# Tire Technology Conference 2026

# Tire Wear Prediction with Combined Test-bench and Simulation Method


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KIT

Fraunhofer ITWM

Content

# The RAMUS Project
## Overview

RAMUS = **R**eifen**A**briebs**M**essung **U**nd **S**imulation

Public funding line of the former Federal Ministry of Digital and Economic Affairs (BMDV), now BMV: Federal Ministry of Transport

mFUND funding line 1 application (“Small projects/studies”):
Topic 2024 Open data for new business models in mobility

Partner:

Karlsruhe Institute of Technology, Institute of Vehicle System Technology:

Martin Gießler, Philipp Bühler

Fraunhofer-Institut für Techno- und Wirtschaftsmathematik ITWM (Kaiserslautern):

Christoph Burkhart, Georg Franosch, Hannes Christiansen

Duration:

01/12/2024 – 31/05/2026

With funding from the

Federal Ministry of Transport

by decision of the German Bundestag

mFUND
Das Startkapital für die Mobilität der Zukunft



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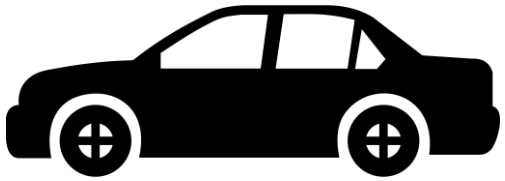
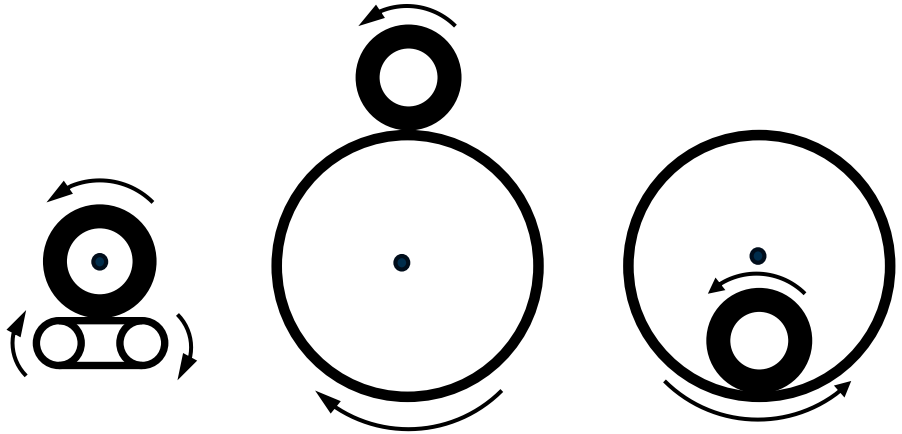
# Motivation
## Tire Wear Measurements

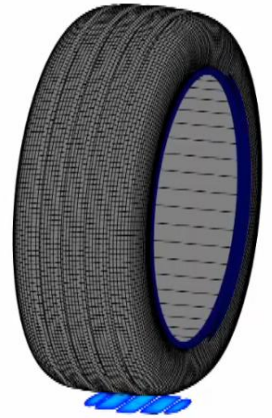
***Mobile Measurements in Fleet Testing***



***Test Bench Measurements***



***Simulation***



***State of the Art***

***Extension***

# Question?

**How can tire simulation increase the efficiency of tire wear prediction, so that conventional test campaigns can be reduced?**

# The RAMUS Project
## Overview

Public Databases

Driving Data via GPS Tracker

Vehicle Simulation (VMC, CarMaker)

Tire Parameters $C_X$, $C_Z$, $C_\alpha$

FAST

Summarize and Analyze

Tire Tests using Driving Cycles

Mechanical Model

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Wear Model

Deformation

Friction

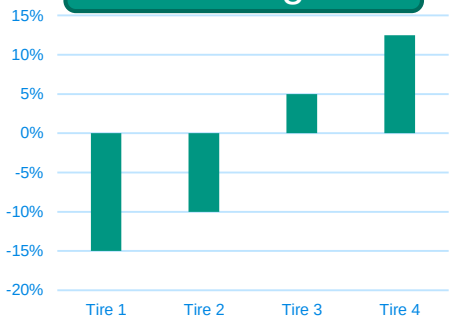
Energy loss

Wear

Ranking

2 1 3

Rating




Mass Loss

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# Procedure
## Tire Selection

| Tire Size | Percentage in 2022 |
|---|---|
| 235/65R16 | 12.20 % |
| 215/65R16 | 11.30 % |
| 205/65R16 | 10.06 % |
| 195/75R16 | 10.05 % |
| 225/65R16 | 8.72 % |
| 215/70R15 | 6.18 % |
| 195/70R15 | 5.40 % |
| 205/75R16 | 4.45 % |
| 215/75R16 | 4.21 % |
| 225/75R16 | 3.91 % |
| 225/70R15 | 2.90 % |
| 215/65R15 | 2.43 % |
| 195/60R16 | 2.26 % |
| 195/65R16 | 2.10 % |
| 215/60R17 | 2.04 % |
| 185/80R14 | 1.40 % |

[1]

