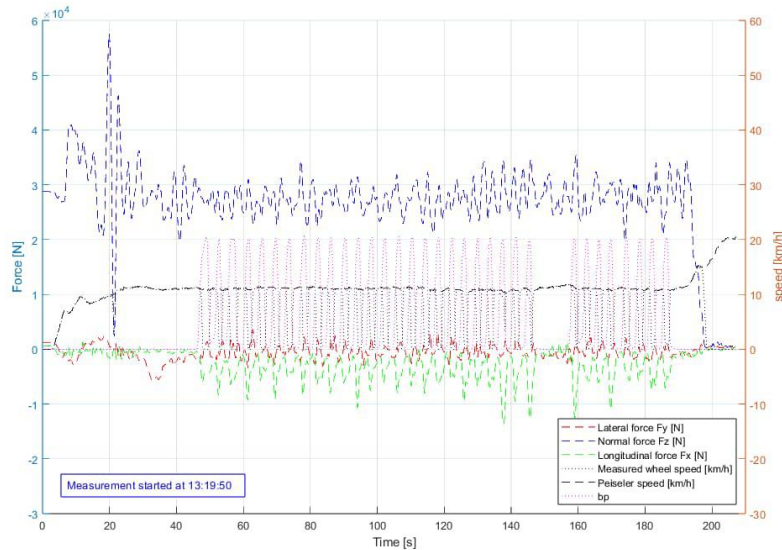
*Tests are usually run on two directions to use time efficiently



Processing F_x measurement data

Individual brake cycles are separated based on brake pressure and slip ratio

Snip filtered data from first brake pressure minimum to last minimum



- Normalized F_x (F_x/F_z) of brake cycles is plotted against slip %
- Results from individual cycles are averaged by slip ratio for longitudinal slip curve



