

MAY 14th-16th, 2024
VI-GRADE SIMCENTER UDINE - ITALY



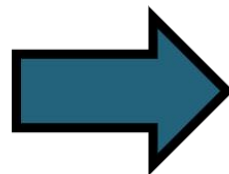
A HAPTIC ENHANCED STEERING SIMULATION BASED ON MULTI-CONTACT TIRE MODEL AND MIXED HARDWARE-IN-THE-LOOP STEERING BENCH

Andrea Sammartino – Project Coordination Manager @ MegaRide
Luca Veneroso – Control System Engineer @ Meccanica 42

MEGARIDE COMPANY OVERVIEW



UniNa Vehicle Dynamics research group



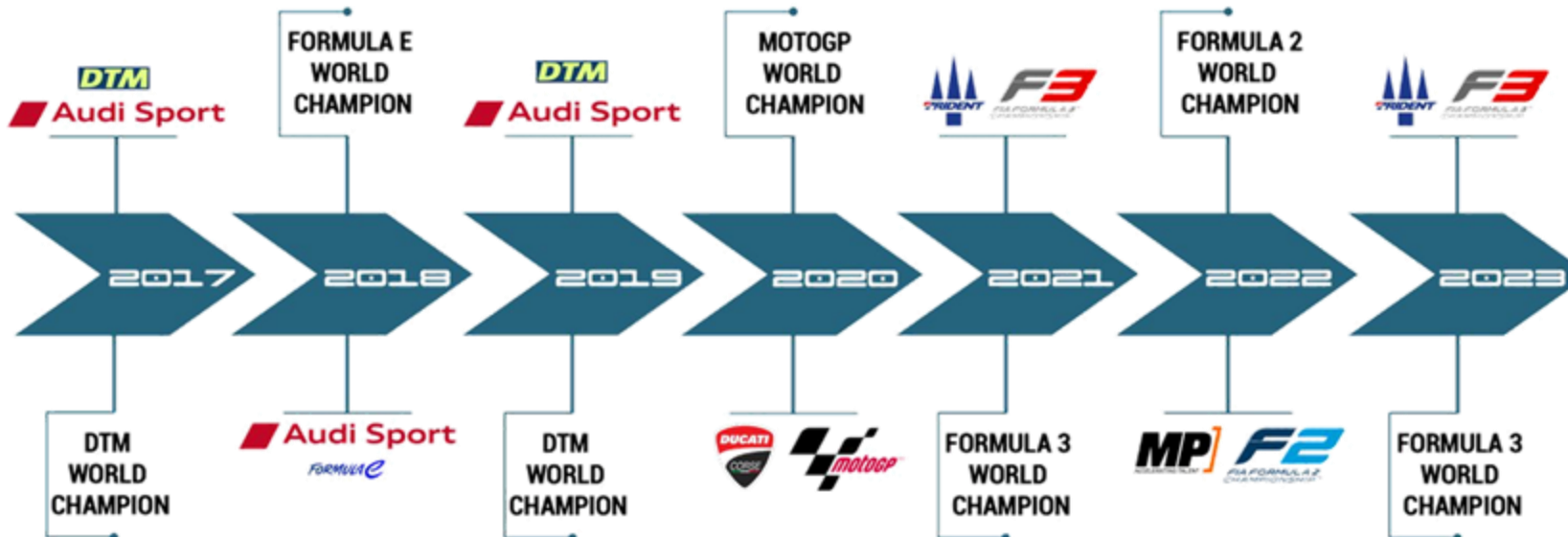
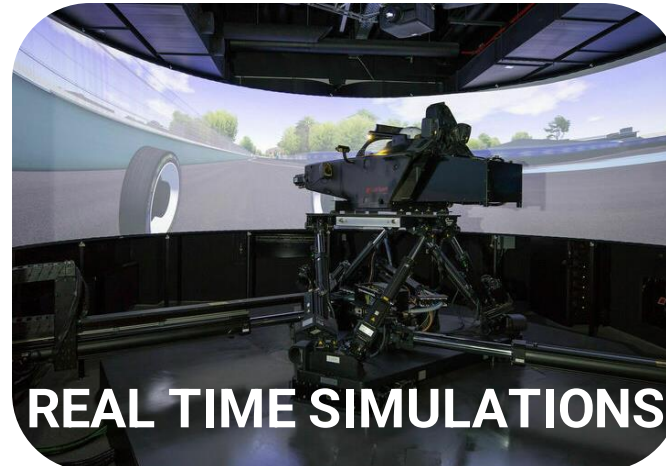
MEGARIDE®
APPLIED VEHICLE RESEARCH
an official UniNa spinoff company

MULTI-PHYSICAL TIRE MODELS

MODULAR SIMULATION PLATFORM

SCIENCE APPLIED TO RACES

TECHNOLOGIES FOR



MECCANICA 42 COMPANY OVERVIEW



Unleash your **vehicles'** performance with Meccanica 42's cutting-edge technology

M42 PRODUCT LINES

Real-time test benches

Exploiting real components on virtual vehicles for testing and validation



On-board devices

Orchestrating control over high-performance vehicles for autonomous and by-Wire systems



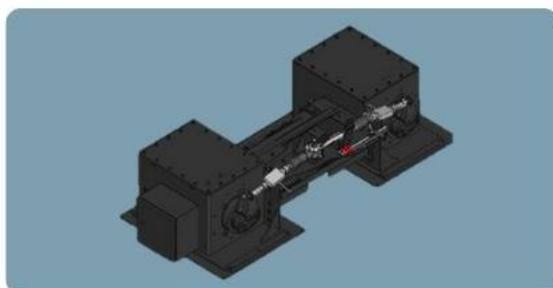
M42 PRODUCTS

Real time test benches

SMC



EPSiL



CamiL



BrakeiL



On-board devices

PSA



CBA

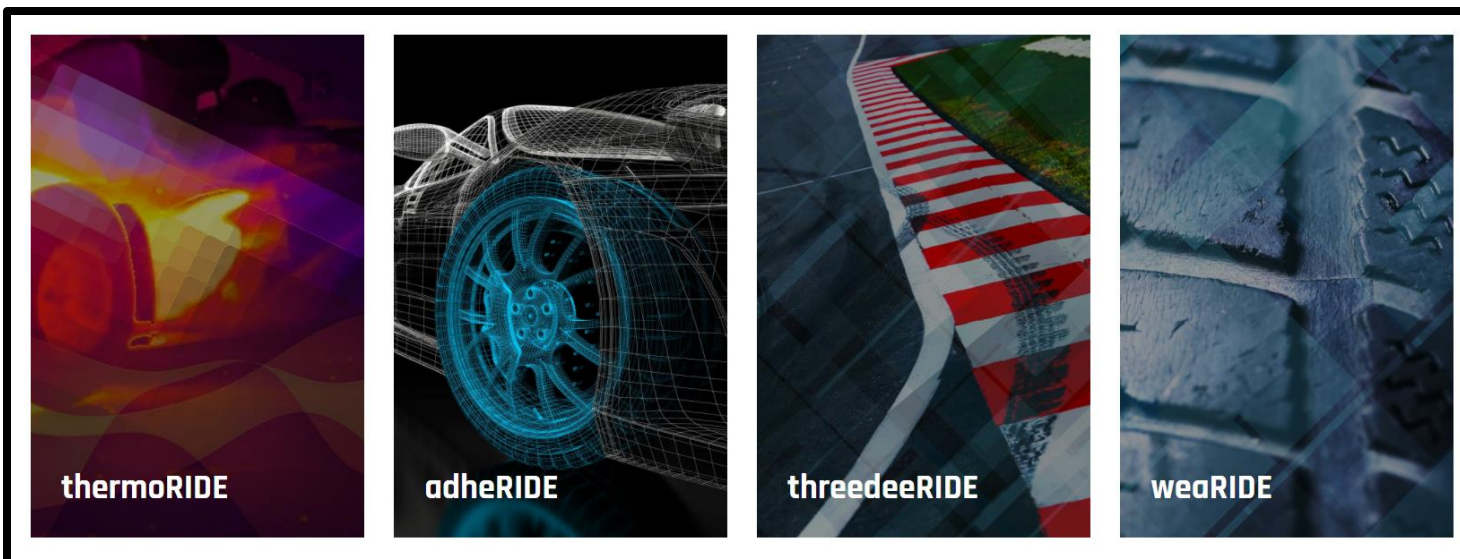


BSU



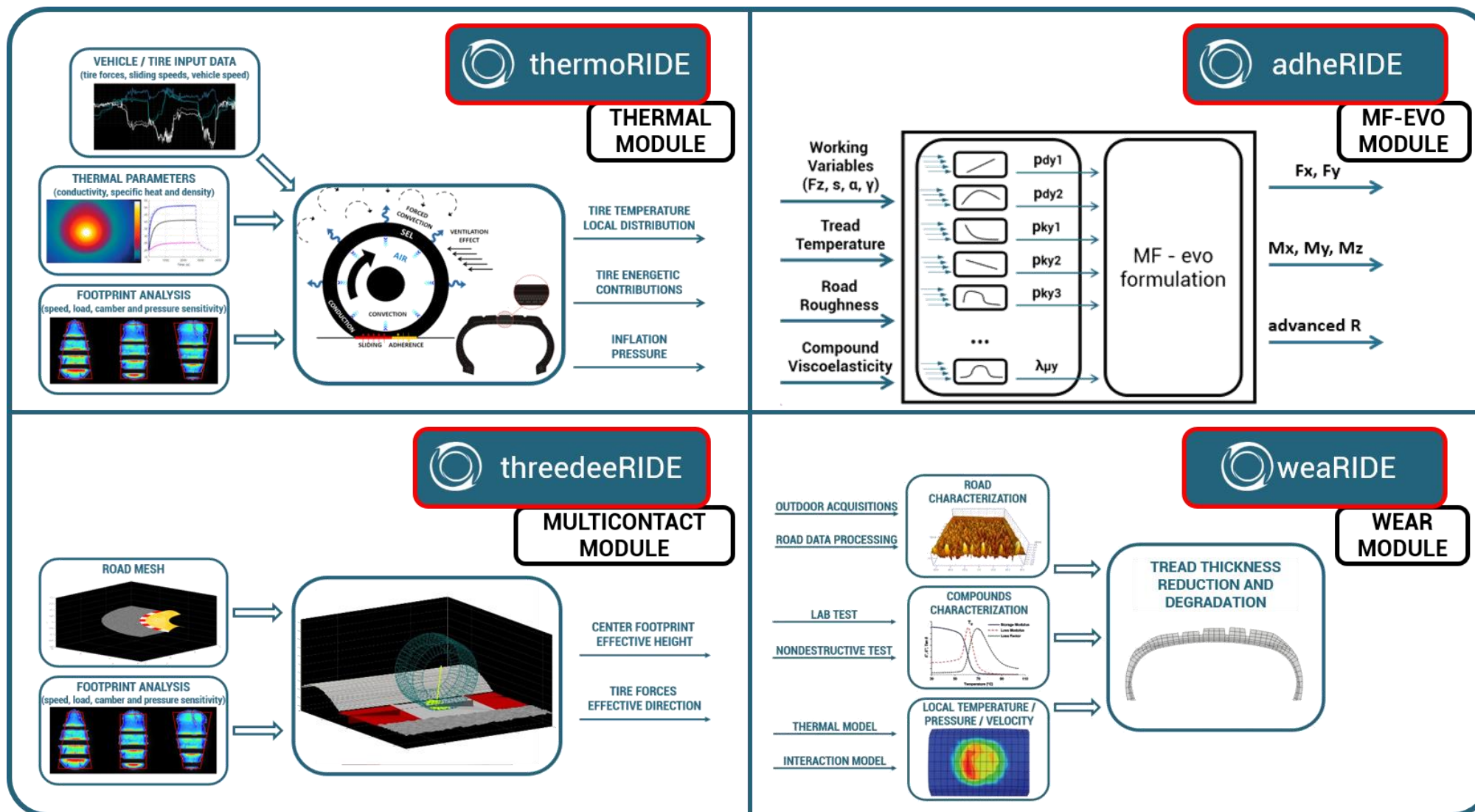
MEGARIDE RIDESUITE

A modular multiphysical simulation platform for a holistic view of tire behavior



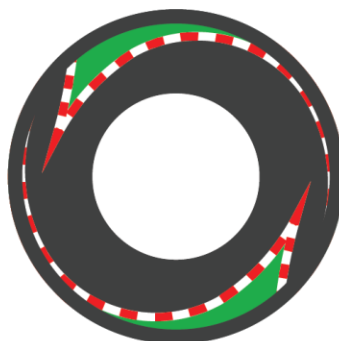
It comprises four main elements, able to simulate in detail the physical effects characterizing a vehicle interacting with the external environment.