### Selected tires for the tests

**235 65 R 16C 115/113R**

**All-Season Tire**

**235 65 R 16C 121/119R**

**Summer Tire**

**225 75 R 16C 116/114**

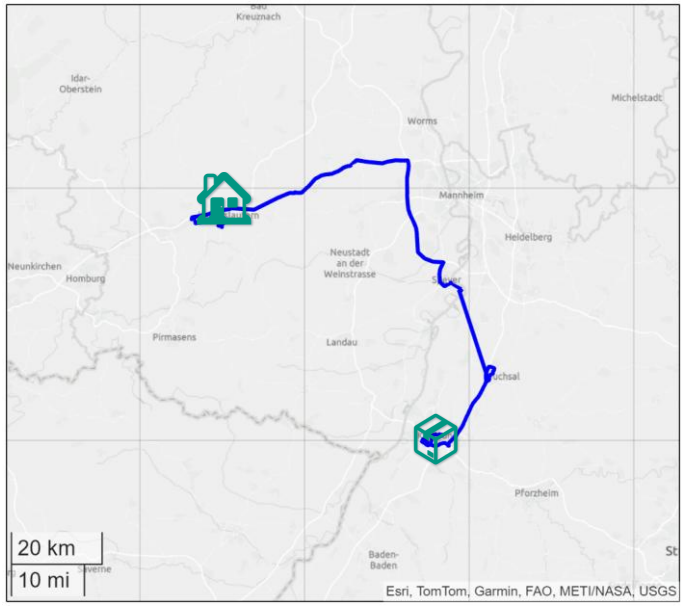
**ASTM F2872 SRTT**

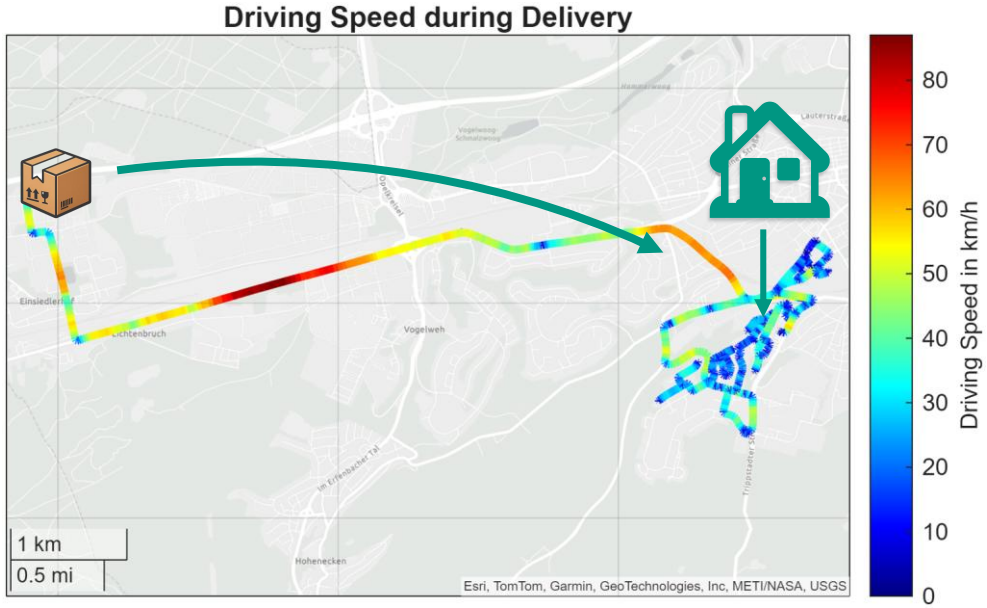
→ Tires were selected based on the classification of the ETRTO working group and statistics on the use of C2 tires

# Procedure
## Recording Delivery Trips

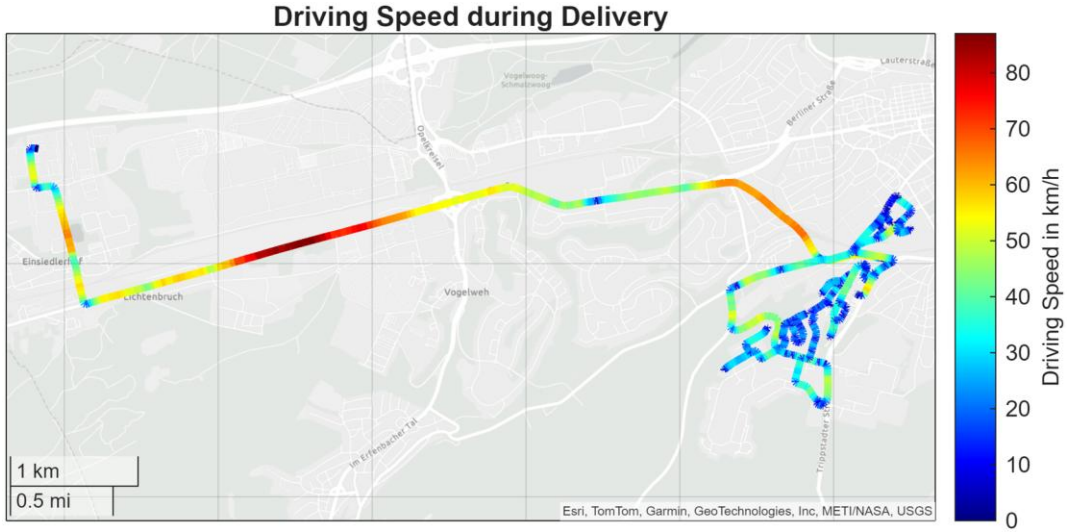
- Parcels were sent: KIT FAST (Karlsruhe) – Fraunhofer ITWM (Kaiserslautern)
- Parcel contains a GPS tracker (CANedge3)
  - Recording of longitude, latitude, altitude, and speed at rate of 5 Hz
- Evaluation range adapted to the ‘last mile‘ (from parcel center to parcel delivery)
  - Analysis of data
  - Generated .kml files are used as input for the vehicle simulation

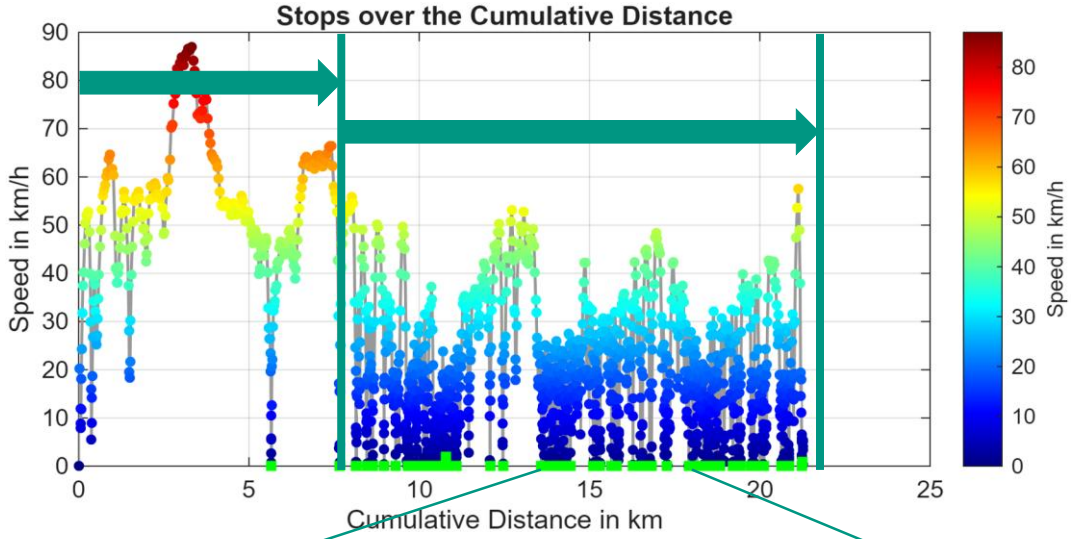

[2]