2024 measurements and results



– Week 6

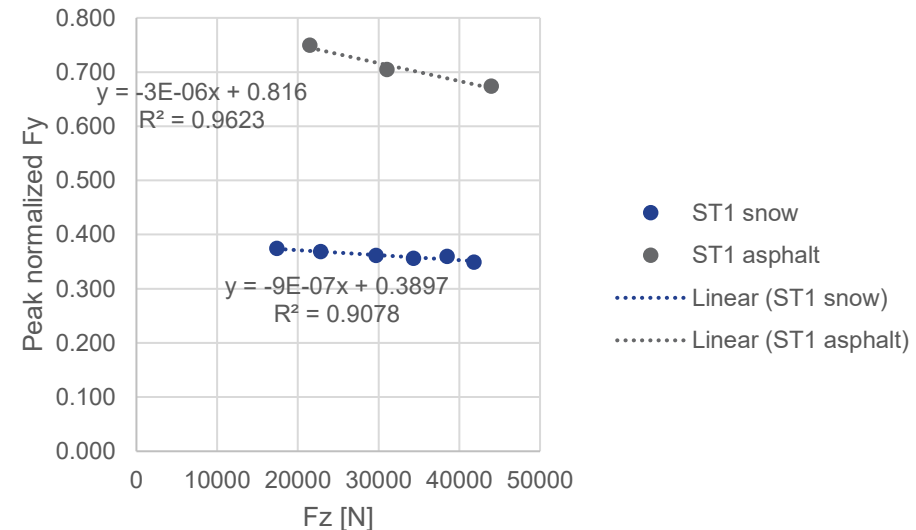
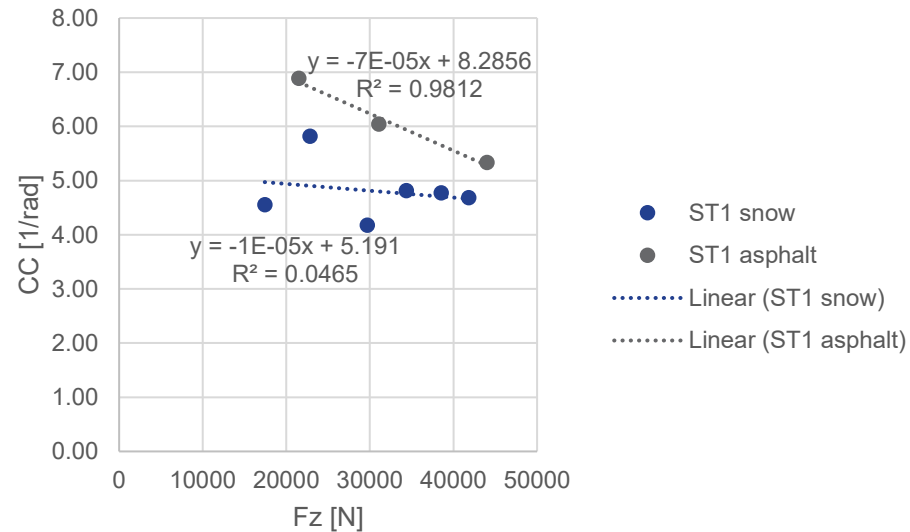
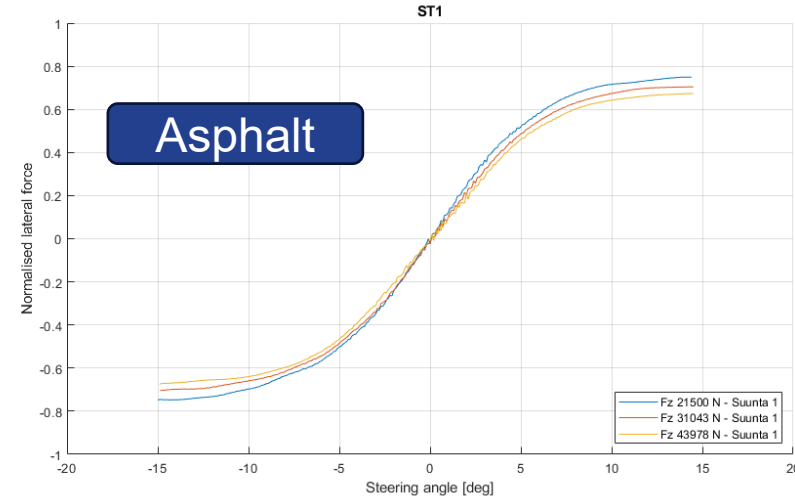
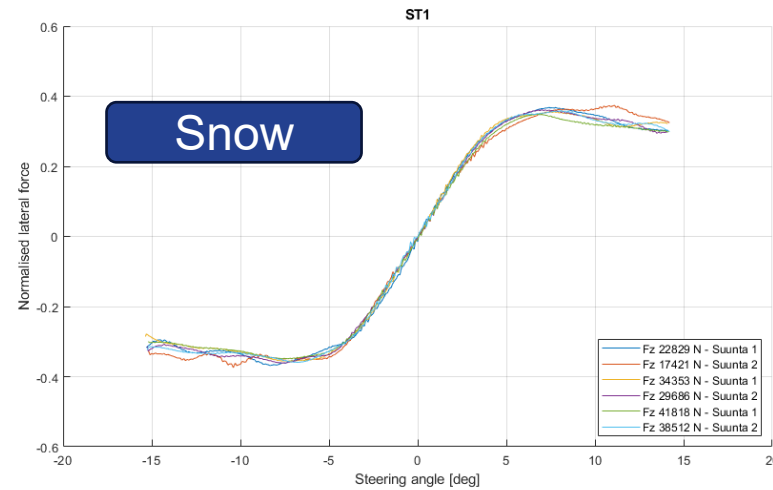
- Hard packed snow
- Limited tyre set
- First runs with updated brake setup
- Running time limited due to harsh temperatures
 - Daytime temperatures around -25°C , nighttime and morning temperatures under -30°C

– Week 10

- Asphalt
- Temperatures around 0°C , was not possible to freeze an ice surface



2024 measurements and results





2025 measurements and results



– Week 6

- Hard packed snow and icy hard packed snow
- Temperatures in suitable range
- Limited testing time due to excessive snowing
- First braking pilot with multiple heavy vehicles and vehicle combinations