A HOLISTIC VIEW IN TIRE MODELING



THREEDeerIDE

Introduction



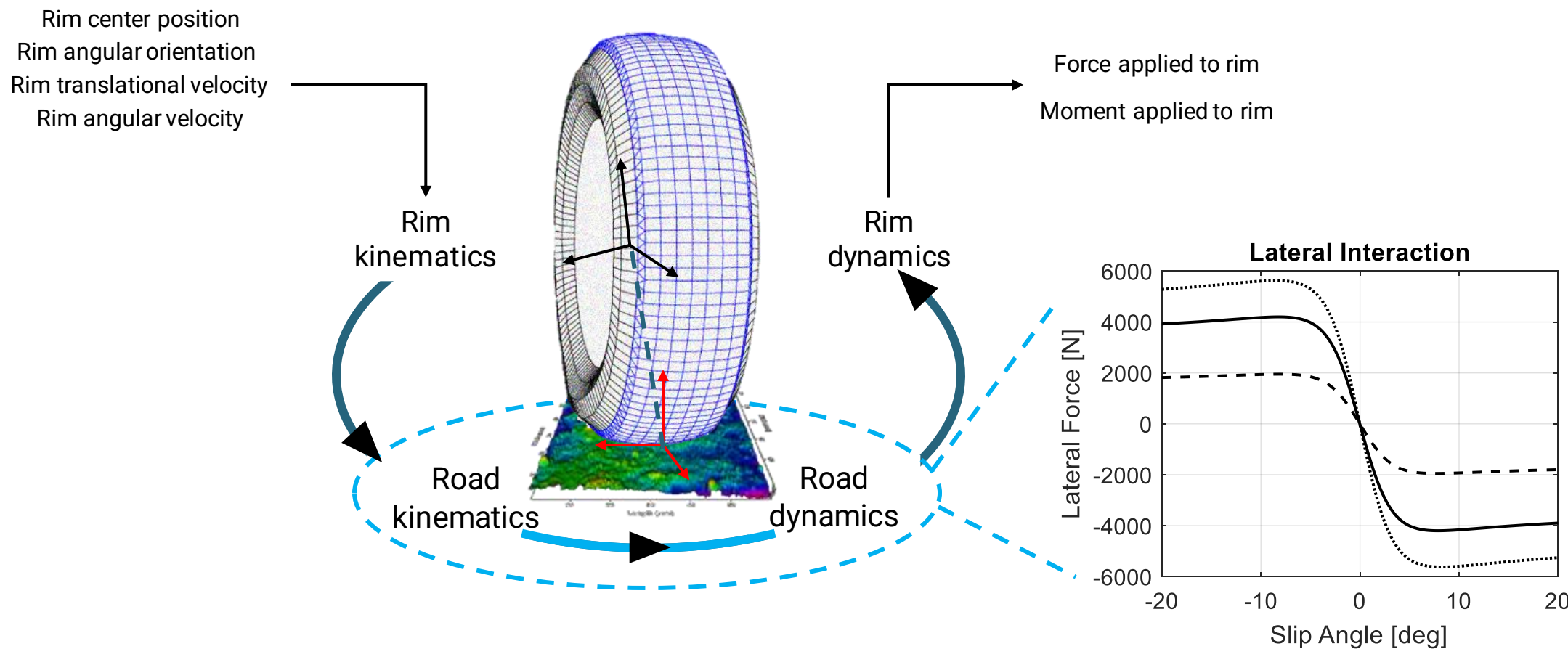
threedeeRIDE



- reproduction of real contact between the tire and the road macro/micro-asperities
- enhancement of real contact feeling in hard real-time environment
- overcoming the typical issue of single point contact model

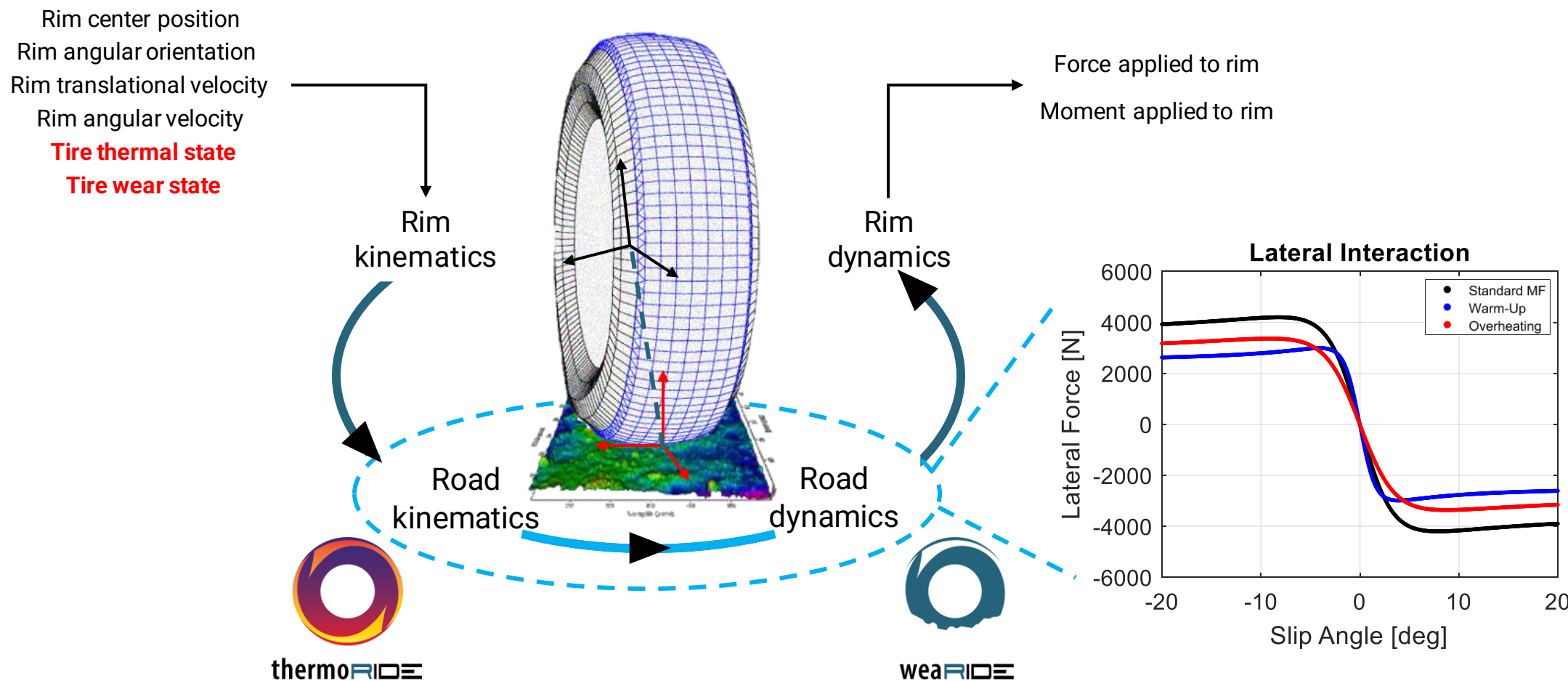
THREED EERIDE

Working principle



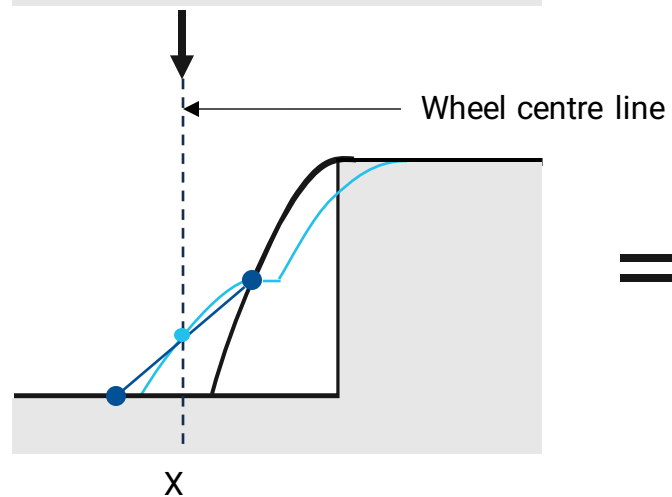
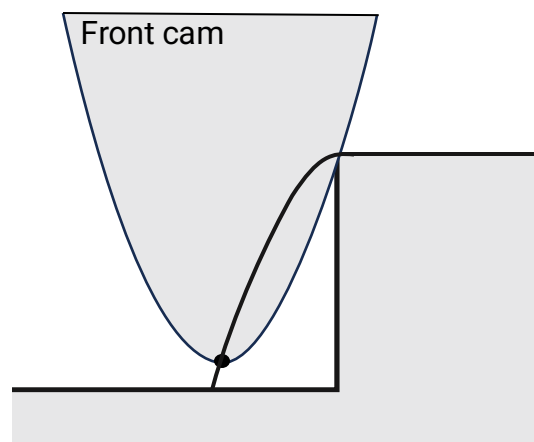
THREED EERIDE

Working principle

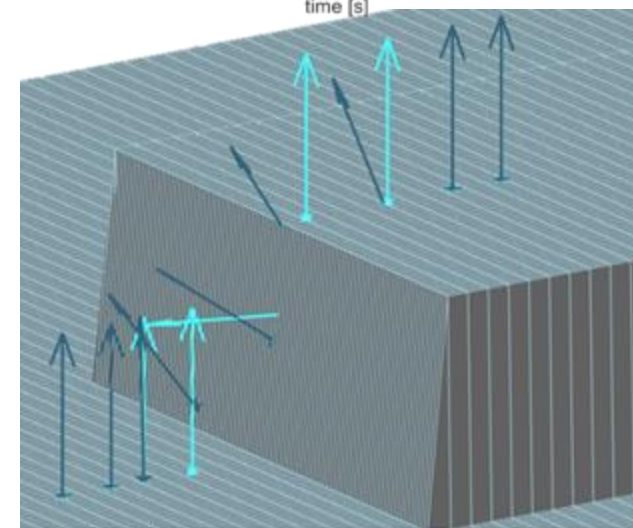
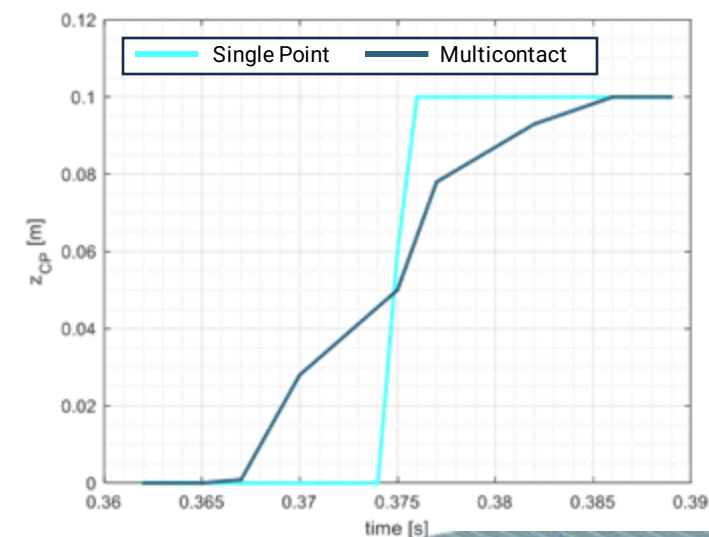
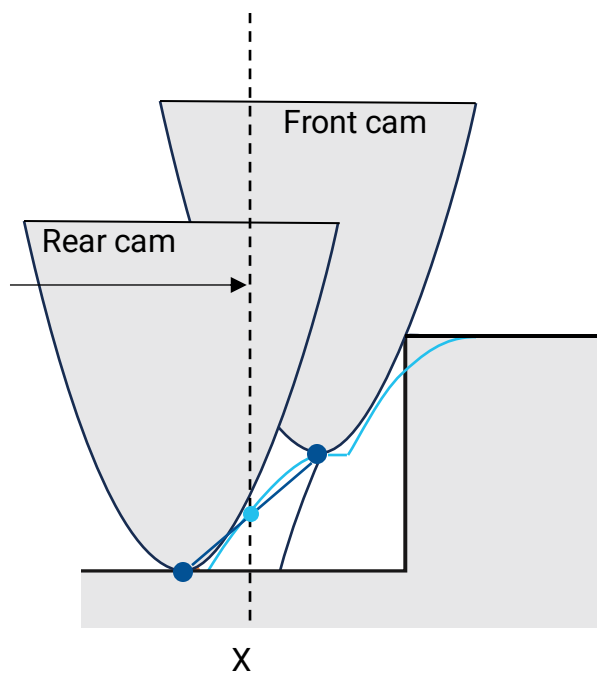


THREED EERIDE

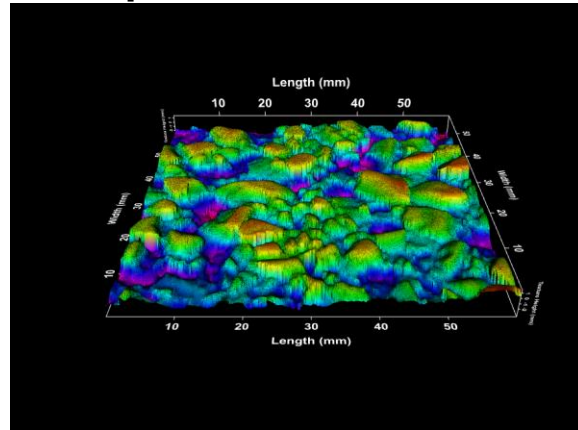
Working principle



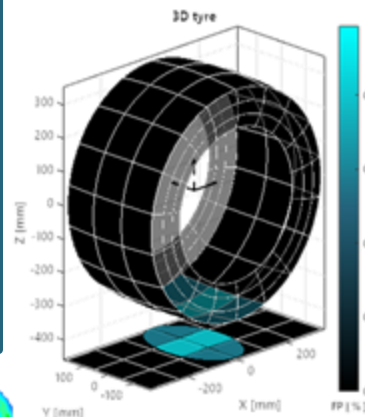
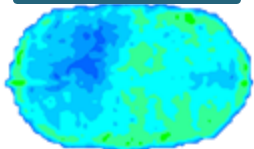
- Basic curve
- Effective height
- Two-points follower



Road profile characterization

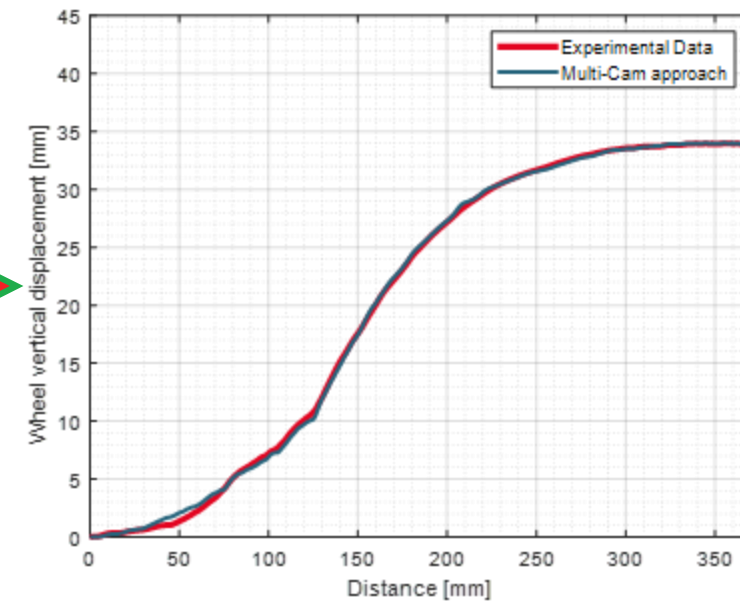
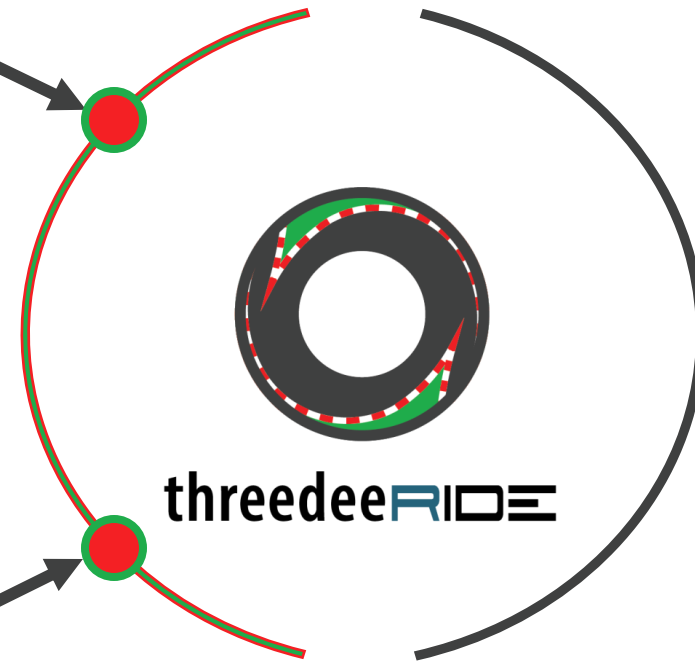