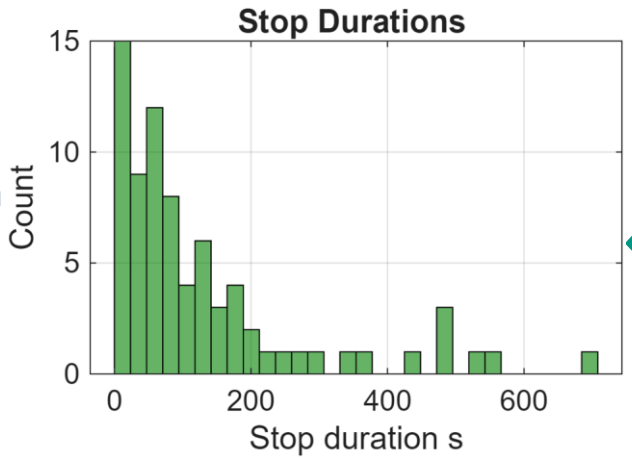
# Procedure
## Analysis and Processing Delivery Trips

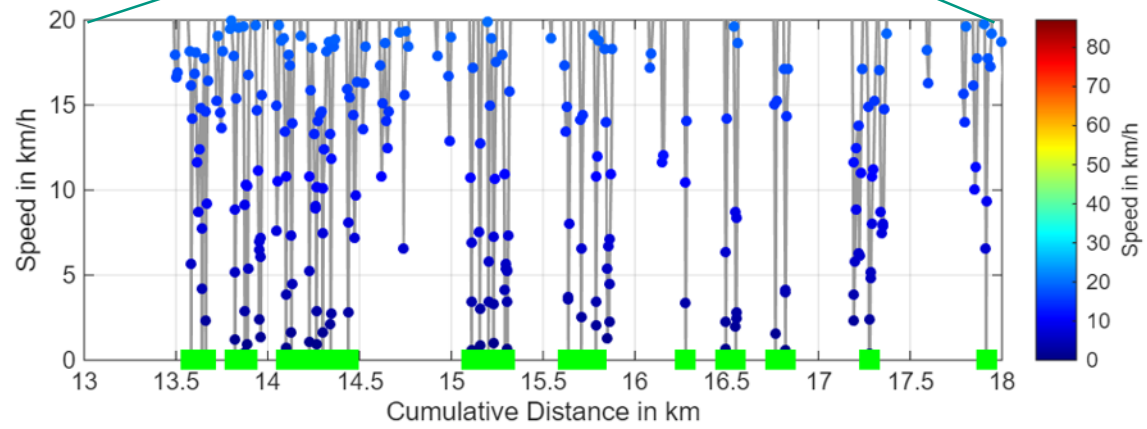



Total distance: 21.270 km
Total time: 4.62 h
Avg. speed (total): 4.50 km/h
Avg. speed (in motion): 24.85 km/h

Stop count: 78
Mean: 171.82 s
Median: 79.00 s



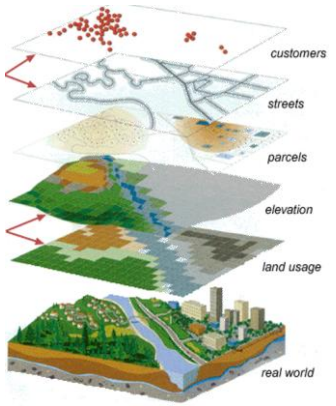



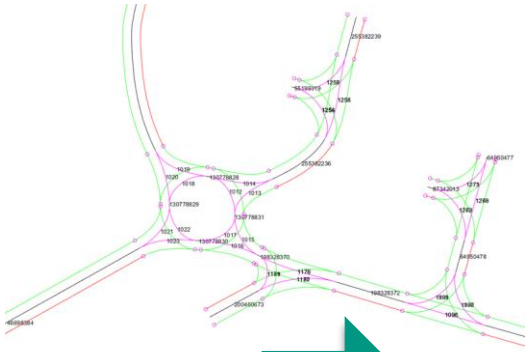
# Procedure
## Vehicle Simulation

Analysis and simulation workflow with VMC® and IPG CarMaker of a delivery trip


.kml

VMC



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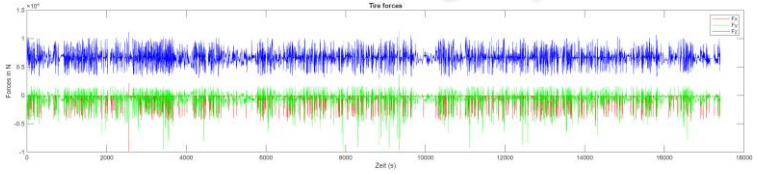
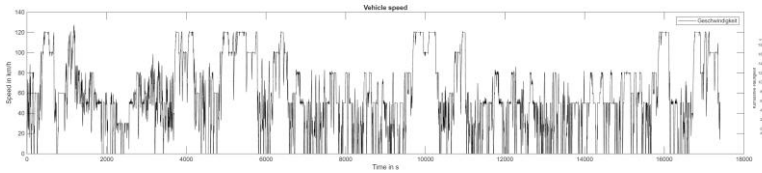
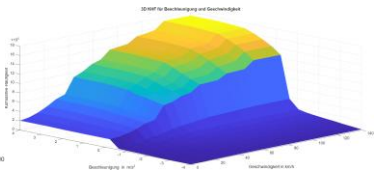
OpenDRIVE®
managing the road ahead

