2026 SMART PROTOTYPES SUMMIT

Customer-oriented virtual tire wear assessment using multi-physical simulations

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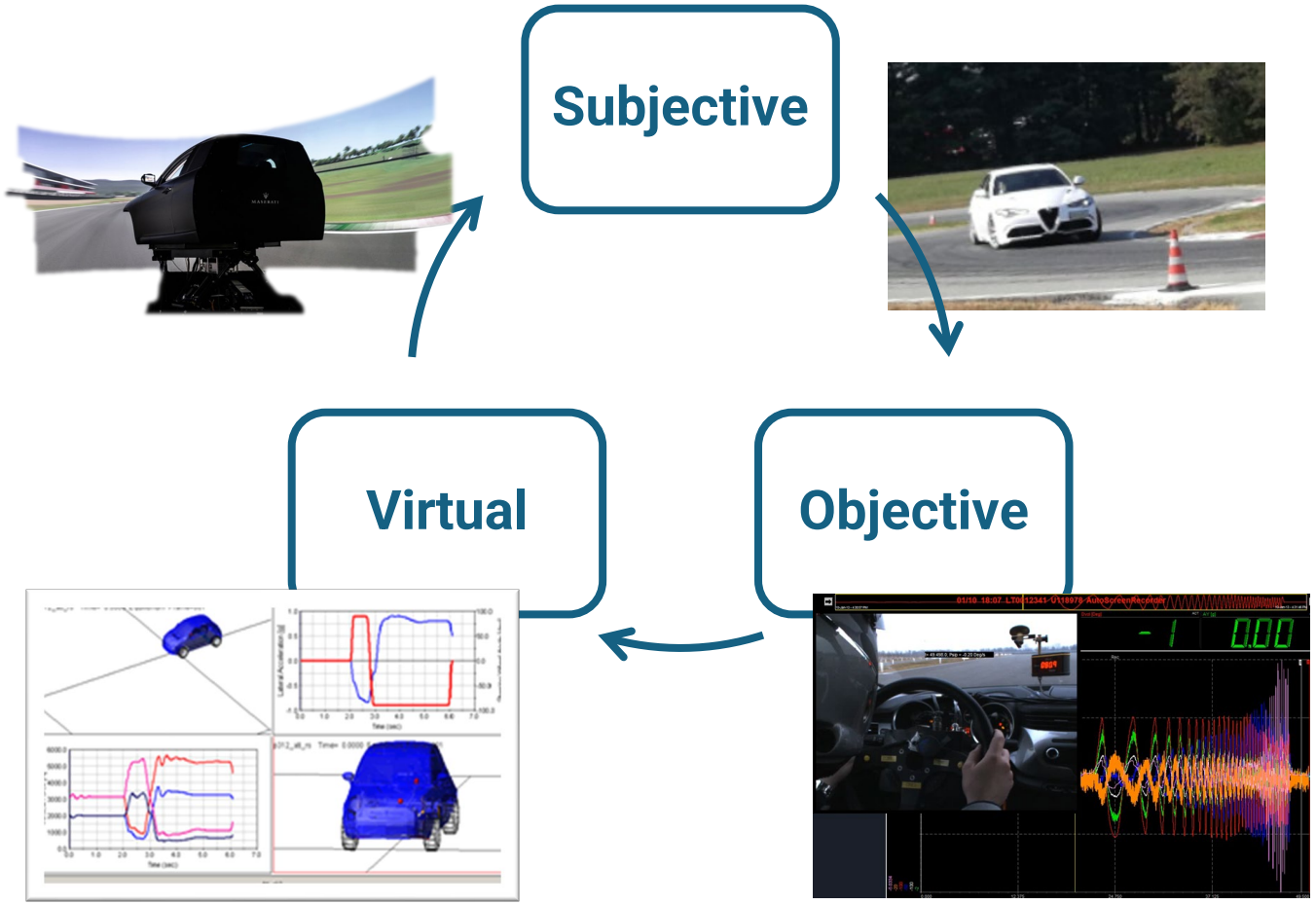
- **MegaRide**: Andrea Sammartino, Giovanni Narducci, Guido Napolitano, Chiara Milone, Antonio Caiazza, Francesco Creazzo.