Tire structural non-destructive characterization



THREEDERIDE

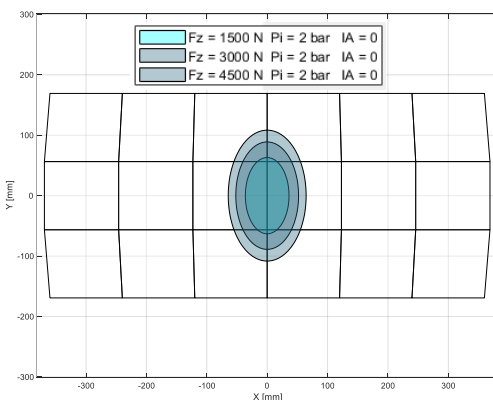
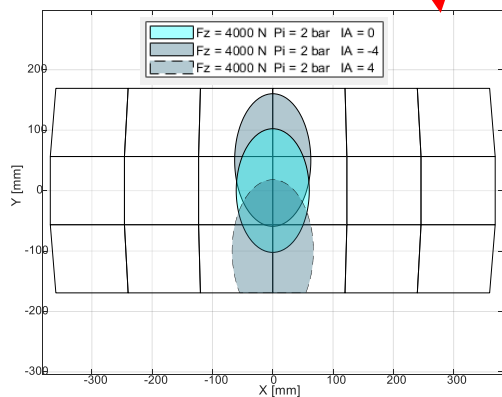
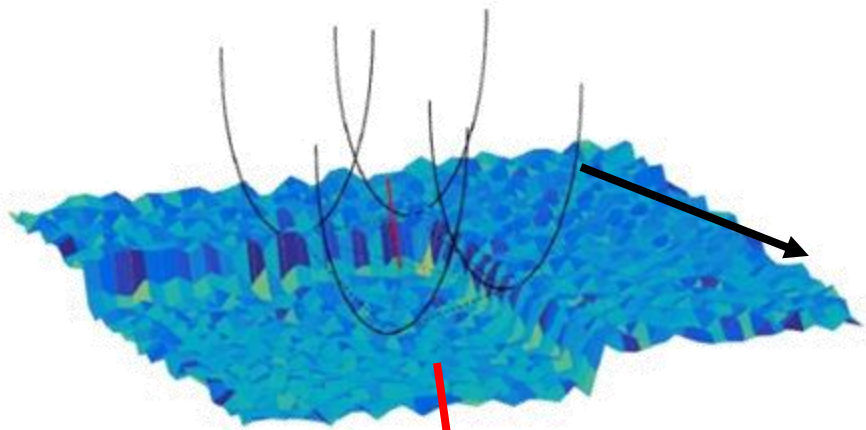
I/O



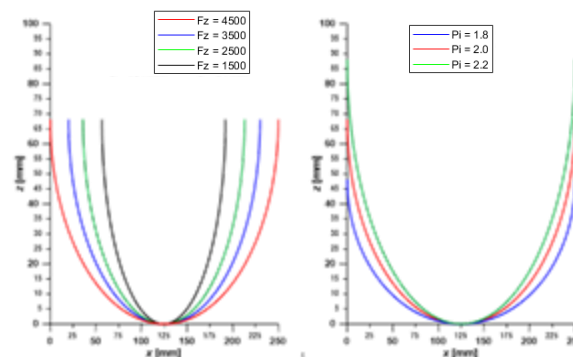
THREEDeerIDE

Output analysis

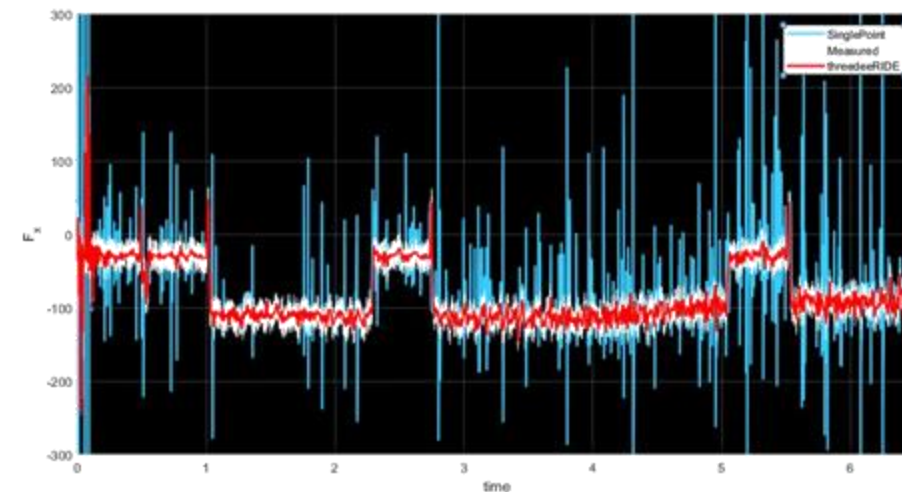
Contact patch variation



Cams dimension variation



Uneven road



The model allows to reproduce the real natural filter that tire represents between the road and the wheel hub, improving the correlation with the measured data.

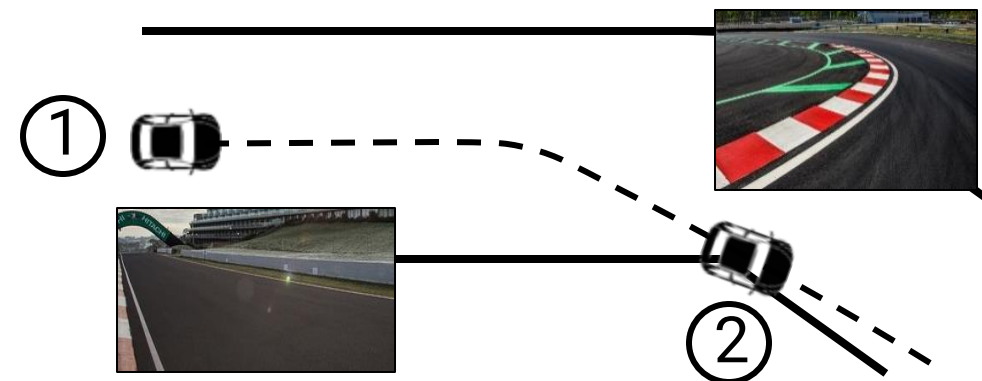
THREEDeerIDE

Output analysis

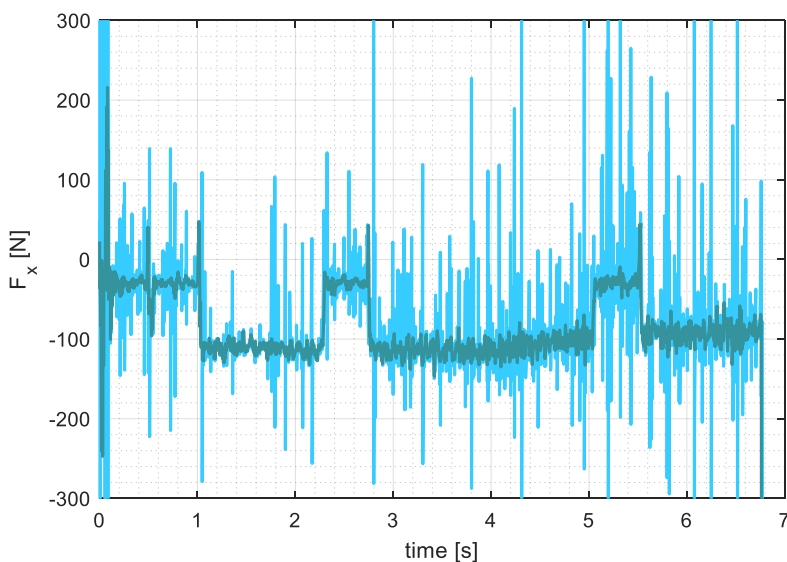
A specific maneuver in a dynamic simulation has been designed to simulate a vehicle which:

- travels on road unevennesses
- impacts on a kerb

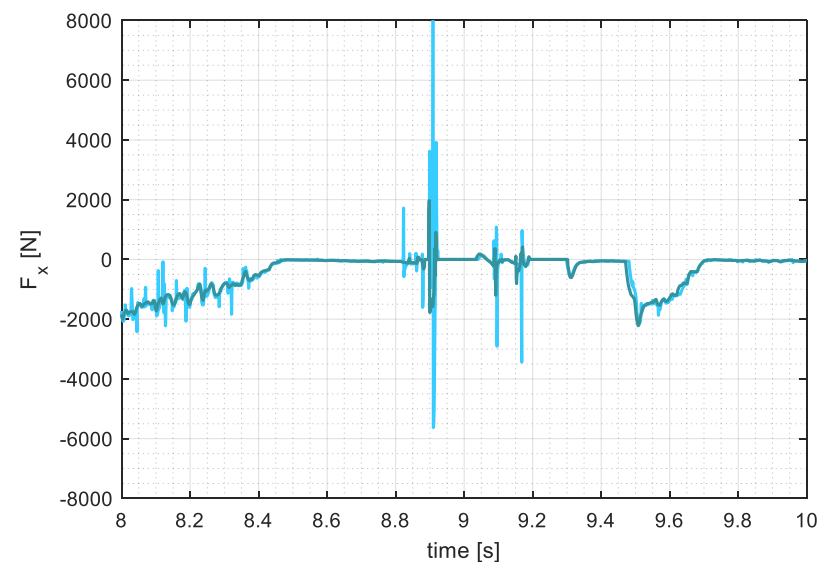
A comparison between the default noisy single point model and threedeeRIDE is presented.



① Uneven road



② Kerb impact



DIGITALIZATION WORKFLOW



DIGITALIZATION WORKFLOW

How to enhance
Steering Feedback?

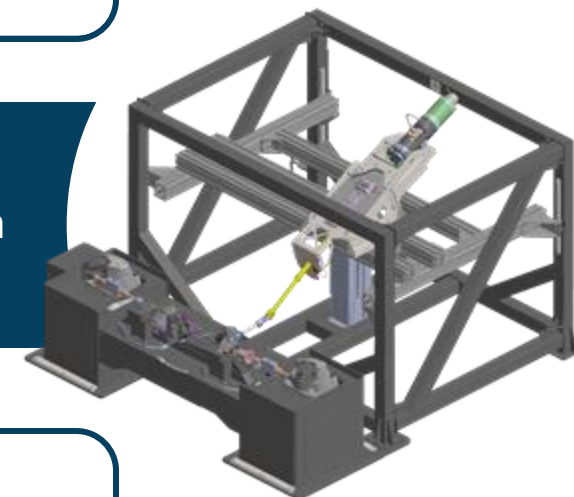


Track test

- Open loop manoeuvres
- Closed loop manoeuvres

- Tie-rod forces
- Steer torque

Test-bench validation



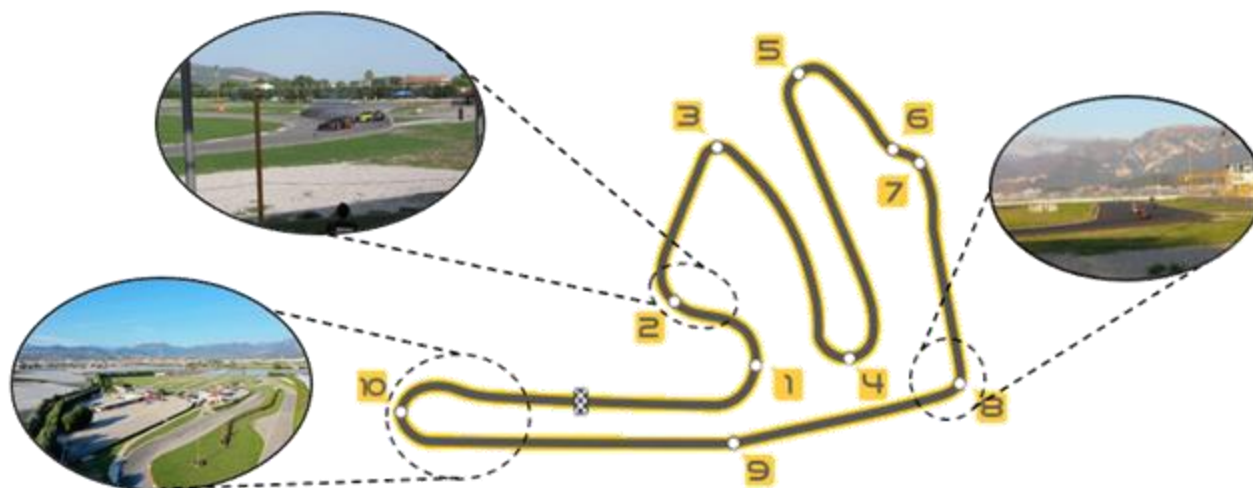
Simulator session

- Steering effort
- Micro-roughness and curb interaction



TRACK TEST

The “Seaside Racing” project: overview



Track



Name: Circuito del Sele
Length: 1664 meters
Corners: 10 (3 left, 7 right)
Longest straight length: about 400 meters



DIPARTIMENTO DI
INGEGNERIA
INDUSTRIALE



UNIVERSITÀ DEGLI STUDI
DI NAPOLI FEDERICO II



measure. analyze. innovate.