Input test bench

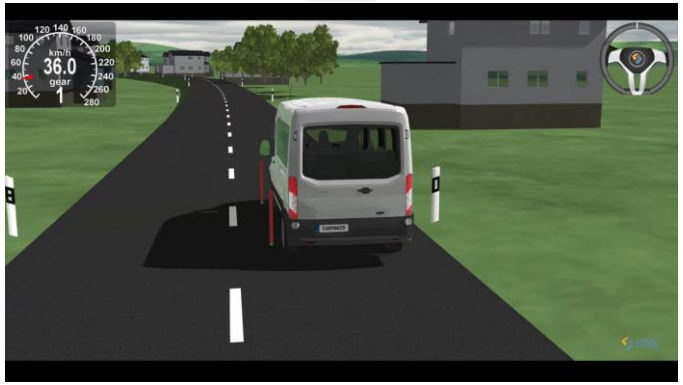


.erg

IPG CM



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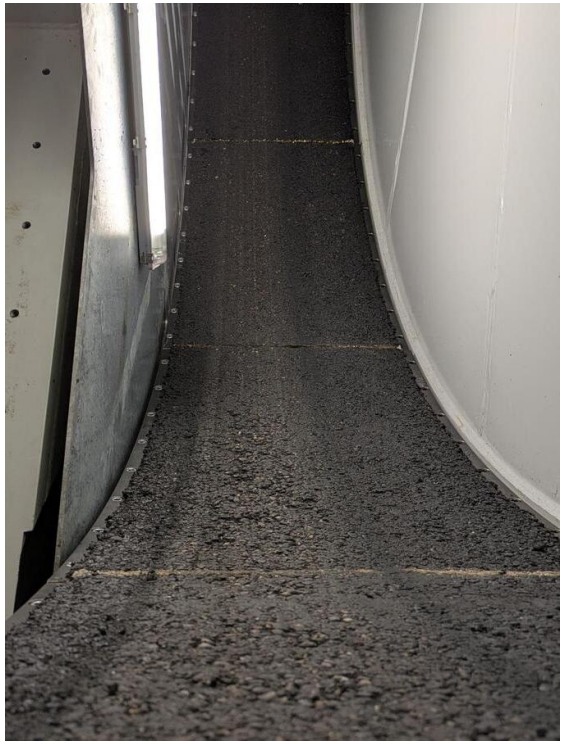
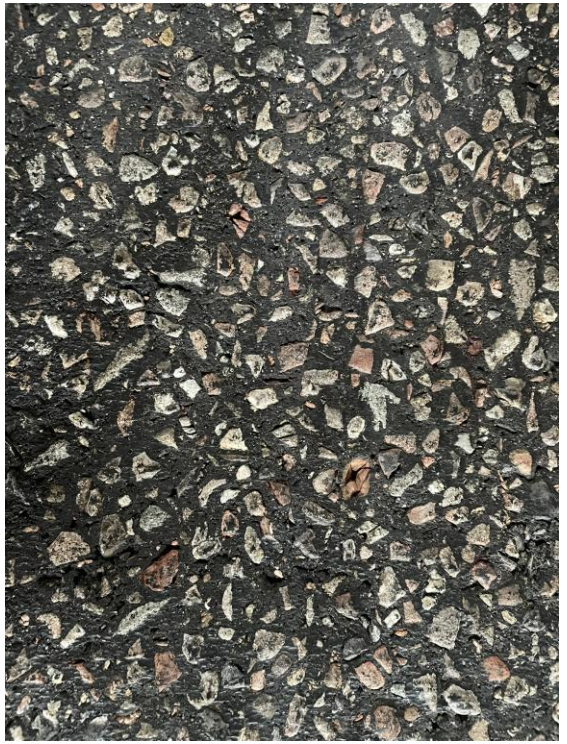
# Production of an Asphalt Surface for Tire Testing at KIT FAST