STELLANTIS | MEGARIDE

STELLANTIS ROAD MAP PHYSICAL TO VIRTUAL: TIRE WEARING



Physical tests:

- Long duration
- High costs
- Late in the program development

Scope of this activity is to explore the possibility to make an **early prediction of tire wearing** with a **smart procedure** able to predict the tire behaviour with a **reasonable precision**

COMPANY OVERVIEW

MEGARIDE®
APPLIED VEHICLE RESEARCH
an official UniNa spinoff company

UniNa Vehicle Dynamics research group

4 Companies

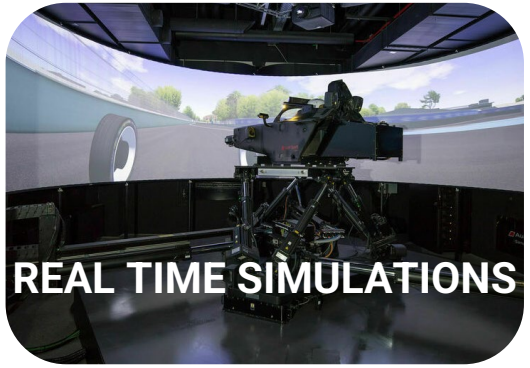
+55 People Involved

18 Funded PhDs

13 Racing Series

+35 Racing Teams

+10 OEMs & Tire-makers



A MODULAR REAL-TIME TIRE SIMULATION PLATFORM

thermoRIDE

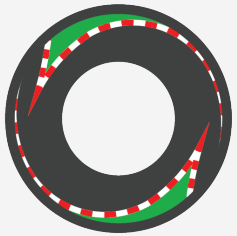
THERMAL MODULE

Real-time model to simulate tire temperature for vehicle and components development.

weaRIDE

WEAR MODULE

Real-time model to simulate tire wear for vehicle and components development.



threedeeRIDE

MULTI CONTACT MODULE

Real-time model to simulate the contact between tire surface and road asperities.

adheRIDE

MF-EVO & SWIFT-EVO MODULE

Real-time model to simulate tire-road interaction forces, sensitive to temperature, wear, viscoelasticity.

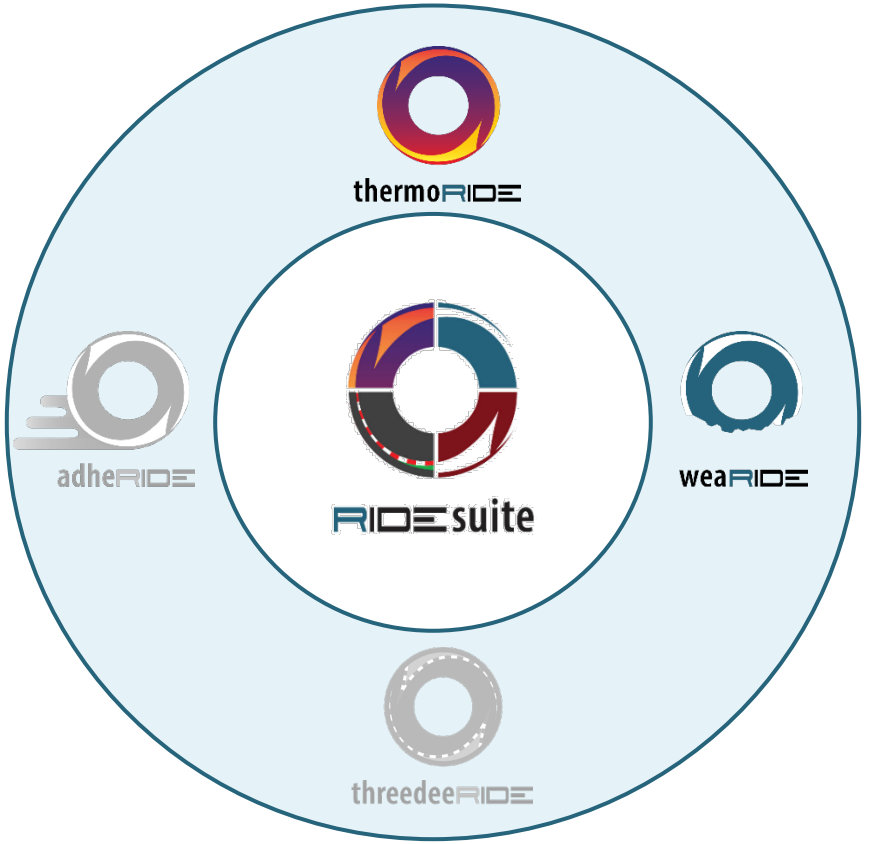
A MODULAR REAL-TIME TIRE SIMULATION PLATFORM