MECCANICA42



SIEMENS



UNIVERSITÀ
DEGLI STUDI
DI BRESCIA



UNIVERSITÀ
DI PAVIA



DIPARTIMENTO DI INGEGNERIA
INDUSTRIALE
UNIVERSITÀ DEGLI STUDI DI PADOVA



Università
di Catania



TRACK TEST



Correvit S-motion
Longitudinal velocity
Lateral velocity
Slip Angle



Steer sensor
Steering torque
Steer angle
Steer velocity

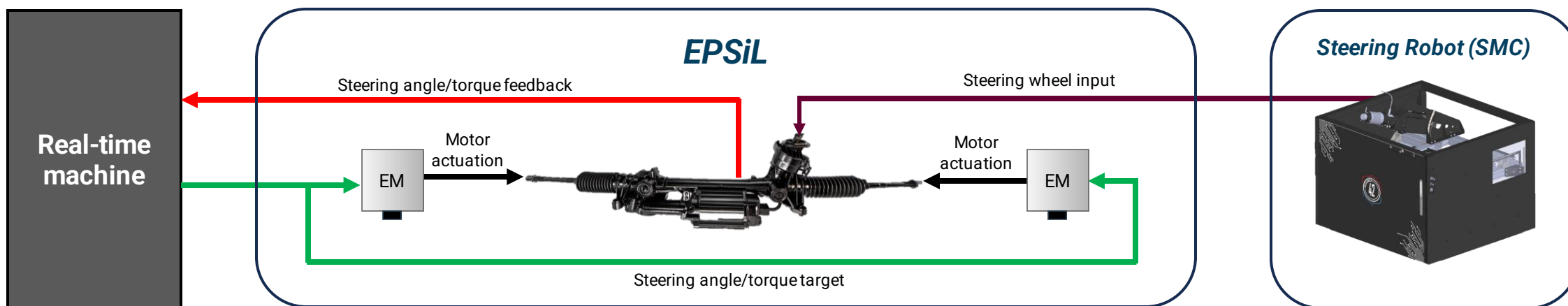
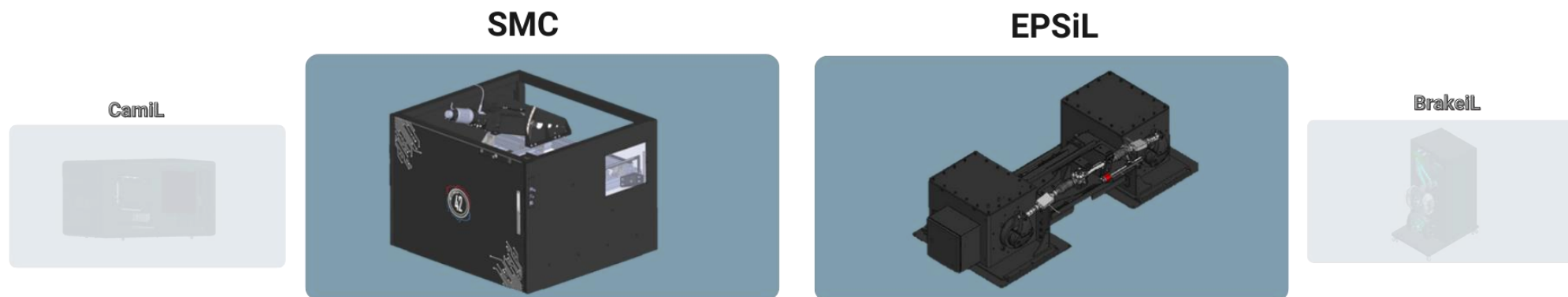


Wheel transducer
Contact patch forces
Wheel speed
Wheel angle



Tie-rod loadcell
Tie-rod forces

TEST-BENCH VALIDATION



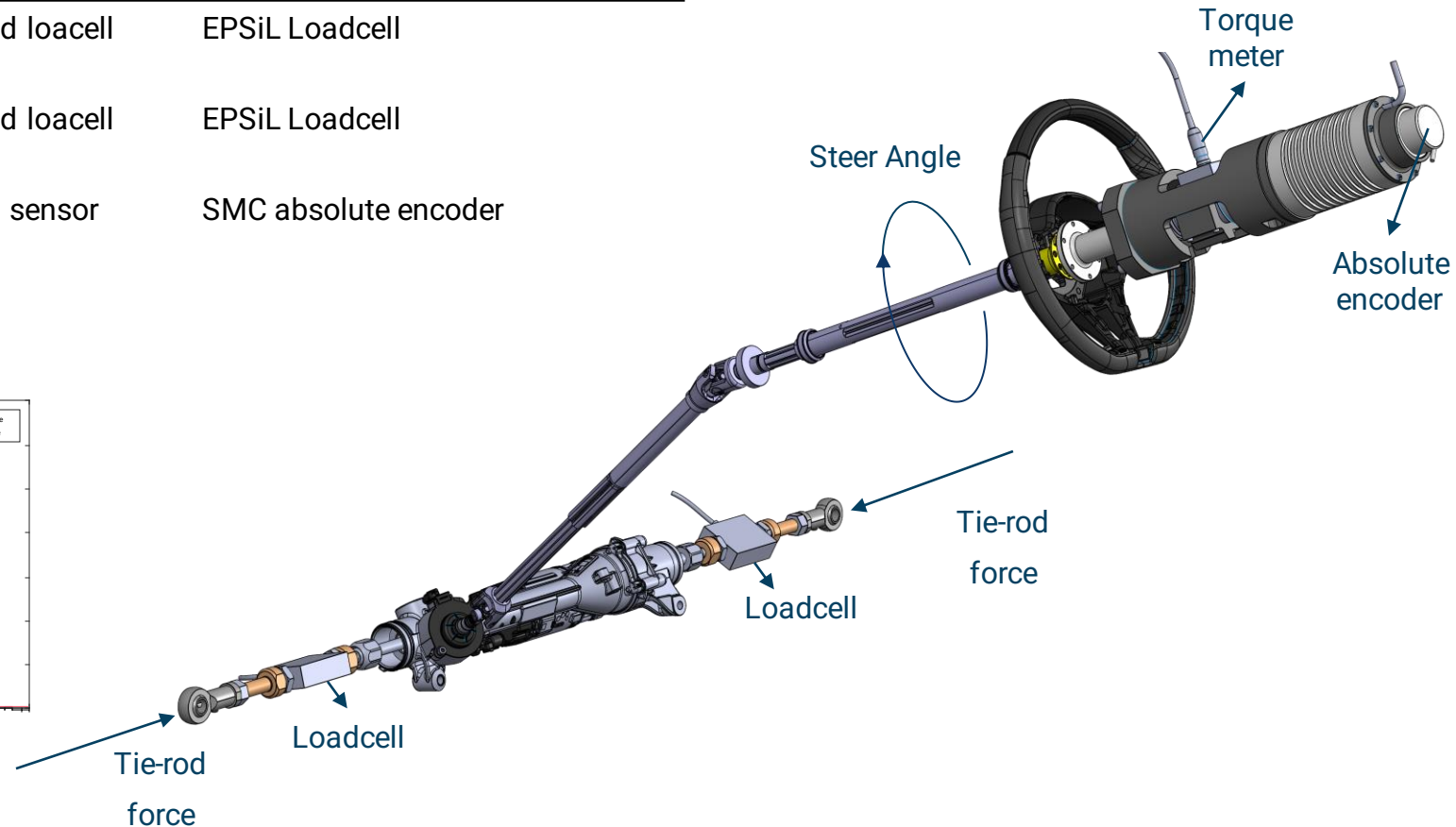
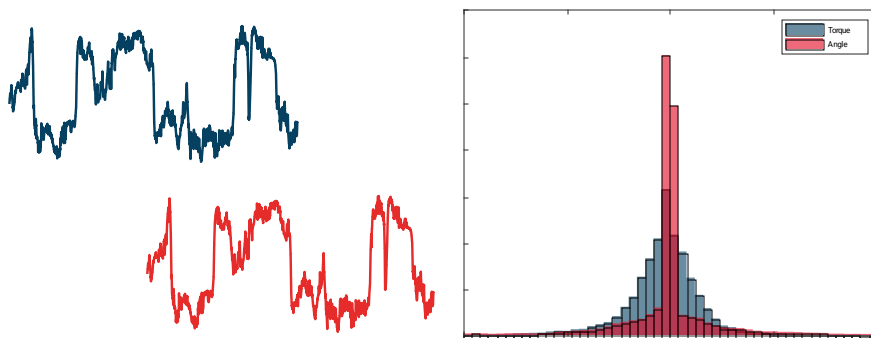
TEST-BENCH VALIDATION

Input data

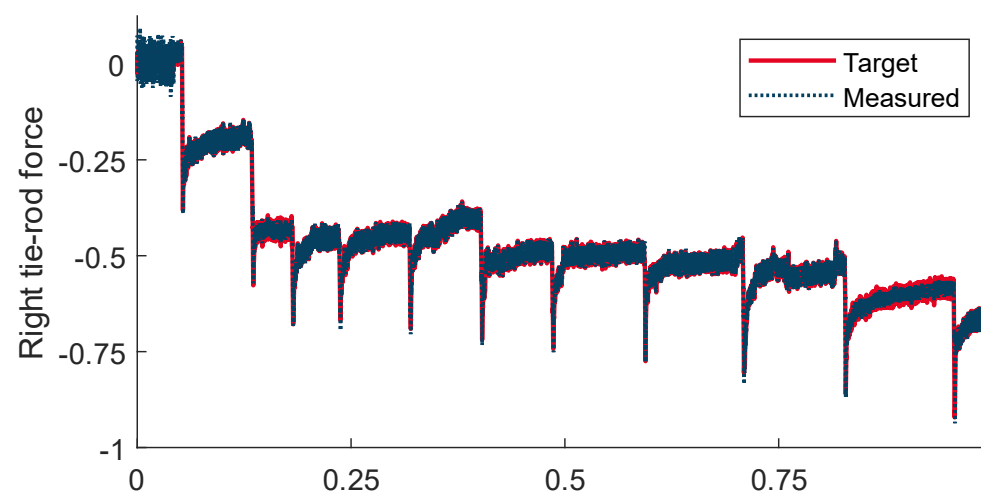
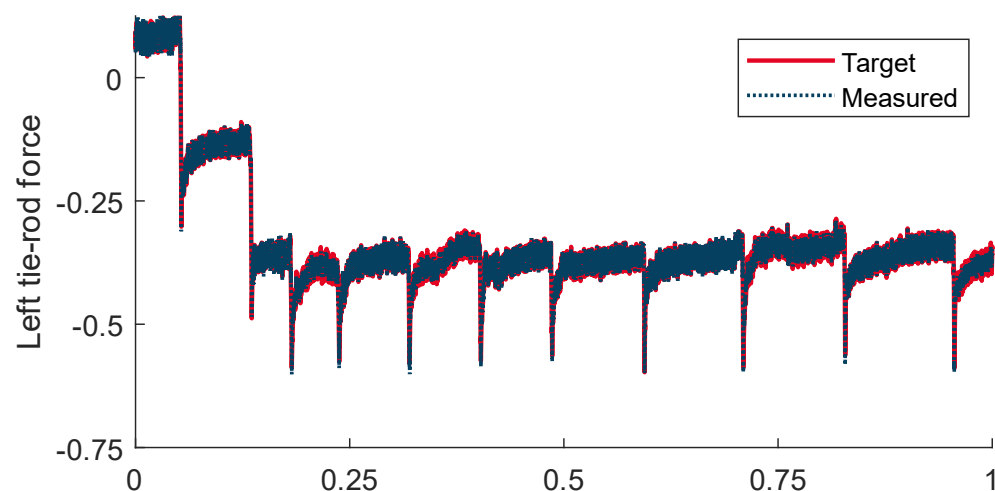
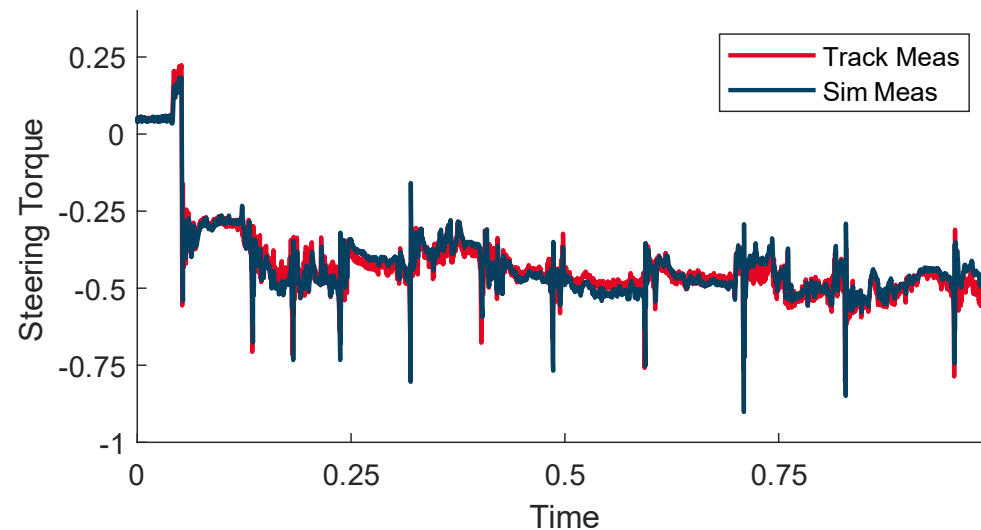
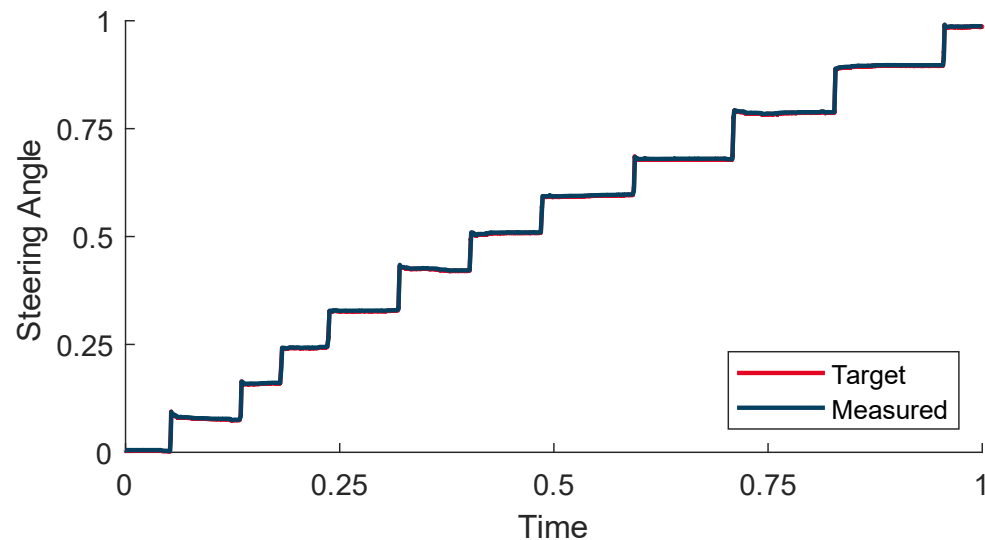
Actuator	Target	Source	Closing loop sensor
Left tie rod motor	Tie rod force	Vehicle tie rod loacell	EPSiL Loadcell
Right tie rod motor	Tie rod force	Vehicle tie rod loacell	EPSiL Loadcell
SMC	Steering angle	Vehicle steer sensor	SMC absolute encoder