Applying asphalt using a funnel

Using a steel drum to level and compact the asphalt

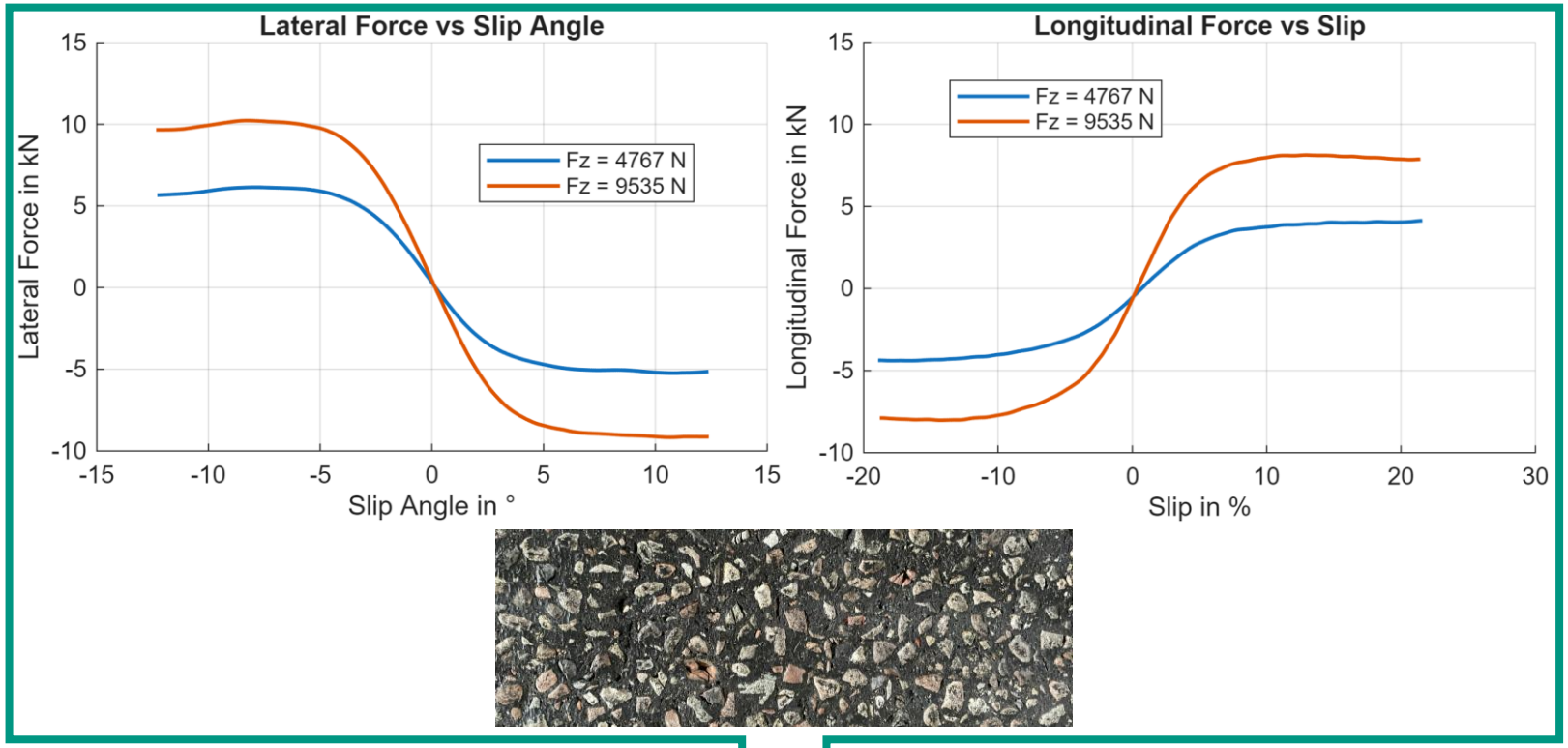


Finished asphalt surface



Finished asphalt surface inside the drum

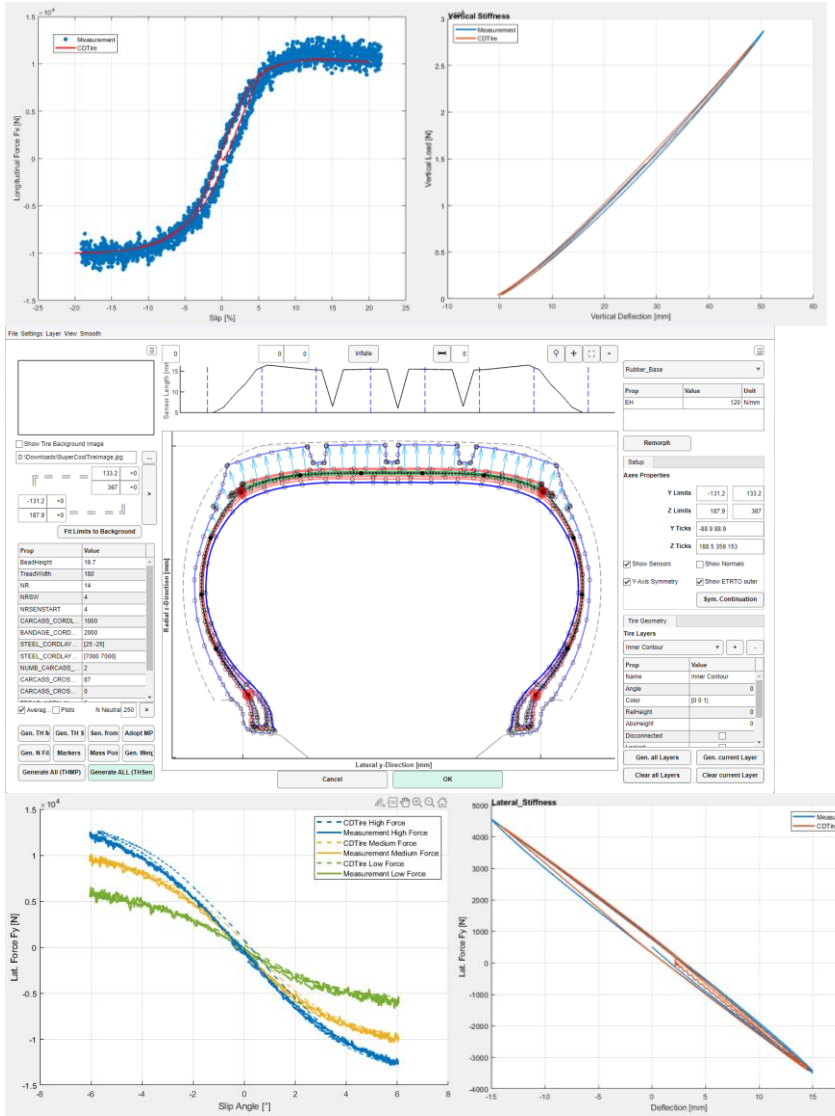
# Tire Model Development
## Measurements on an Asphalt Track at the Inner Drum Test Bench




Tire parameters for the CDTire/3D tire model were determined on the inner drum test bench on a real asphalt surface


Large-scale research equipment funded by the German Research Foundation (DFG) – project number 398470473

# Tire Model Development
## Validation of Simulation with Test Data




**Testing on real asphalt has the advantage of having the correct friction and roughness of a real road, in contrast to other typical materials like sandpaper**


Large-scale research equipment funded by the German Research Foundation (DFG) – project number 398470473



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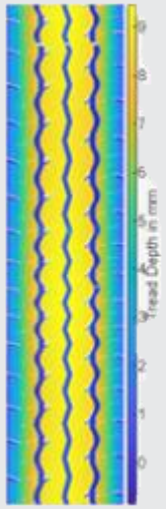
# Measuring Tire Wear During Testing

| Gravimetric | Volumetric | Particle Measurement |
|---|---|---|
| ▪ Weighing wheel: Weight before and after is used to calculate tire wear rate<br>▪ Weighing collected wear particles | ▪ Measuring tread depth:<br>  ▪ Tactile<br>  ▪ Optically with a tire scanner<br>▪ Calculation of mass loss possible | ▪ Real-time particle measurement<br>▪ Direct measurement of the wear process<br>▪ Determination of particle count / mass / size |

[3]





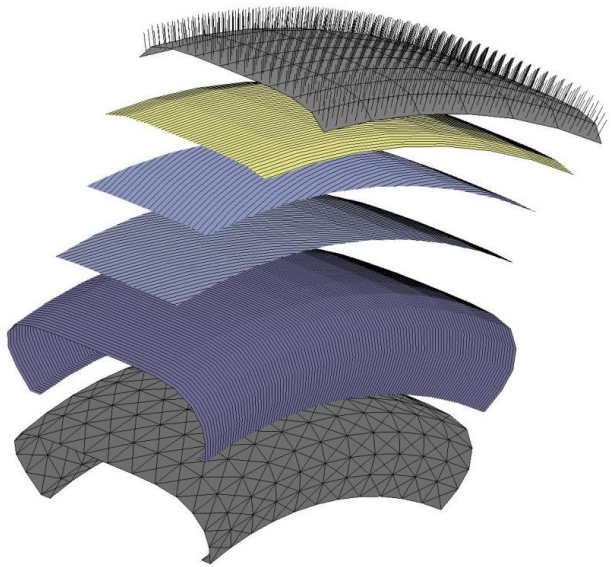
[4]