KEY FEATURES

	RIDEsuite
Same equations for all sim environments, without the need of any scaling to maintain real-time compliance	✓
Fast and easily replicable parameterization through non-destructive methodologies	✓
First and only model to estimate tire wear, taking into account road roughness and tire tread compound	✓
Thermal model sensitive to tire tread compound and brake disc heat generation	✓
Tire temperature influence on vibrational behavior for advanced ride & comfort analyses	✓

RIDESUITE MODULES SELECTED FOR THE PROJECT

The **RIDEsuite** has been used with both **thermoRIDE** and **weaRIDE** model involved. In this way it is possible to take into account not only the abrasive wear, but also the impact of the thermal degradation of the tire.



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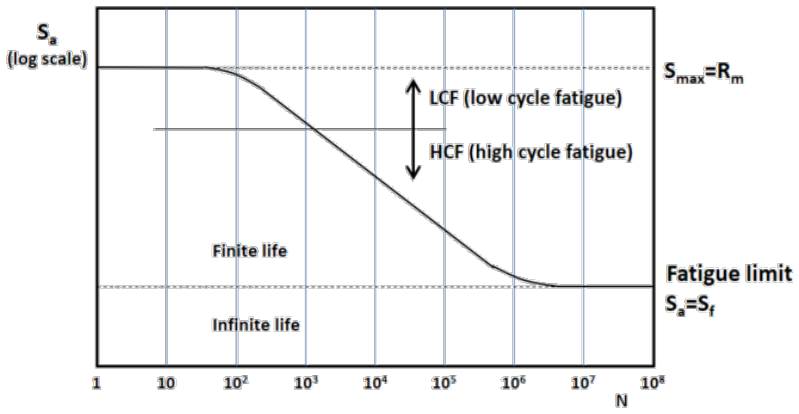
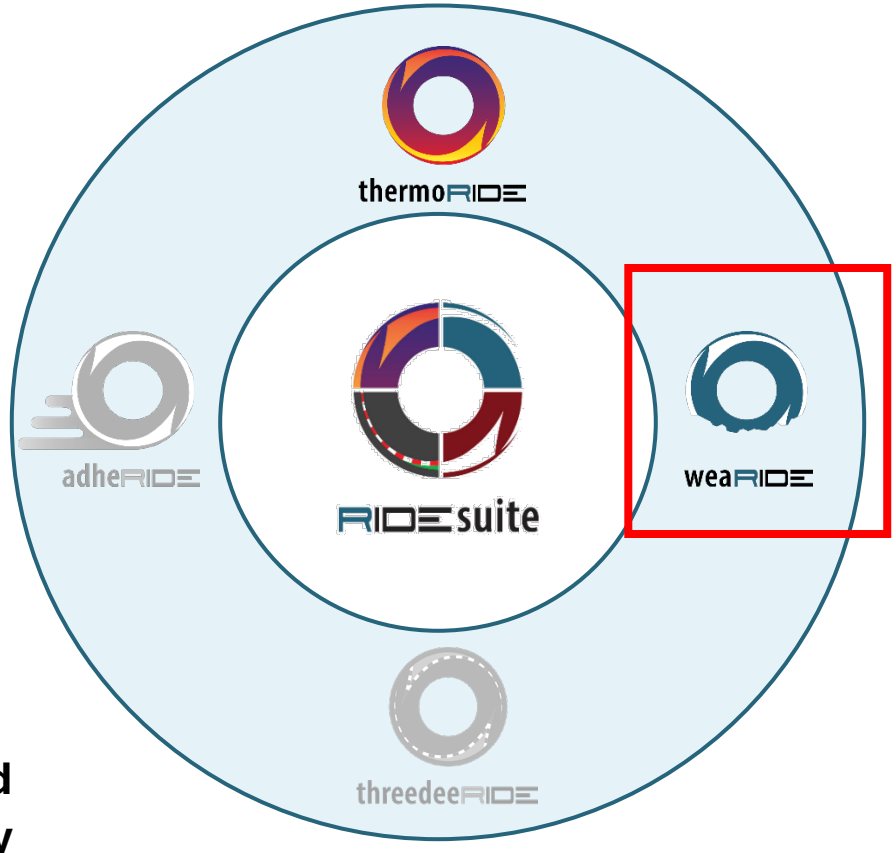
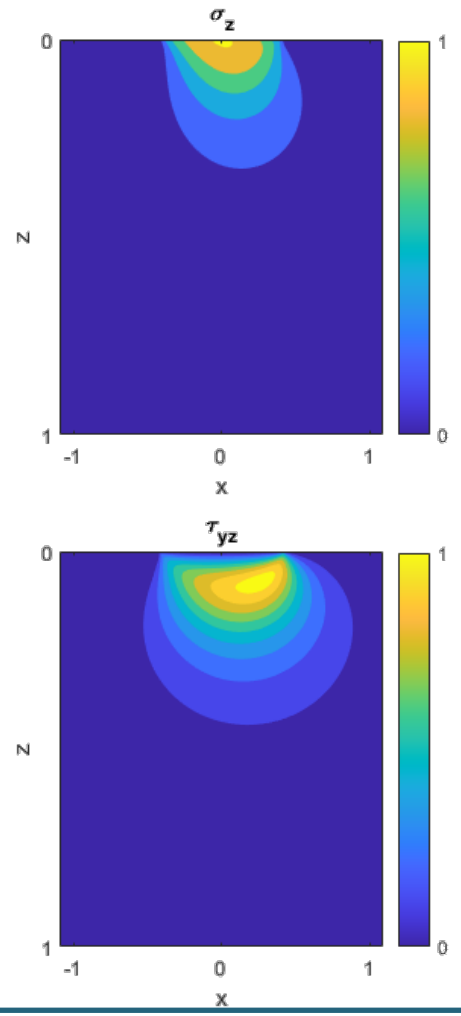


Physical approach based on stress/strain distribution applied within innovative damage theory