Validation data

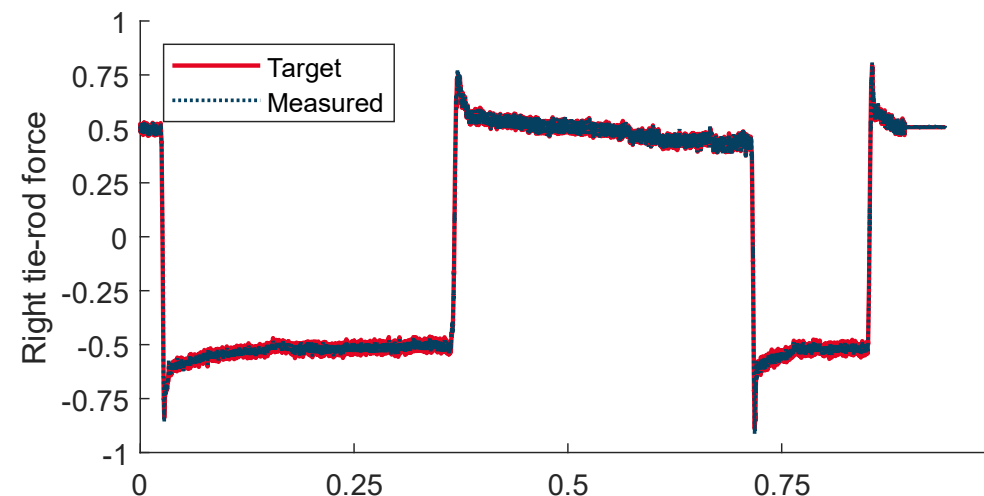
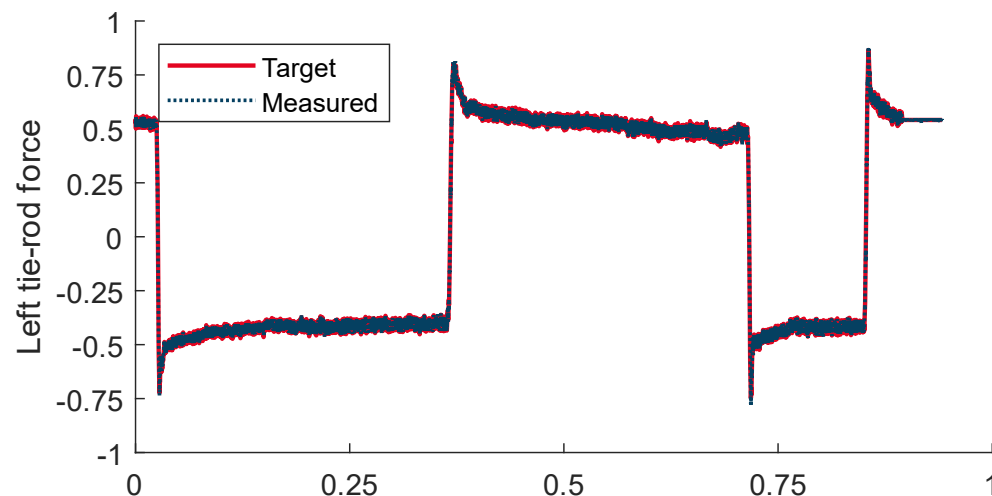
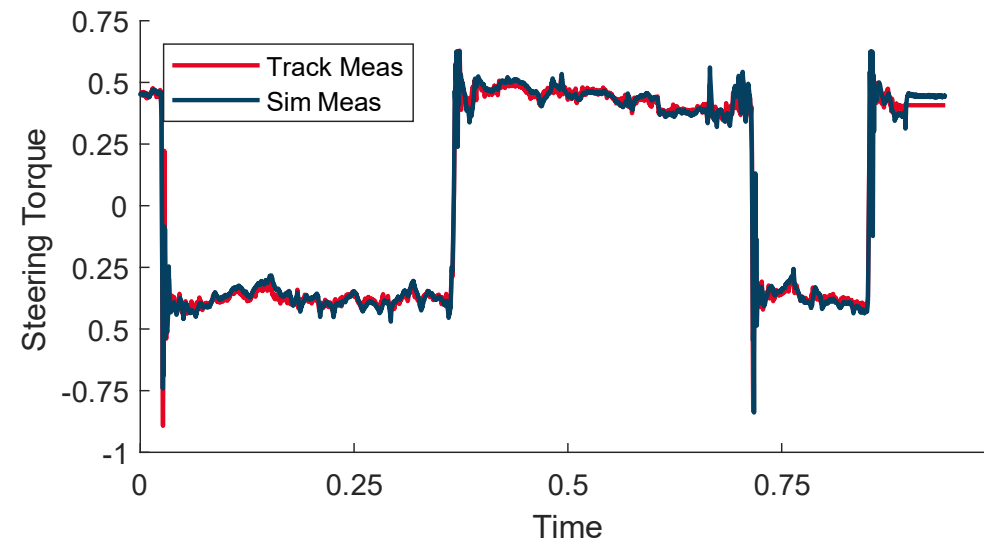
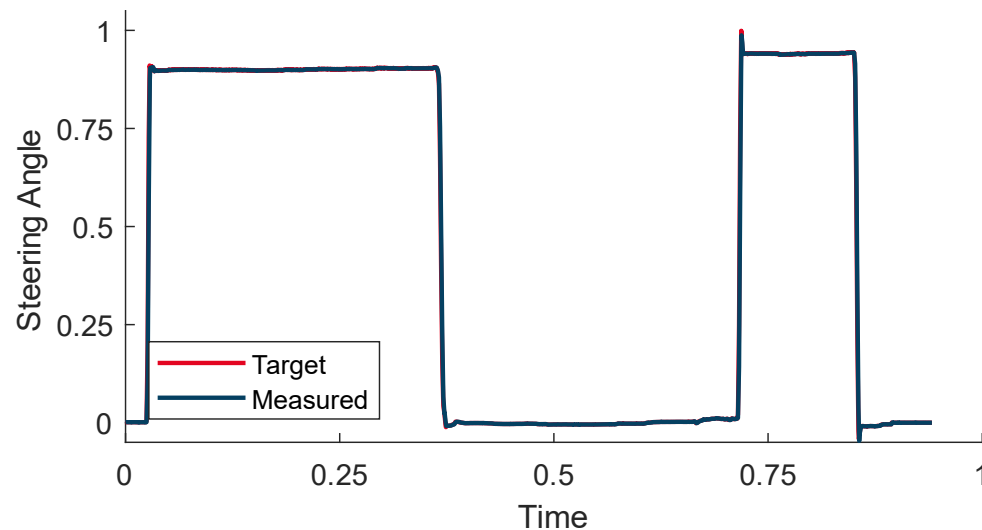
Steering torque



TEST-BENCH VALIDATION

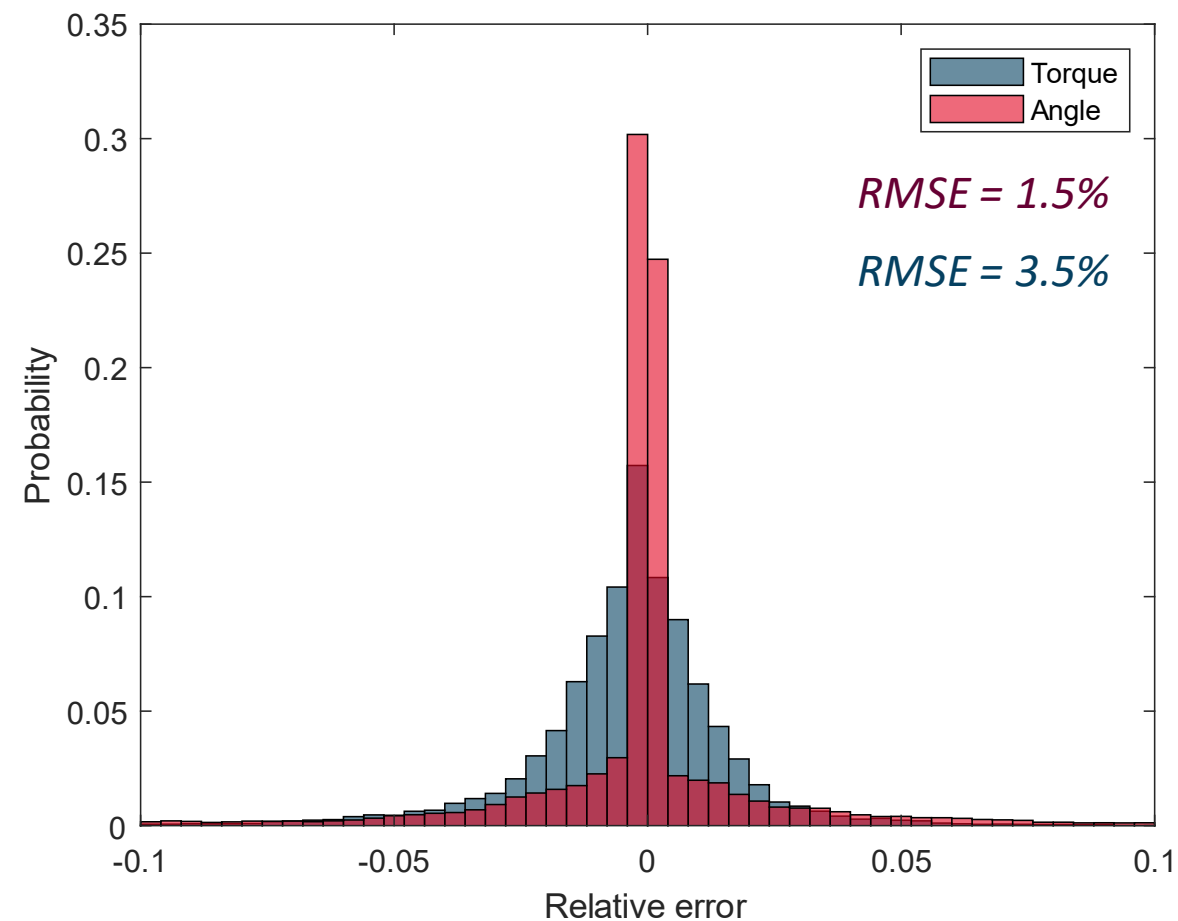
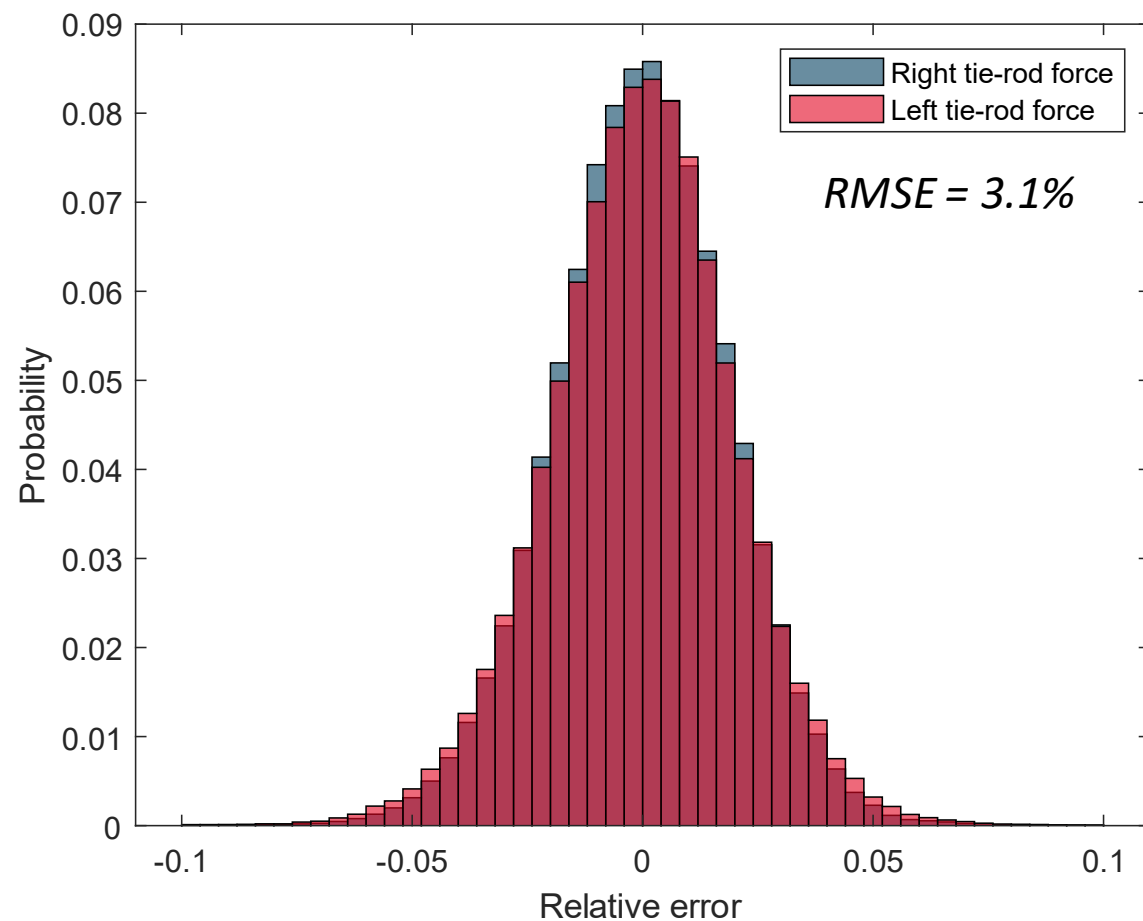