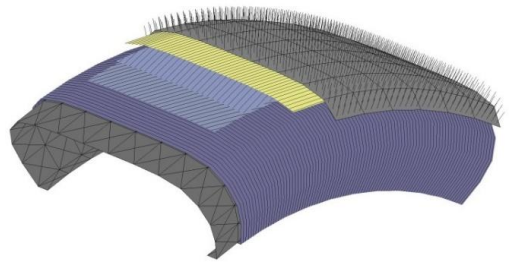
# Tire Model CDTire/3D
## Model Description

Functional layers:

- Tread (brush type)
- Cap ply
- Belt 1
- Belt 2
- Carcass
- Innerliner + Matrix
- Rubber + Bead

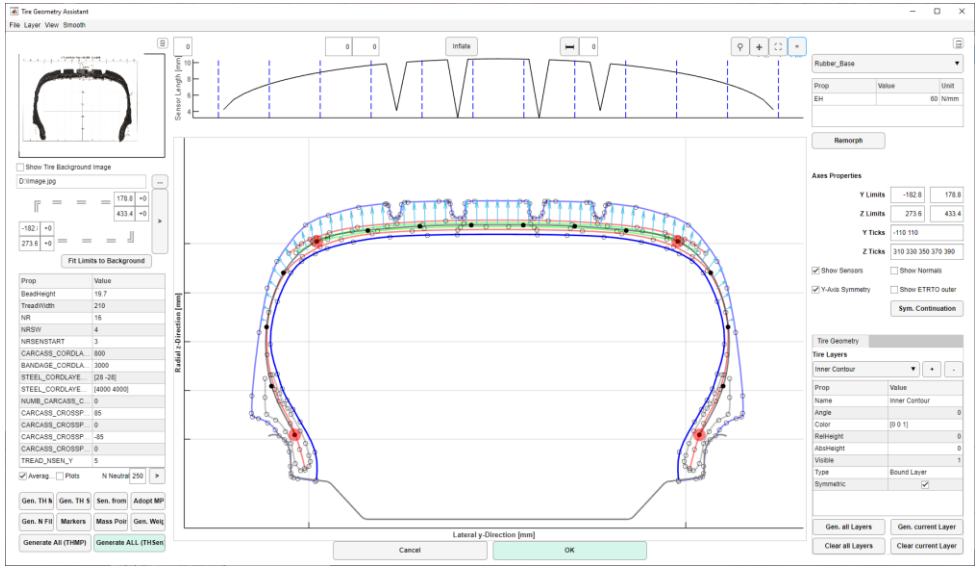
→ Condensed into one shell





Highlights:

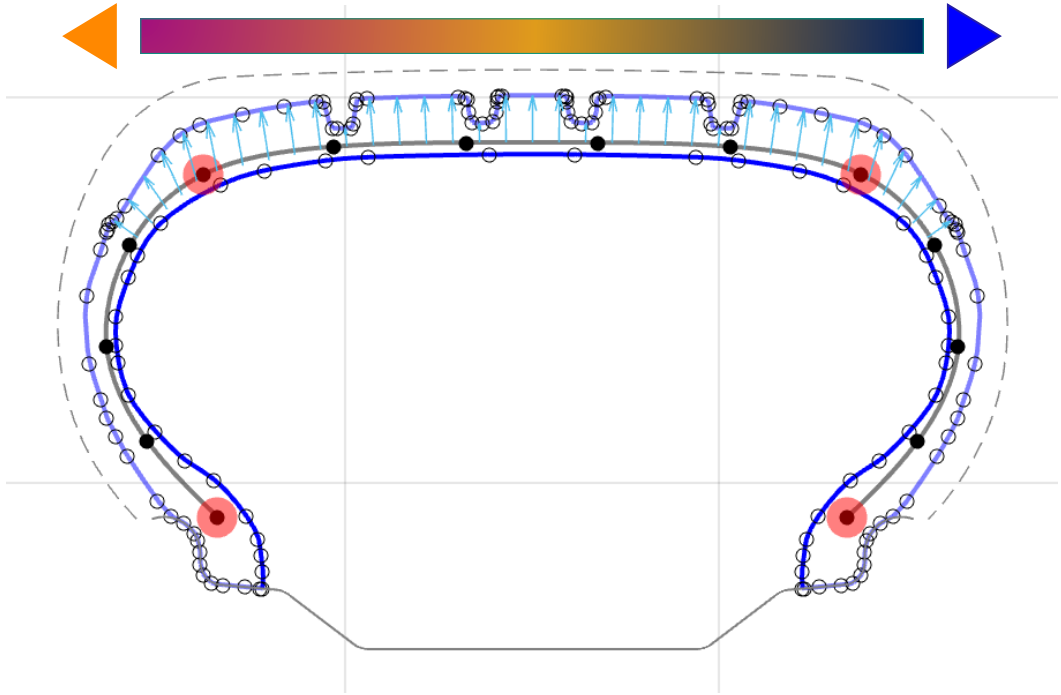
- Strict separation of material and geometry
- Re-mounting / re-sizing
- Inner liner geometry available for inflation pressure application