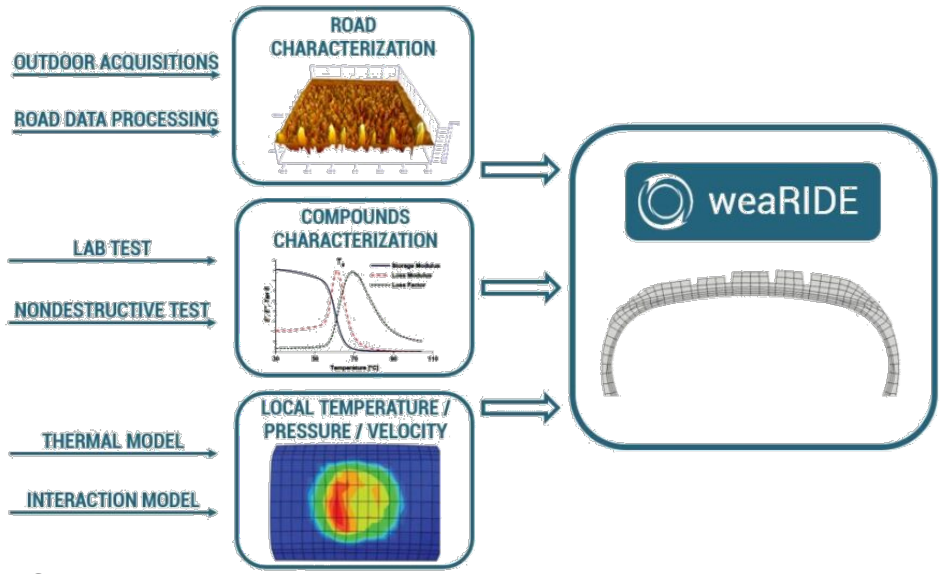




IN DETAIL : weaRIDE MODEL

VD Award 2024

weaRIDE

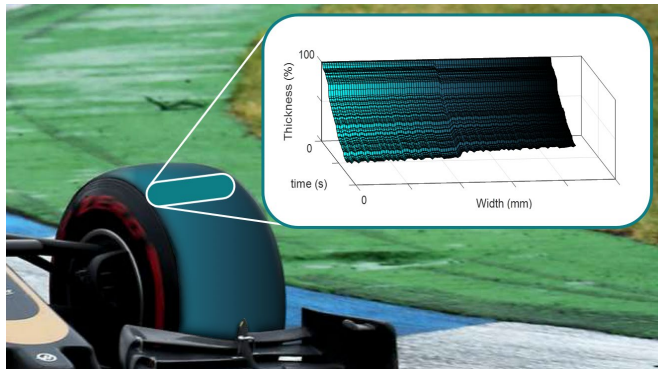


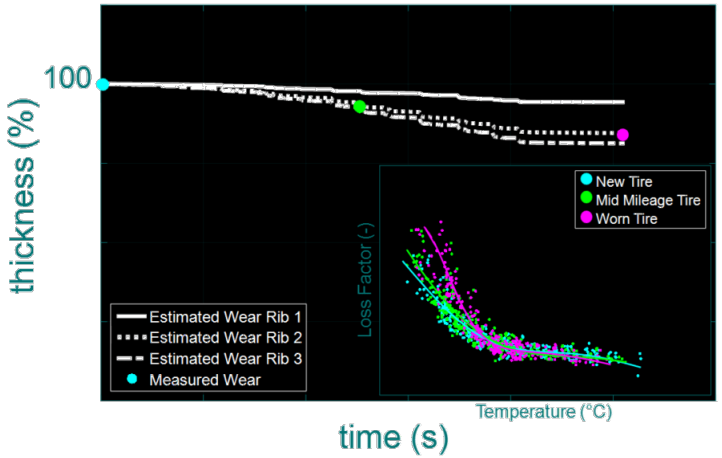
KEY FEATURES

- Parameterization from non-destructive viscoelastic characterization
- Road roughness innovative processing and evaluation
- Effect of tire thermal state and of footprints shape on wear
- Widely real-time for both desktop and DiL applications

TARGET

- Predict tire tread wear as both thickness reduction and mechanical degradation
- Predict impact of tread material and road roughness
- Co-simulation with vehicle models to minimize particulate and evaluate EURO7 compliance