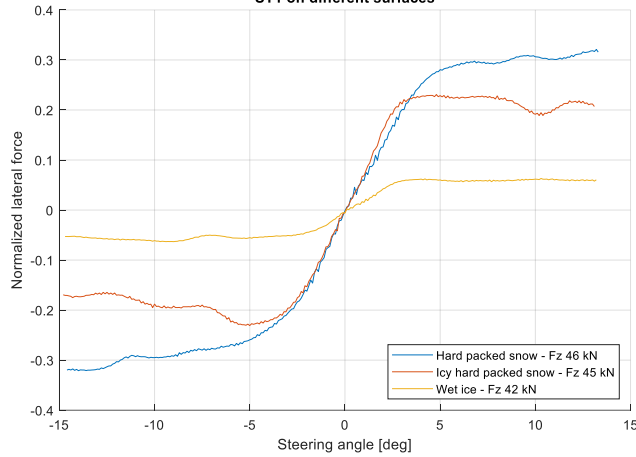
– Week 9

- Wet ice
- Temperatures above 0 °C
- Testing limited to 1½ days due to ice softening

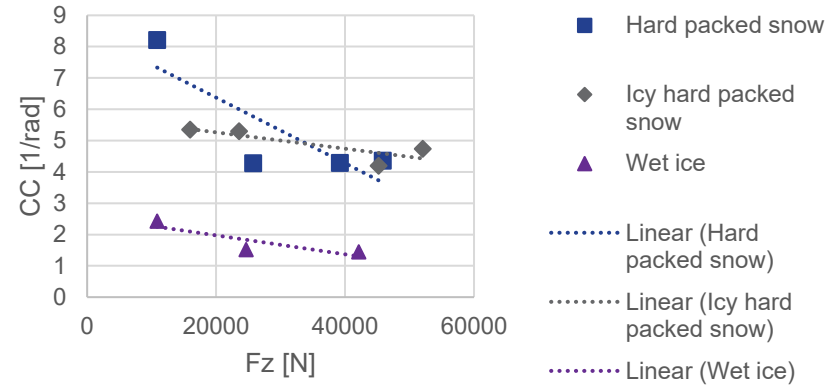


2025 measurements and results

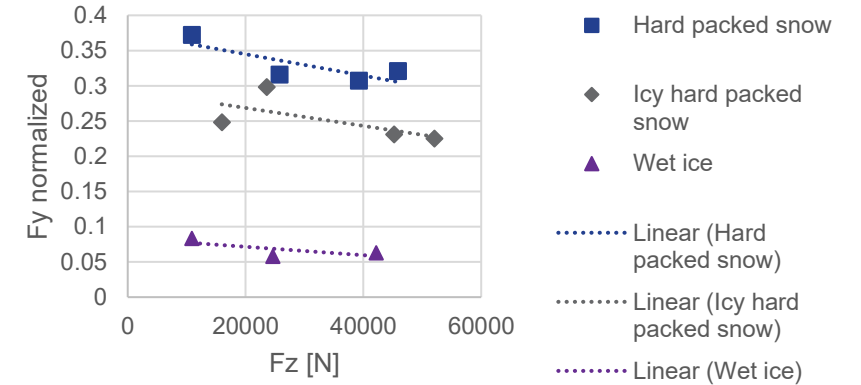
ST1 on different surfaces



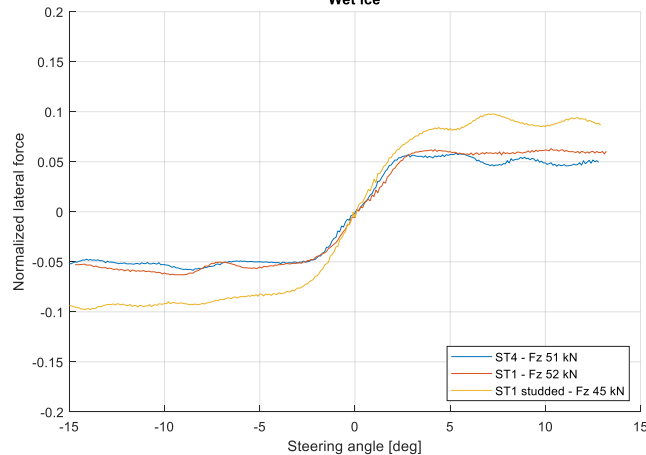