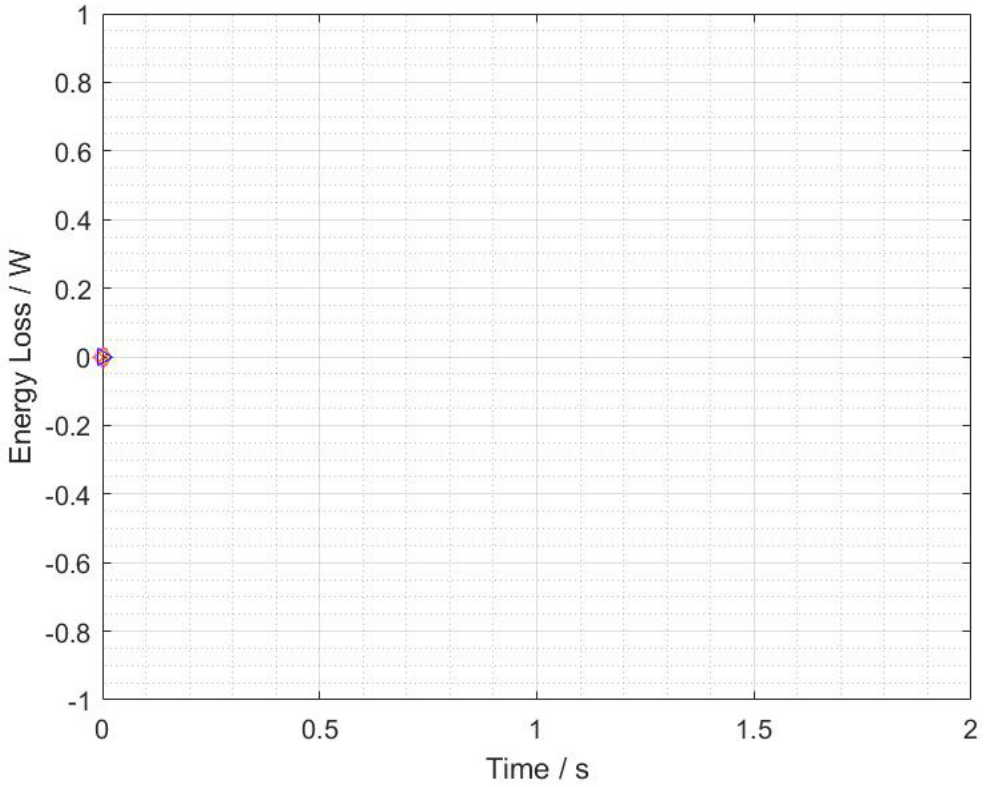
# Tire Model CDTire/3D
## Abrasion Model

Detailed abrasion model with:

- Fine resolution
- Abrasion applied local to the source
- Abrasion is online during the simulation
- Transient wear effect can be considered (e.g. change of cornering stiffness)