ROADMAP - CHARACTERIZATION AND MODEL IDENTIFICATION PROCESS

VI-CRT TEST CASES ANALYSIS

NON-DESTRUCTIVE CHARACTERIZATION PROCESS

WEAR EVALUATION

RIDEsuite

ROADMAP - CHARACTERIZATION AND MODEL IDENTIFICATION PROCESS

VI-CRT TEST CASES ANALYSIS

VISCOELASTIC CHARACTERIZATION

STRUCTURAL CHARACTERIZATION

RIDEtool

thermoRIDE

weaRIDE

threedeeRIDE

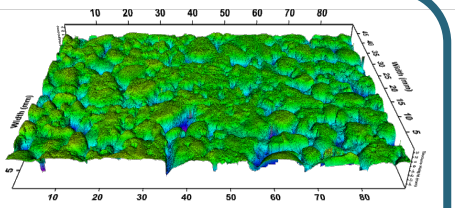
adheRIDE

NON-DESTRUCTIVE CHARACTERIZATION PROCESS

WEAR EVALUATION

RIDEsuite

ROAD ROUGHNESS ANALYSIS



VALIDATED VEHICLE MODEL

TIRE WEARING ROAD TEST

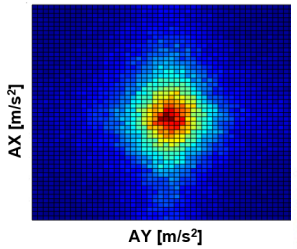
DEFINITION OF TEST CASES

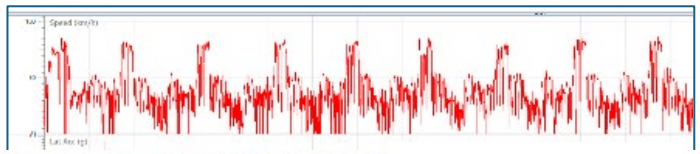
VI-CRT TEST CASES ANALYSIS

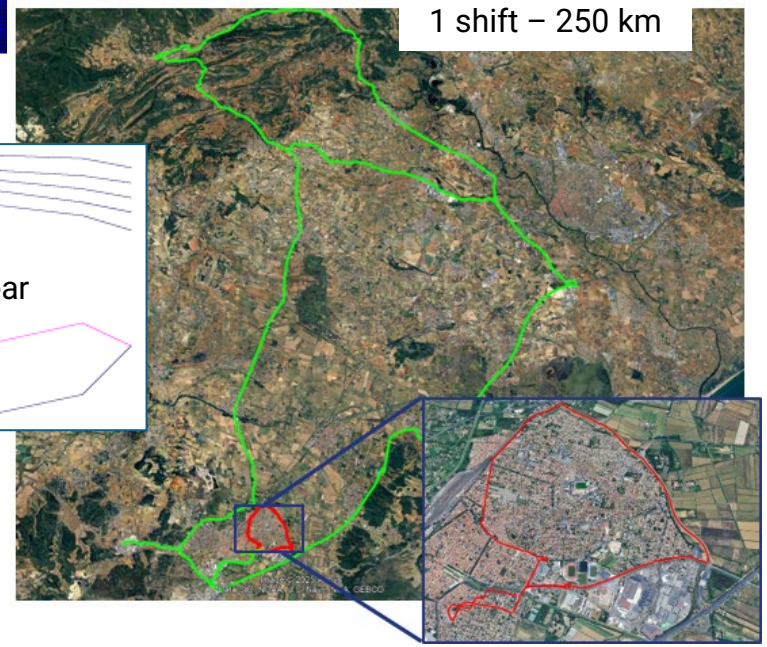
NON-DESTRUCTIVE CHARACTERIZATION PROCESS