TEST-BENCH VALIDATION



TEST-BENCH VALIDATION

Steering angle and torque



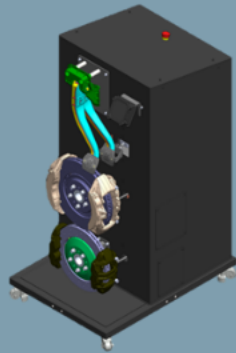
SIMULATOR SESSION

Real time test benches

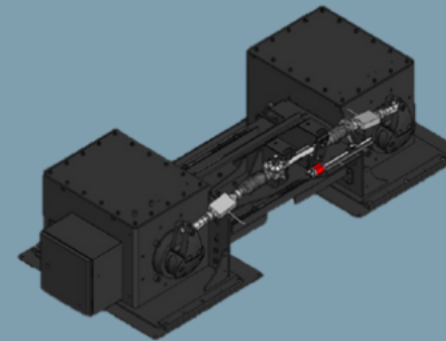
Camil



BrakeiL



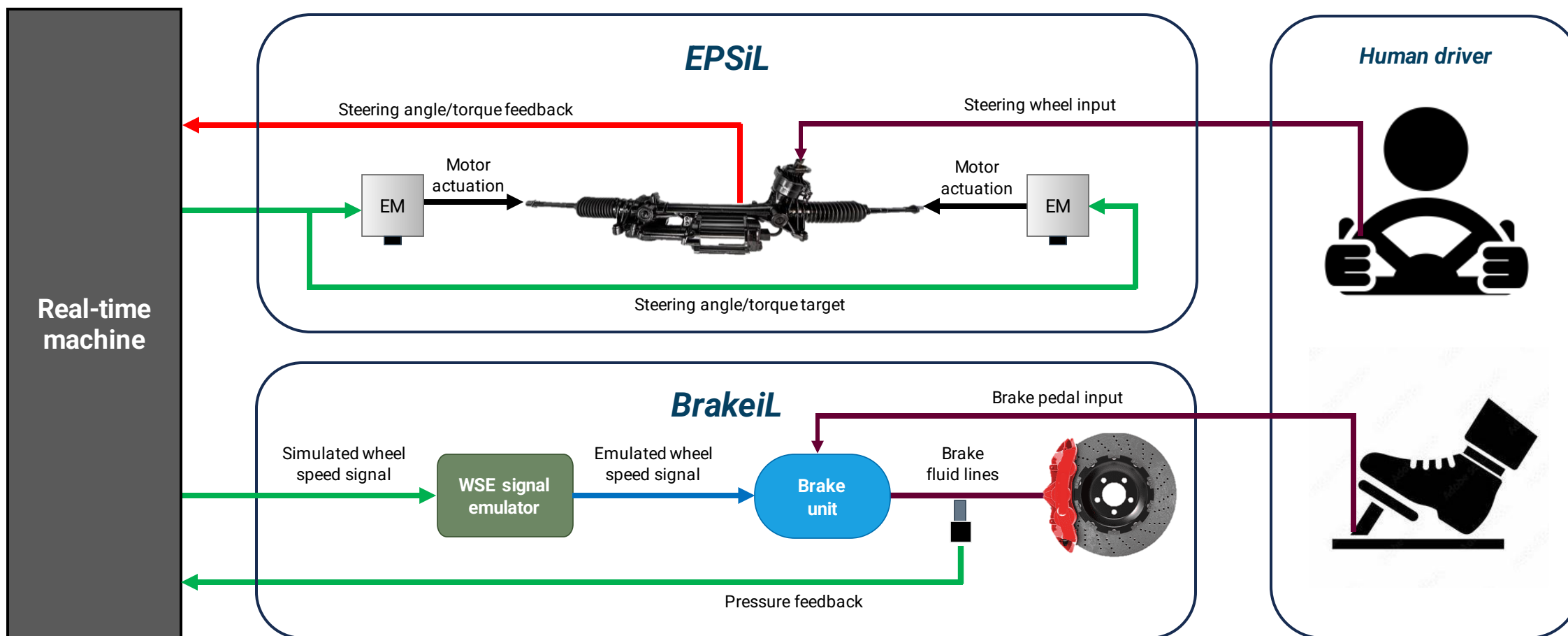
EPSiL



SMC



SIMULATOR SESSION



SIMULATOR SESSION

Driver in the loop simulator session

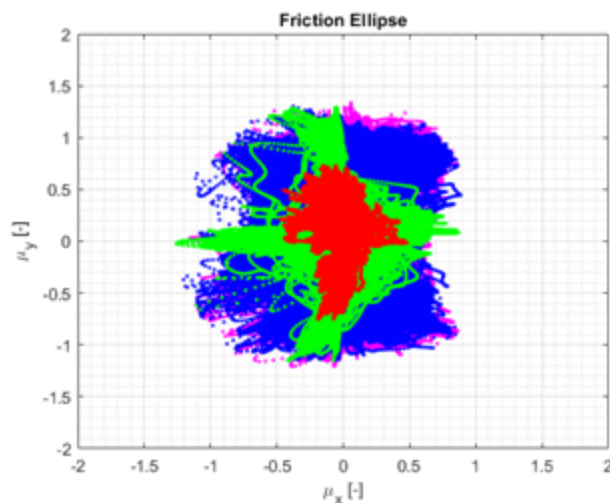
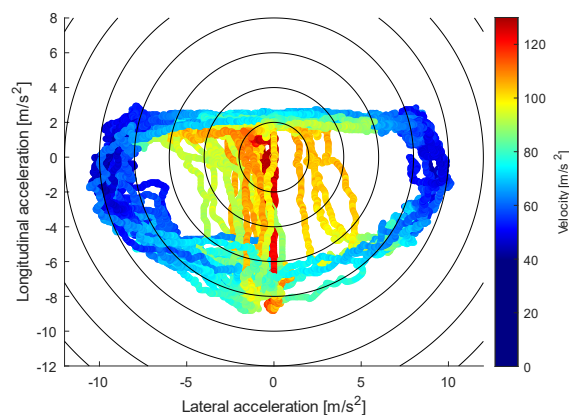
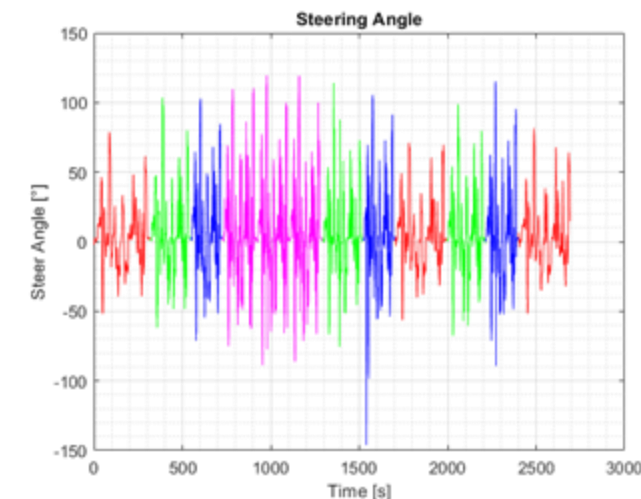
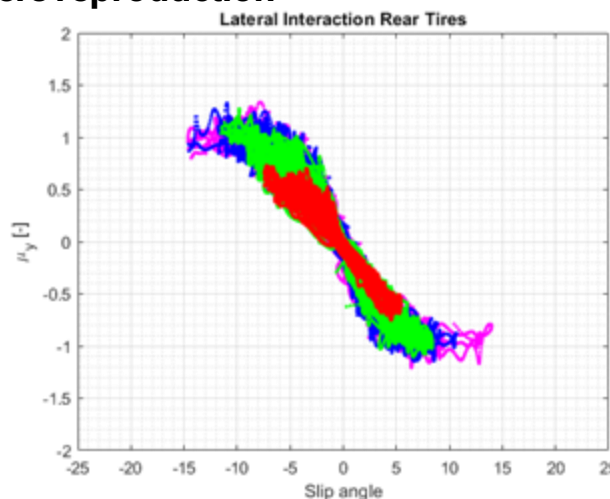
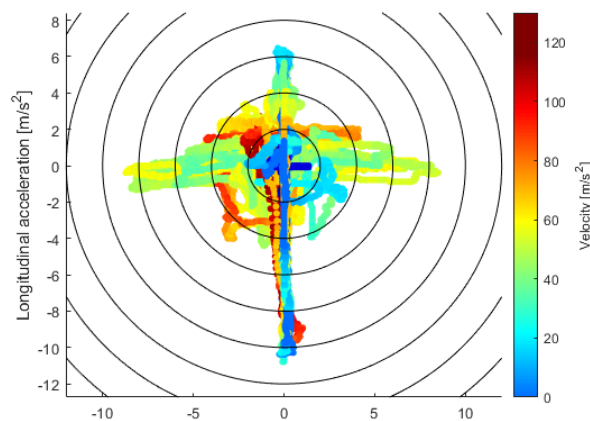


SIMULATOR SESSION

Maneuvers reproduction

Track test:

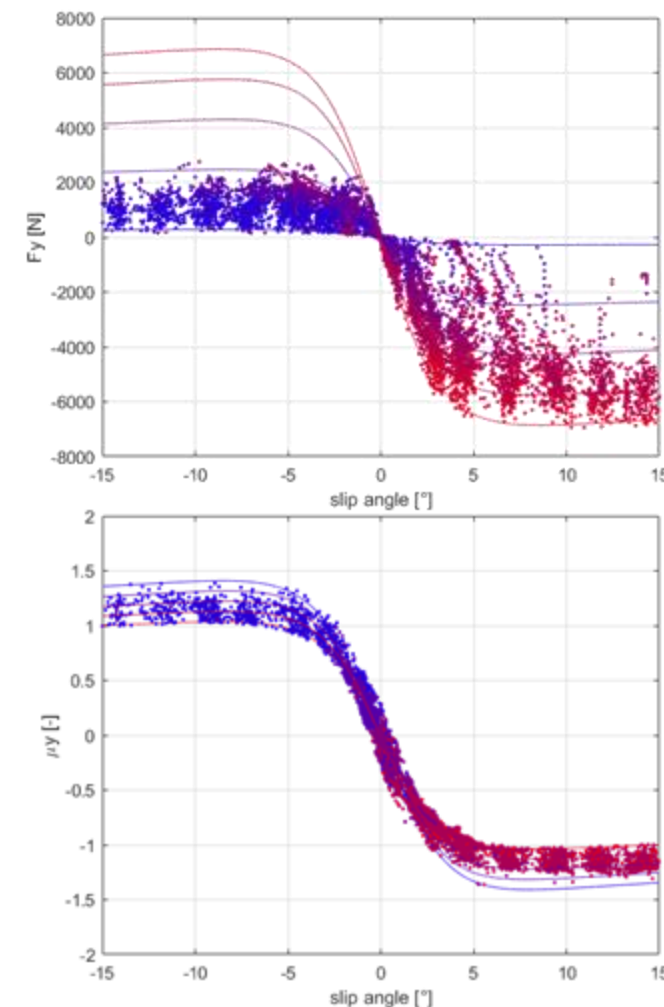
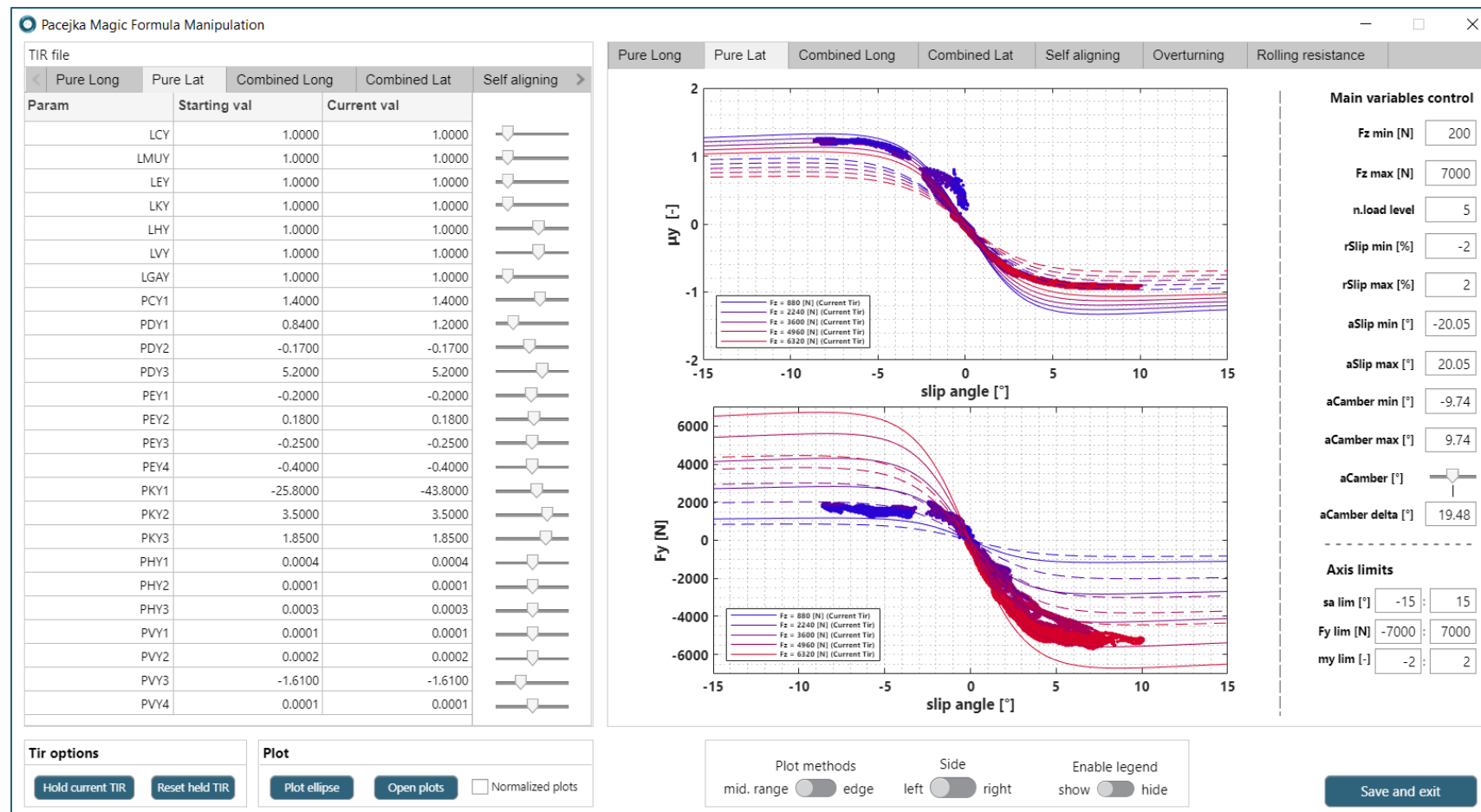
- Straight line
- Gentleman driving
- Pure-Interaction
- Max-performance



SIMULATOR SESSION

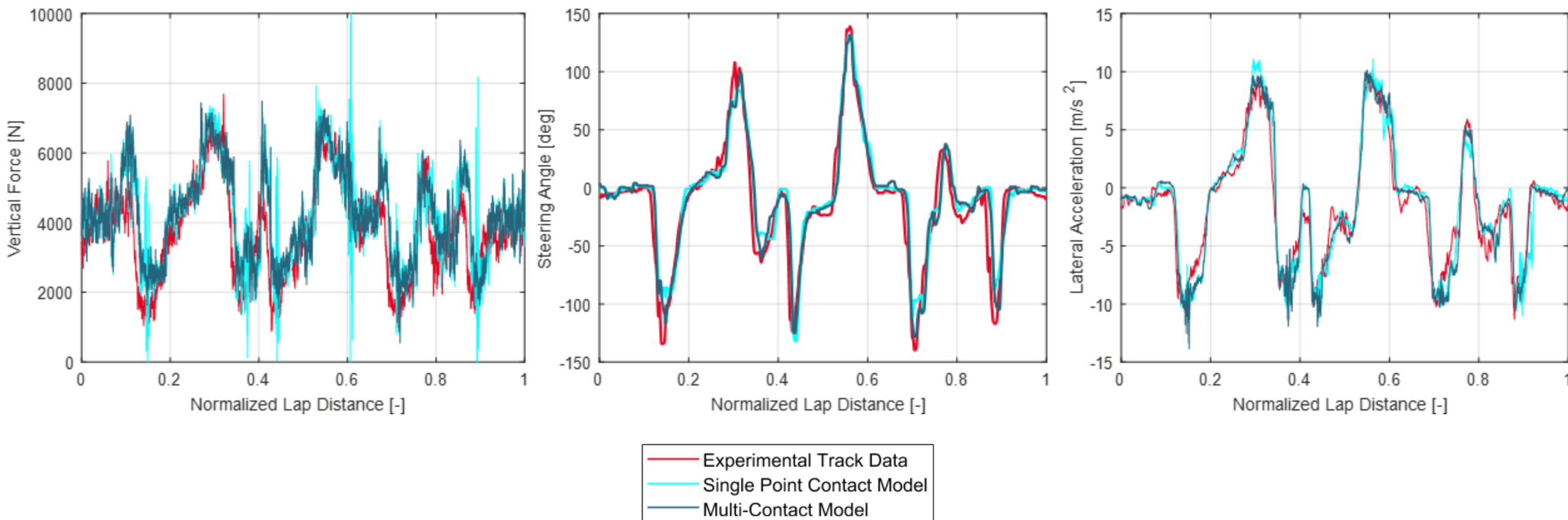
Tire model identification

Identification of the MF parameters based on the track data.