Cumulative energy loss over time for single lane change maneuver



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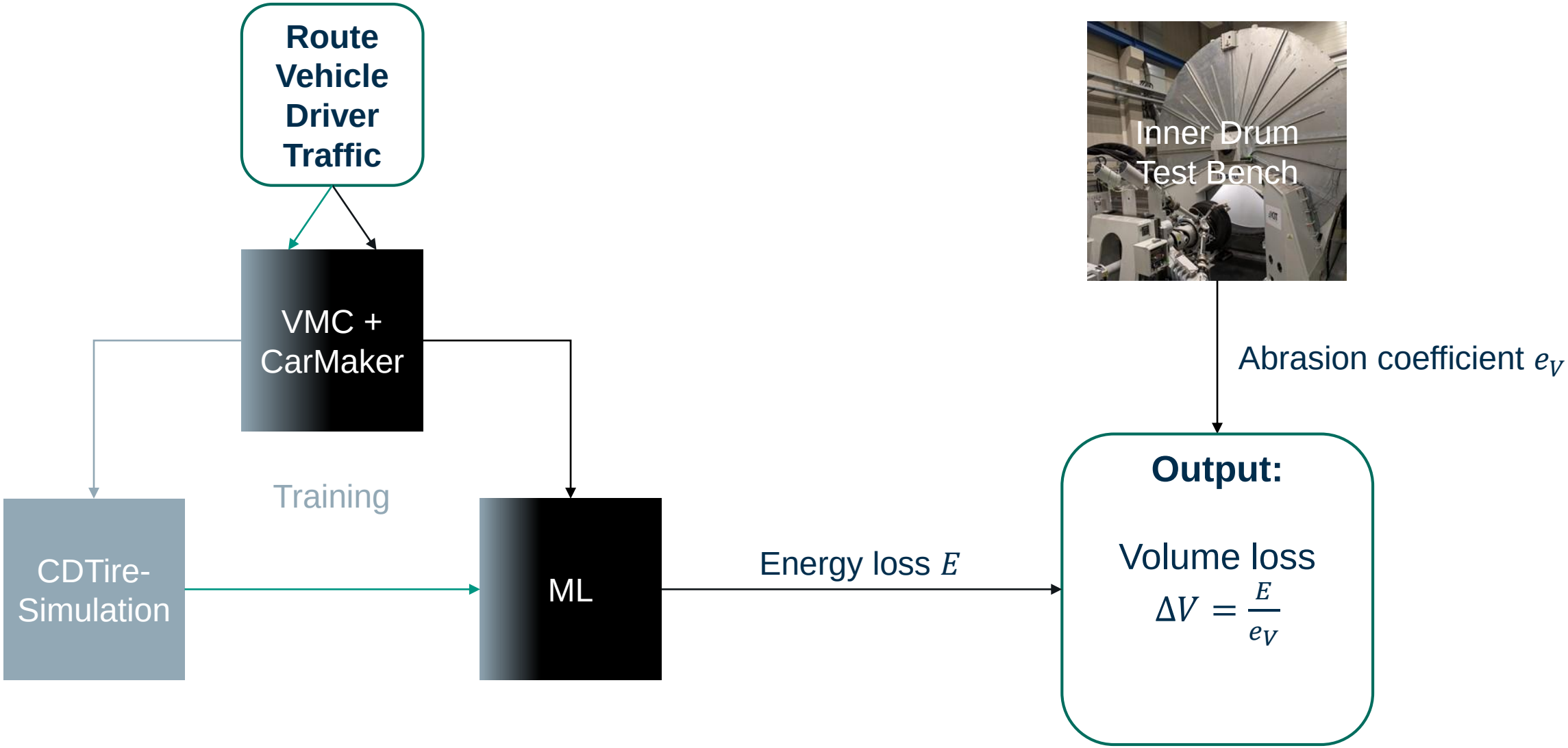
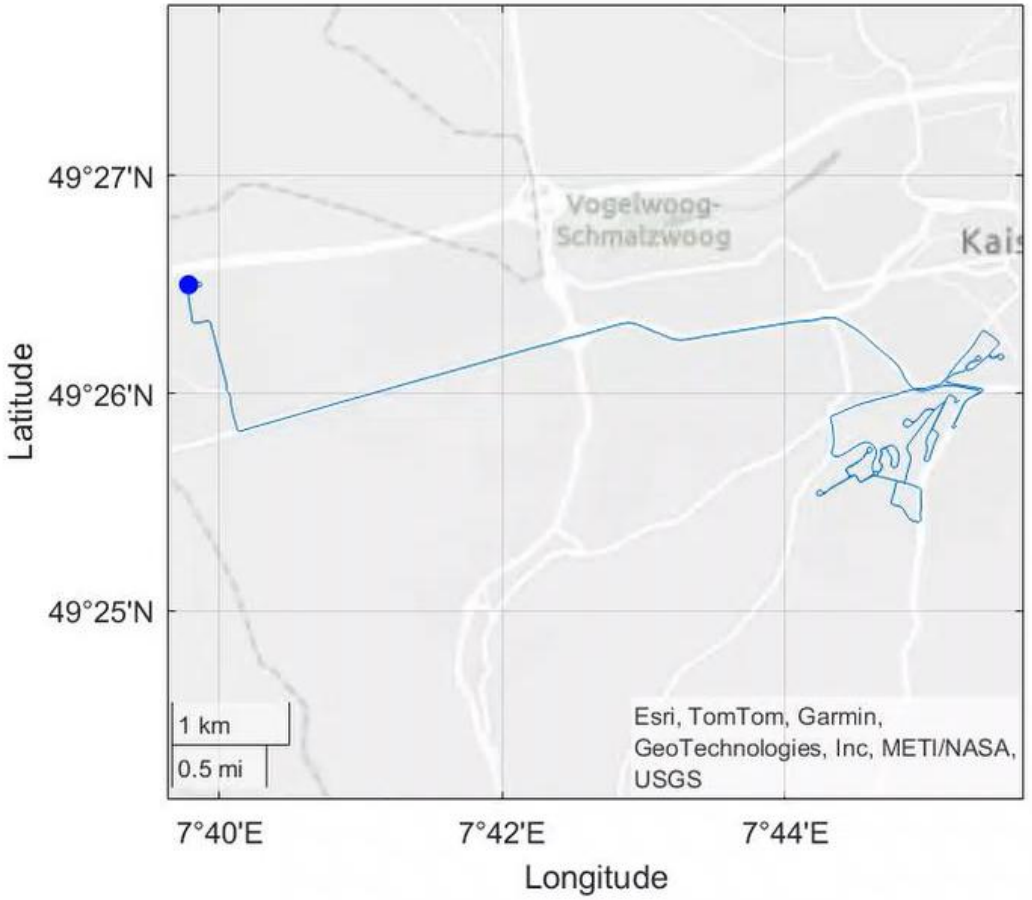
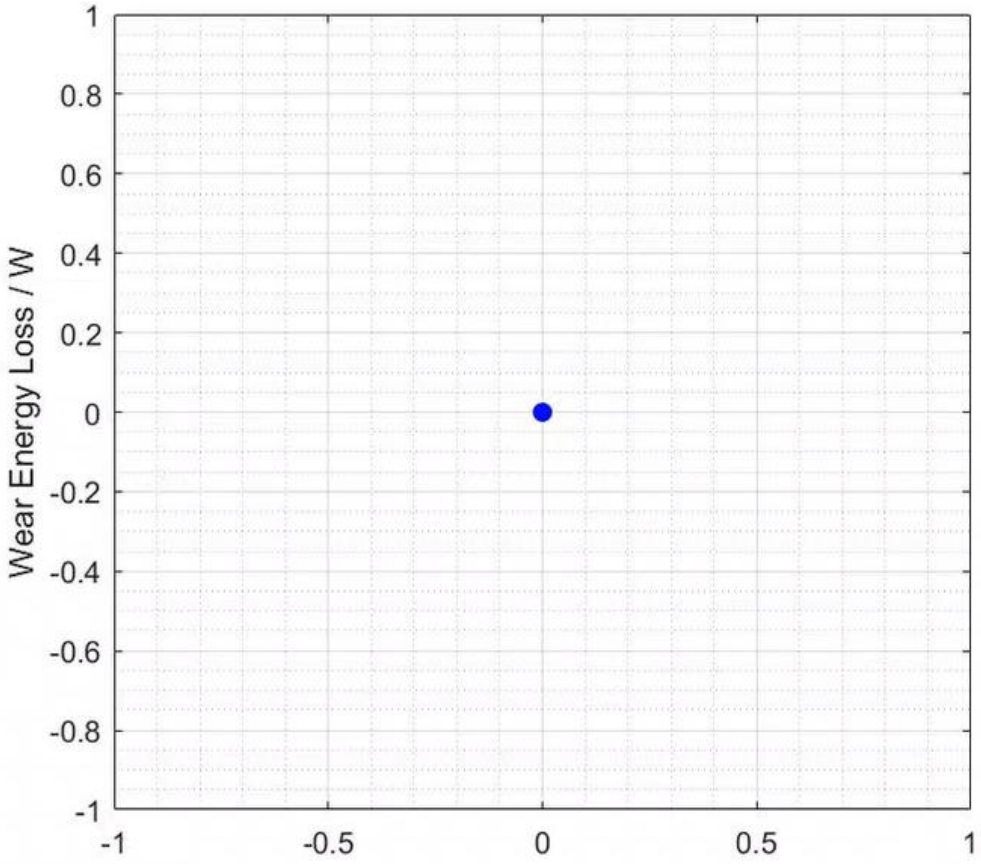
# Tire Model CDTire/3D
## Detailed Workflow



# Tire Model CDTire/3D
## Comparison between Aggressive and Restrained Driver




# Outlook

- An extraction system for TRWP was installed at the inner drum test bench at KIT:
  - Determining the mass of the collected tire and road wear particles
  - Further analyzes possible with the TRWP
- Abrasion measurements on test bench to start soon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# Sources


[1] ETRTO, „TA-38-5 ETRTO C2 Tyres Vehicle Method Description 20251030 for TFTA“, held at the38th session of the Task Force on Tyre Abrasion TFTA, 30. October 2025.

[2] https://www.csselectronics.com/cdn/shop/products/canedge3-3g-4g-can-bus-data-logger-gps-antenna-v3.jpg?v=1680173131

[3] https://www.kern-sohn.com/shop/de/produkte/laborwaagen/praezisionswaagen/tfej-33k-4m-a/

[4] https://www.palas.de/product/promo2000