CC



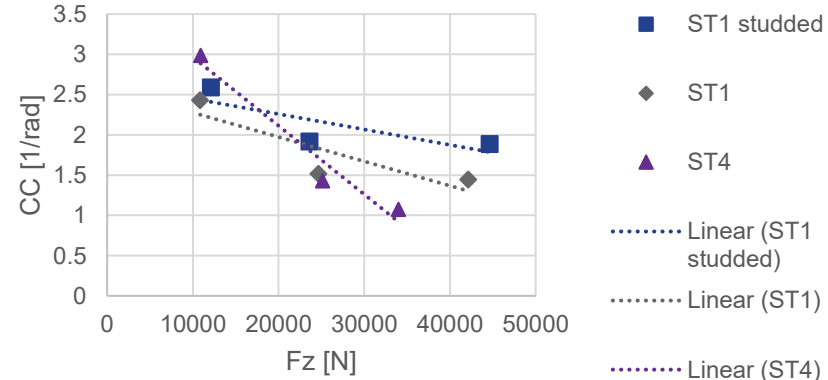
μ peak



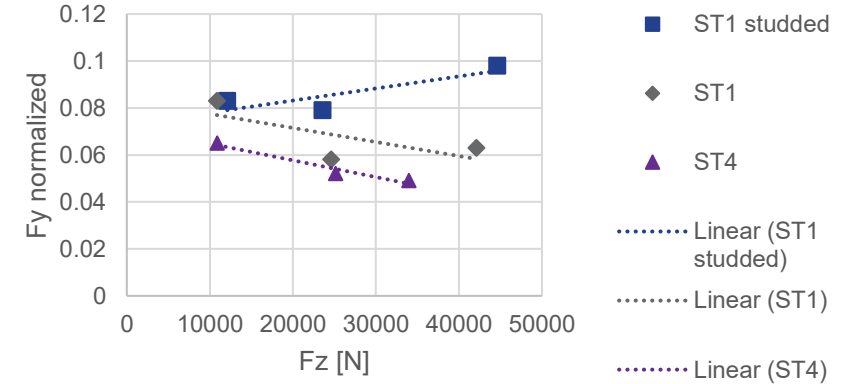
Wet ice



CC



μ peak





2026 measurements and results



– Week 6

- Hard packed snow, groomed after each day
- Good measurement conditions
- Pure lateral and longitudinal measurement for full tyre set