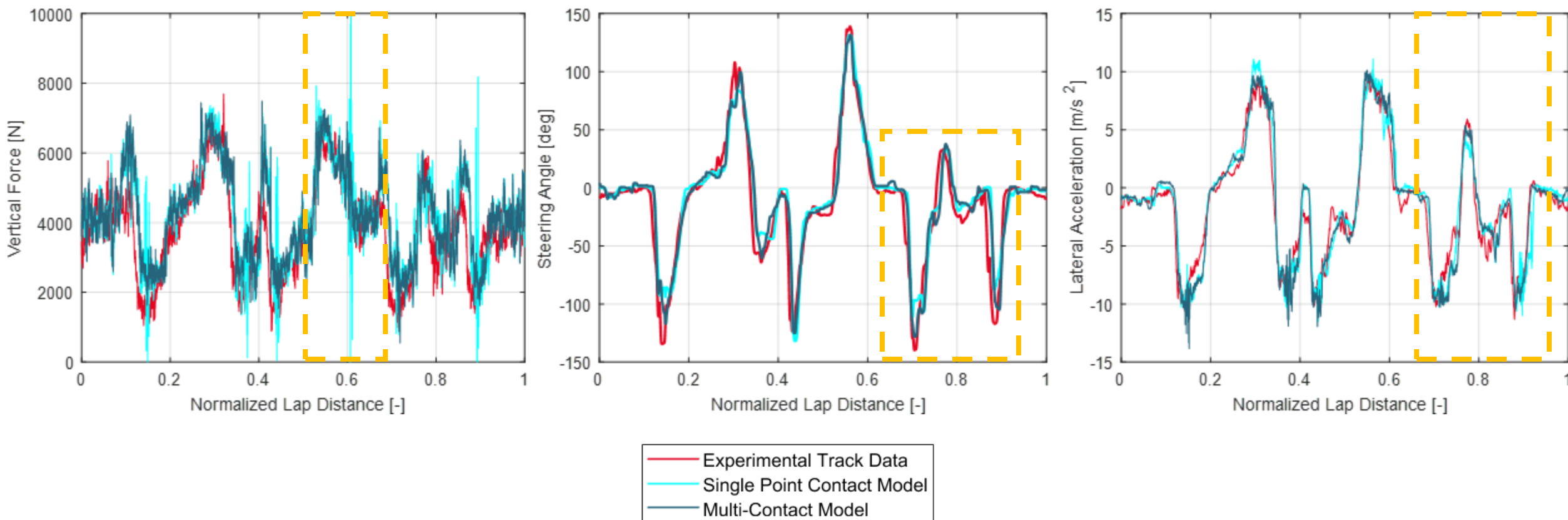
SIMULATOR SESSION

Haptic feeling improvement – nominal load configuration



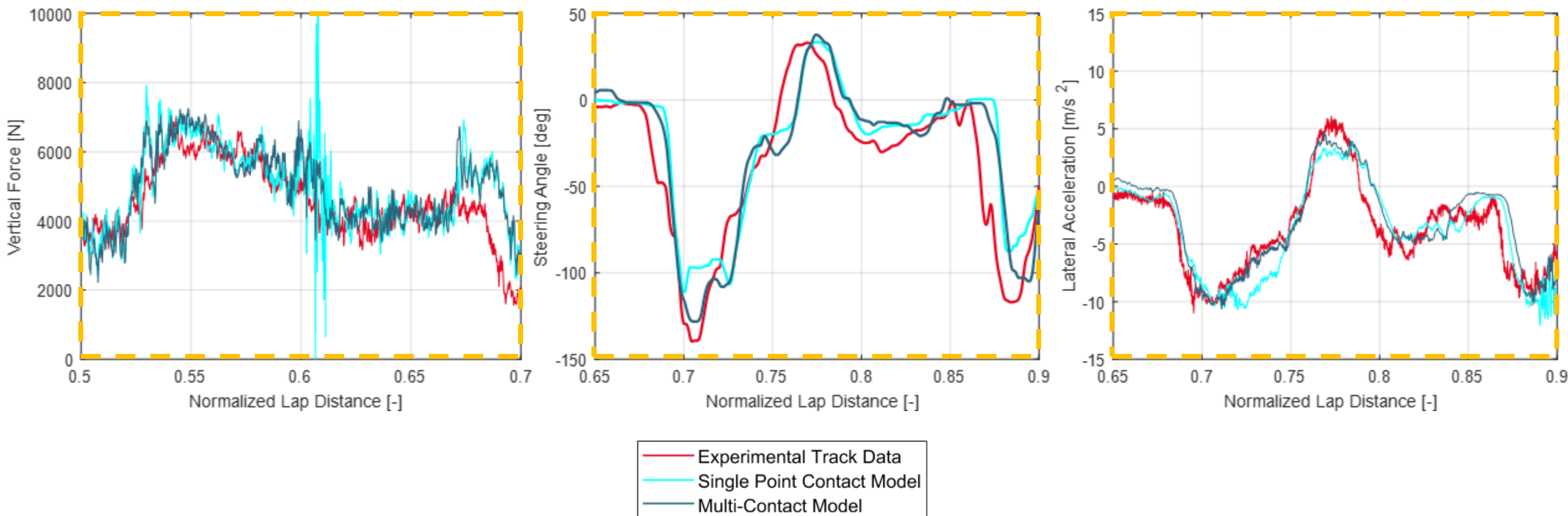
SIMULATOR SESSION

Haptic feeling improvement – nominal load configuration



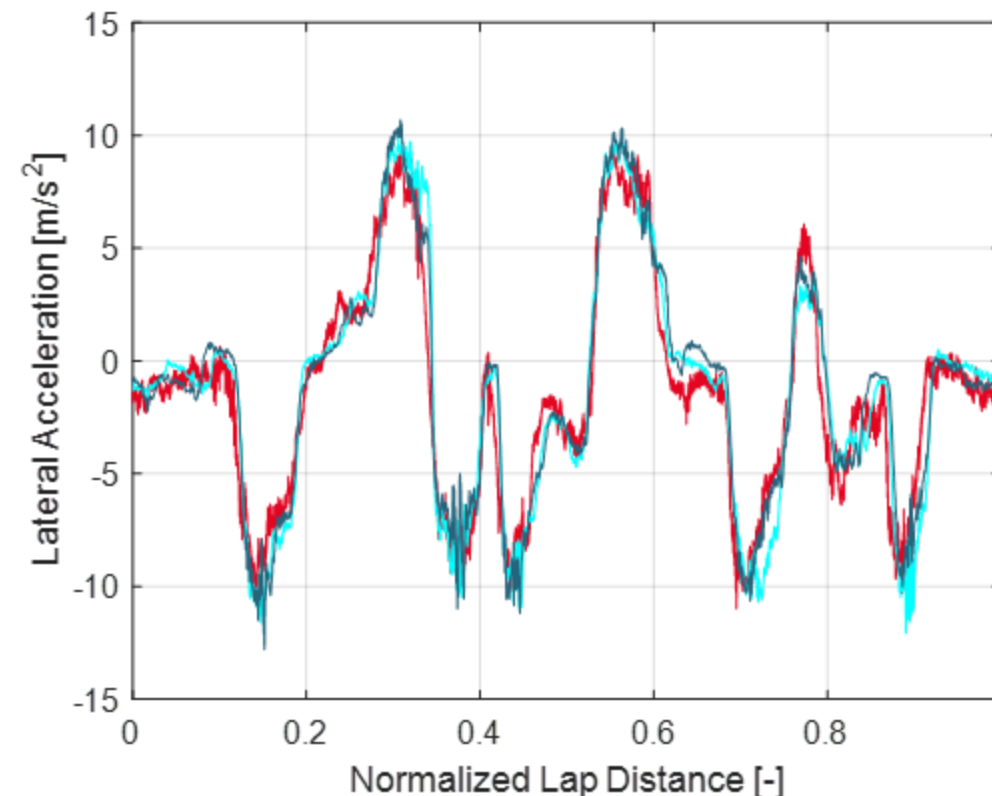
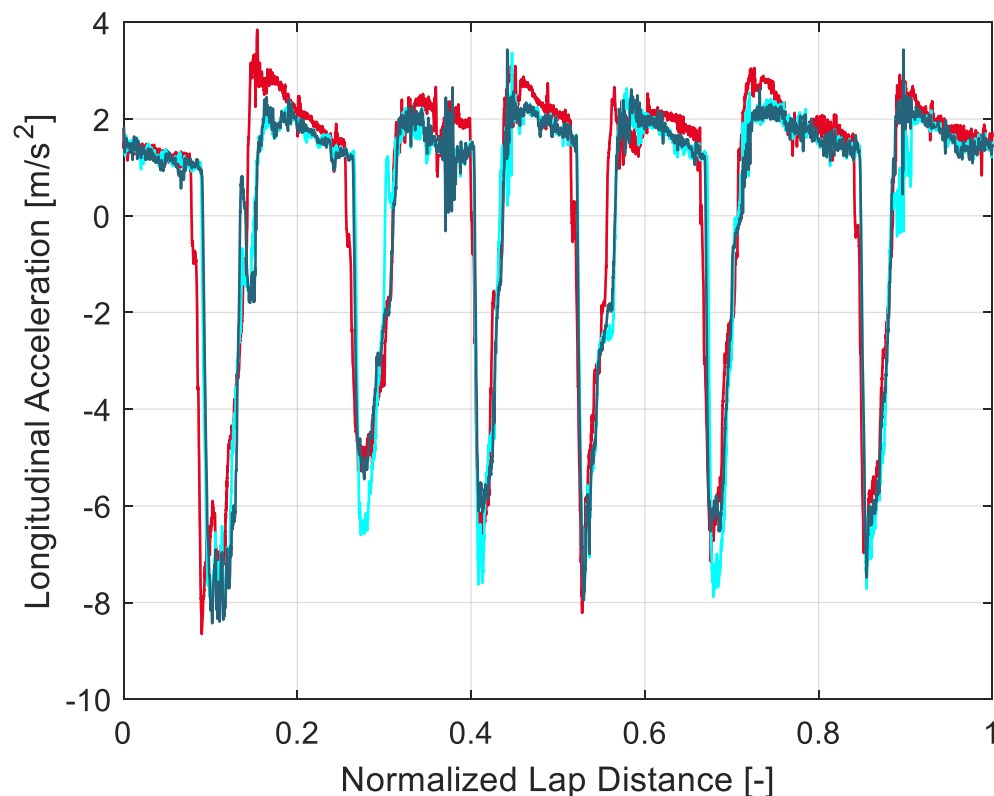
SIMULATOR SESSION

Haptic feeling improvement – nominal load configuration

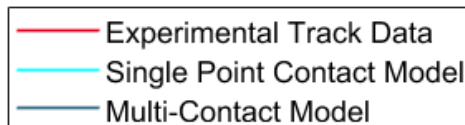


SIMULATOR SESSION

Haptic feeling improvement – ballast configuration

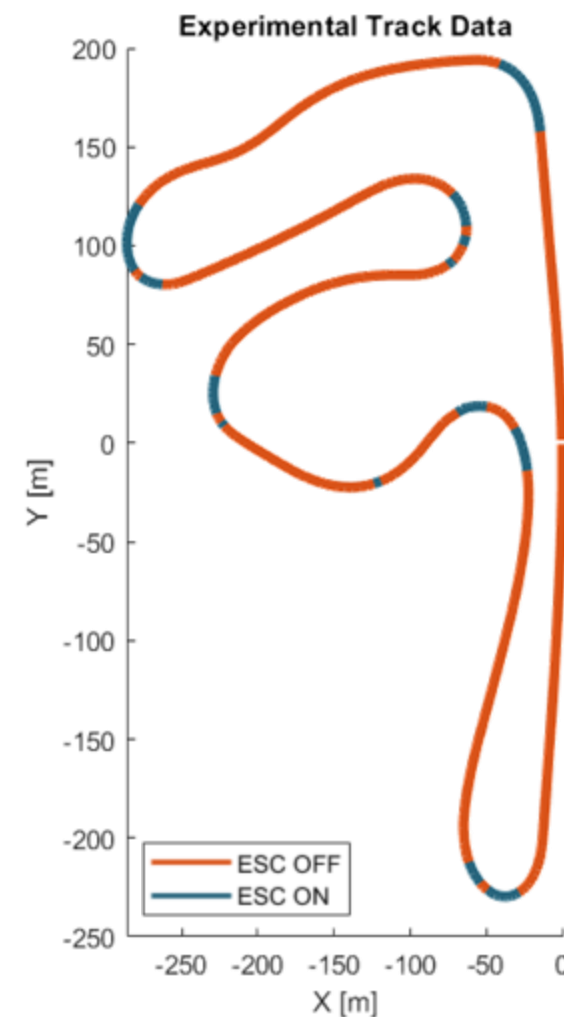
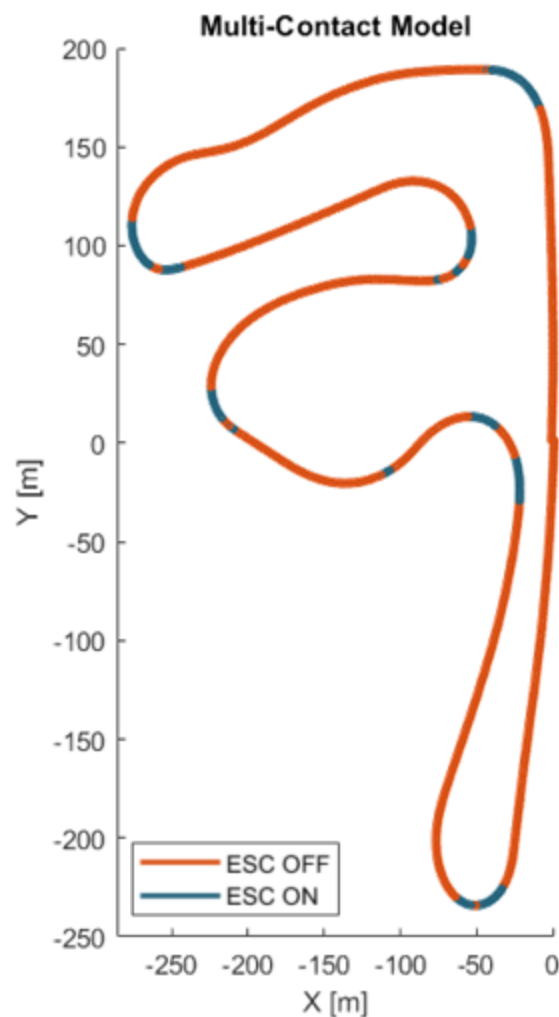
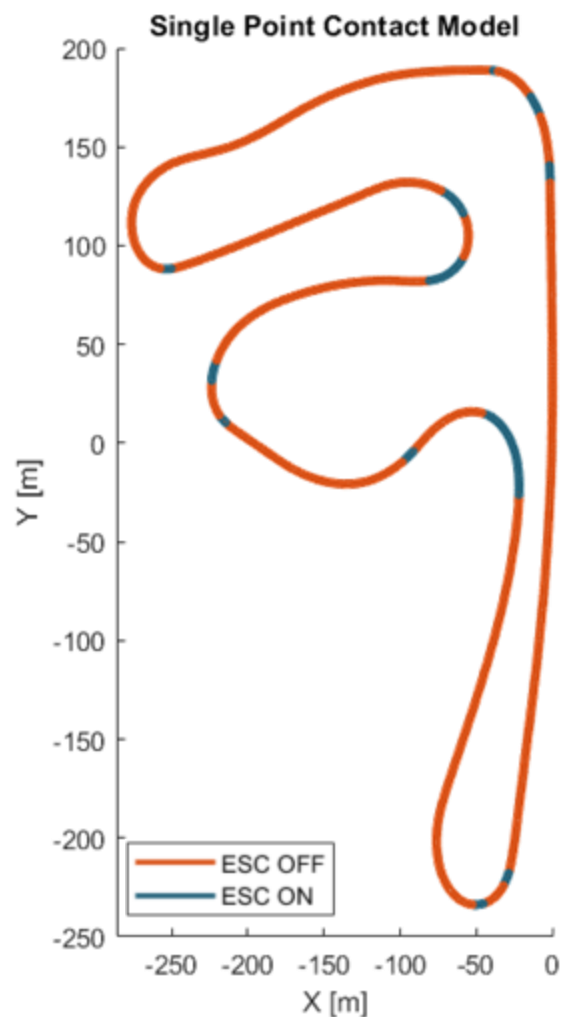


Signal	RMSE Variation
Yaw Rate	9.7%
Lateral Acceleration	12.3%
Longitudinal Acceleration	5.3%



SIMULATOR SESSION

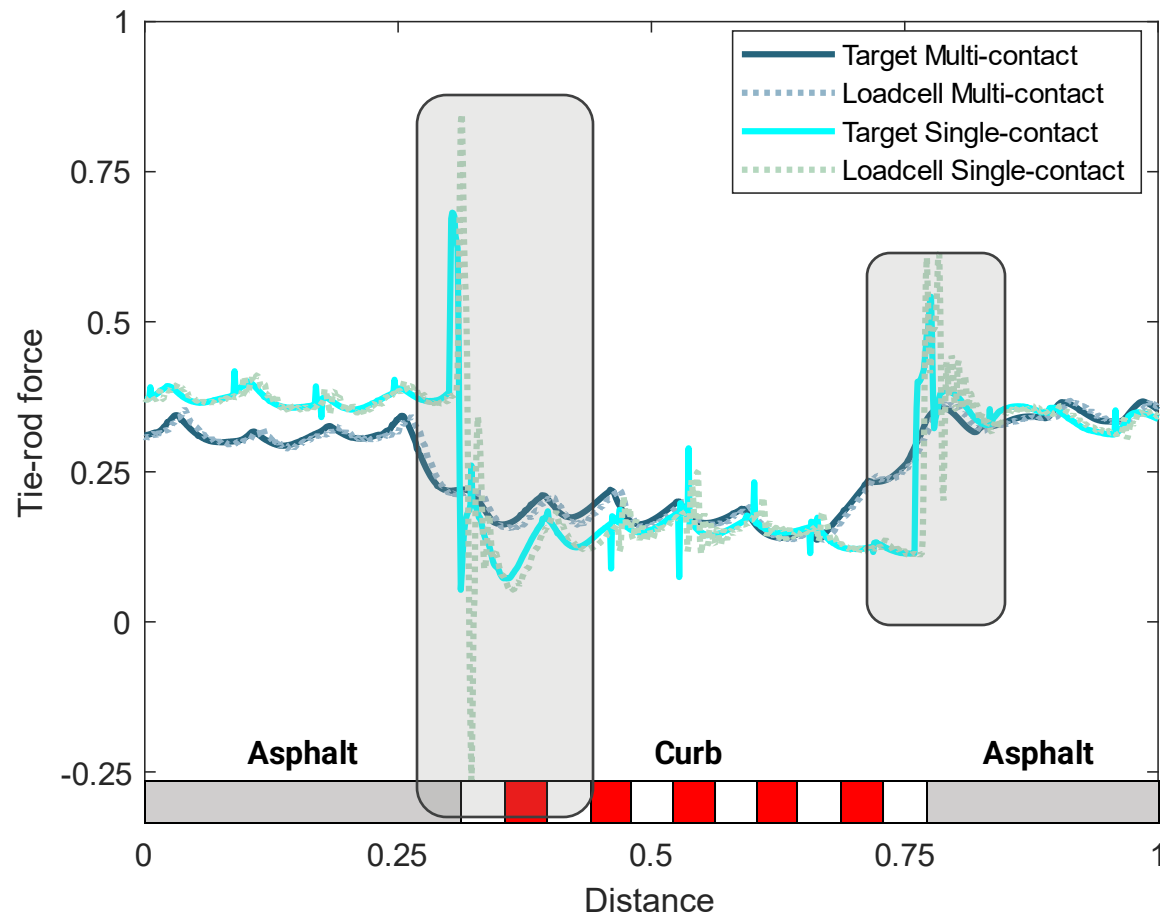
Haptic feeling improvement – ESC activation



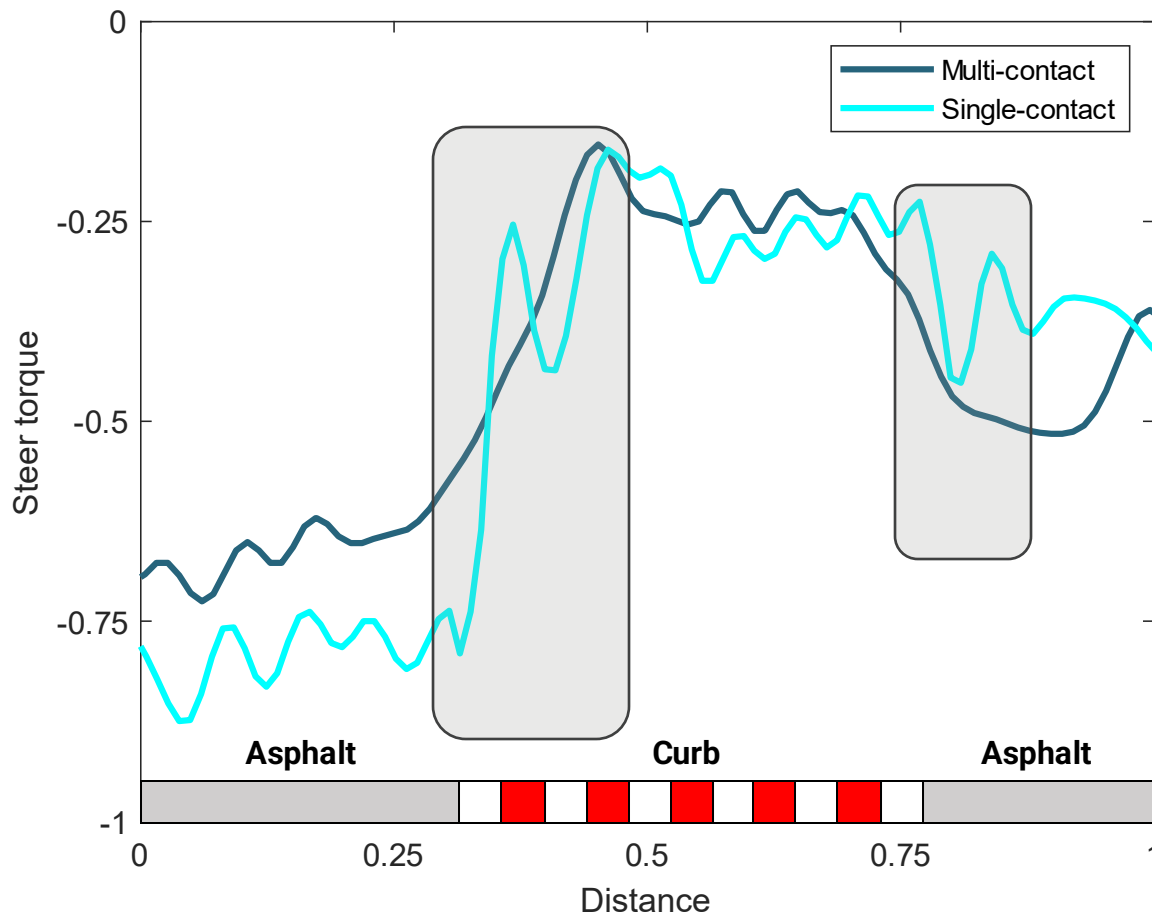
SIMULATOR SESSION

Haptic feeling improvement – asphalt macro-asperities

SINGLE POINT CONTACT



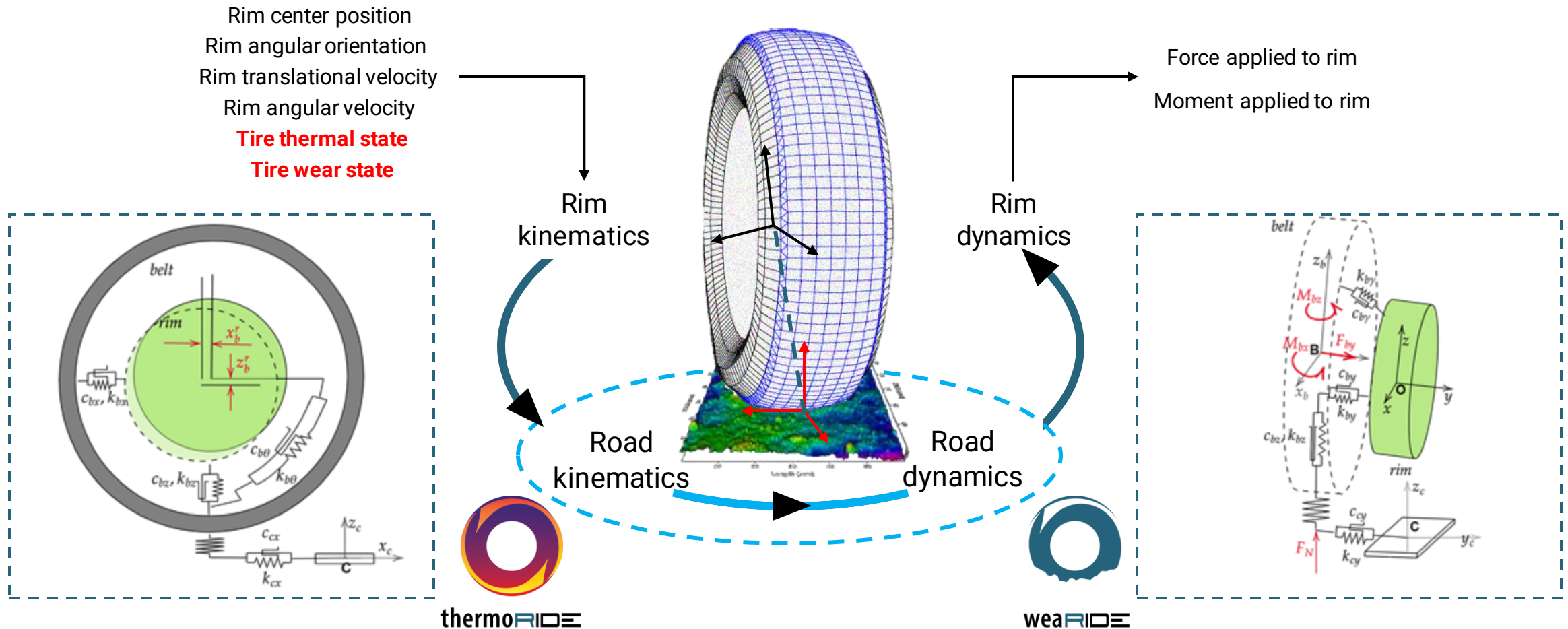
MULTI-CONTACT MODEL



FURTHER DEVELOPMENTS

Swift-Evo model

New SWIFT-Evo tire model born to extend the range of frequency domain up to 100Hz.



MegaRide SRL
Via Claudio 21 80125 Napoli (NA)
info@megaride.eu
<https://www.megaride.eu>



Meccanica 42 SRL
Via Ezio Tarantelli 15 50019 Sesto Fiorentino (FI)
info@meccanica42.com
<https://www.meccanica42.com>