– Week 7

- SafeTrucks pilot demonstration with braking distance demonstrations

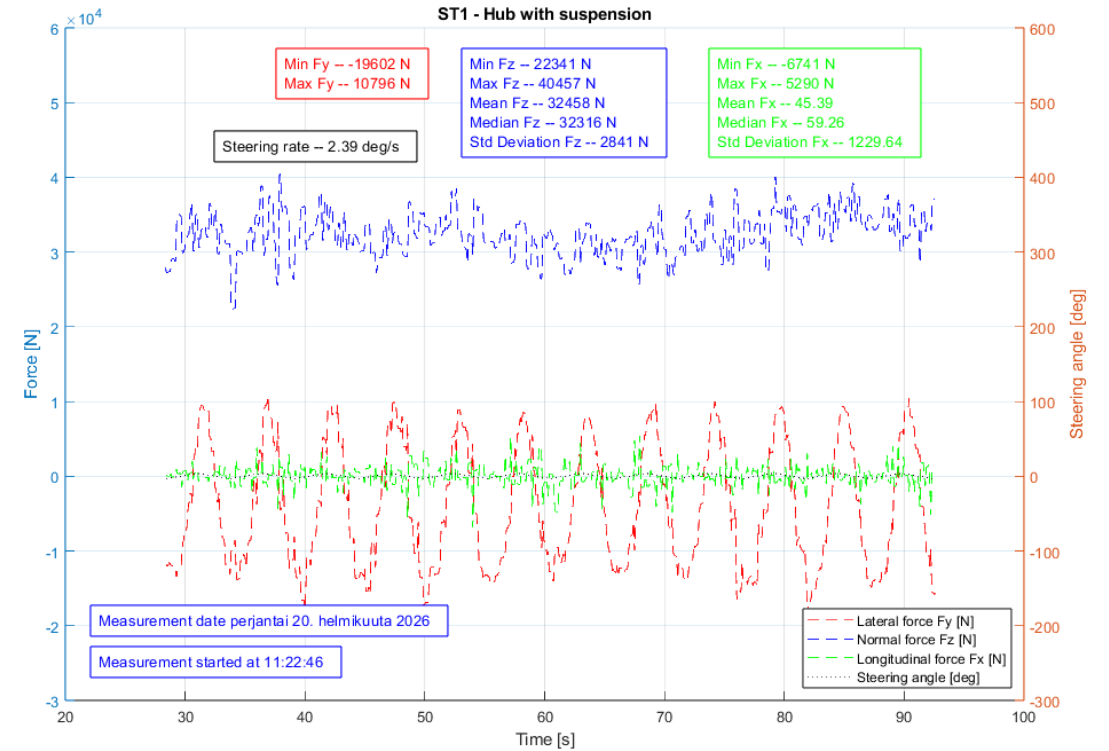
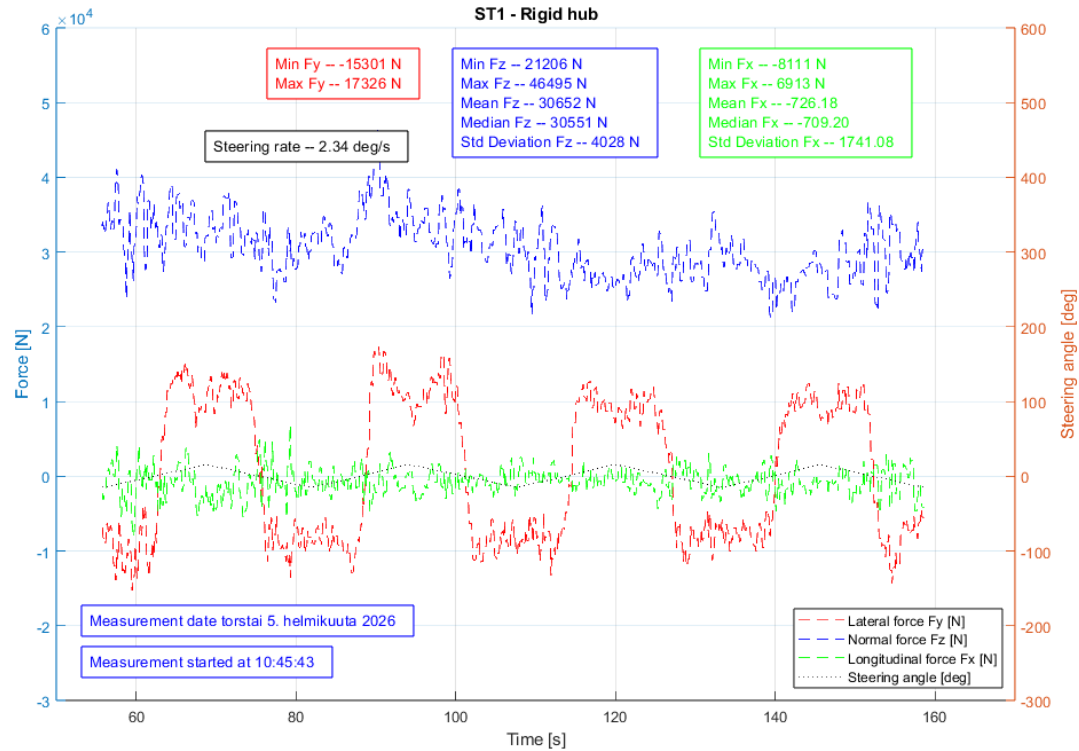
<https://www.youtube.com/watch?v=OpoZWqqDYeg>

– Week 8

- Testing new suspension setup for TTT



2026 measurements and results





Conclusions 1/2



- Winter seasons vary a lot and planning outdoor testing can be challenging and it affects road transport in general
- For these measurements, weather conditions limited testing but gave a good opportunity to measure tyres in highly varied road conditions
 - Wet Ice, icy hard packed snow, hard packed snow and cold asphalt
- Upgrades on the measuring equipment performed in satisfactory level



Conclusions 2/2



- On-going activities now:
- Reviewing all the measurement data
- Pure longitudinal slip measurement data processing and relaxation compensation
- Tyre model fitment to measurement data
 - Aim is to produce generalized tyre models for different road conditions and use cases
- Continue improving slip angle estimation with RTK GPS data



Acknowledgements



BUSINESS
FINLAND



National Research
Council Canada

Conseil national de
recherches Canada

<https://safetrucks.fmi.fi/>



**Thank you for your
attention!**