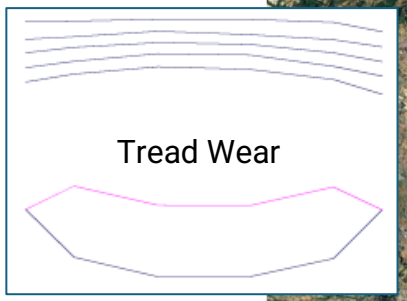
WEAR EVALUATION

AVAILABLE TIRE WEARING OUTDOOR ROAD TEST

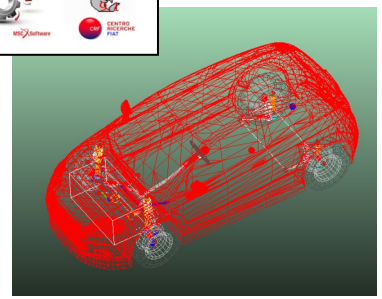


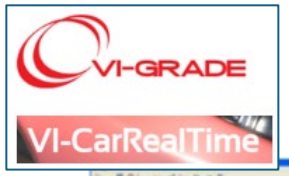


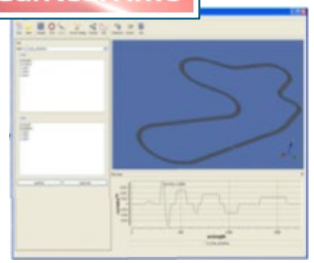




VALIDATED VEHICLE MODELS



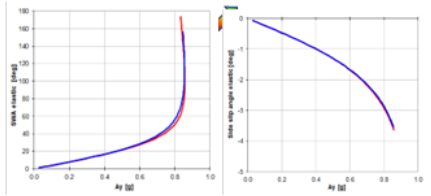




EXPERIMENTAL
VIRTUAL

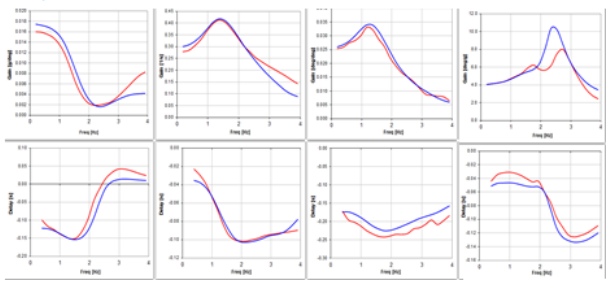
Steady State

Understeer | Sideslip Angle



Dynamic response

Ay/SWA | YawRate/SWA | SSA/SWA | ROLL/Ay



3 TEST CASES HAVE BEEN SELECTED

VEHICLE MISSION SIMULATIONS

VI-GRADE
VI-CarRealTime

VI-CRT TEST CASES ANALYSIS

⇩

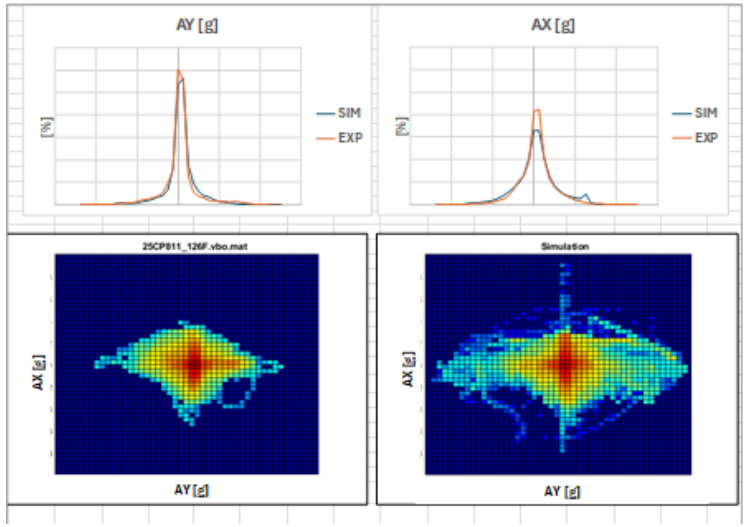
NON-DESTRUCTIVE CHARACTERIZATION PROCESS

⇩

WEAR EVALUATION

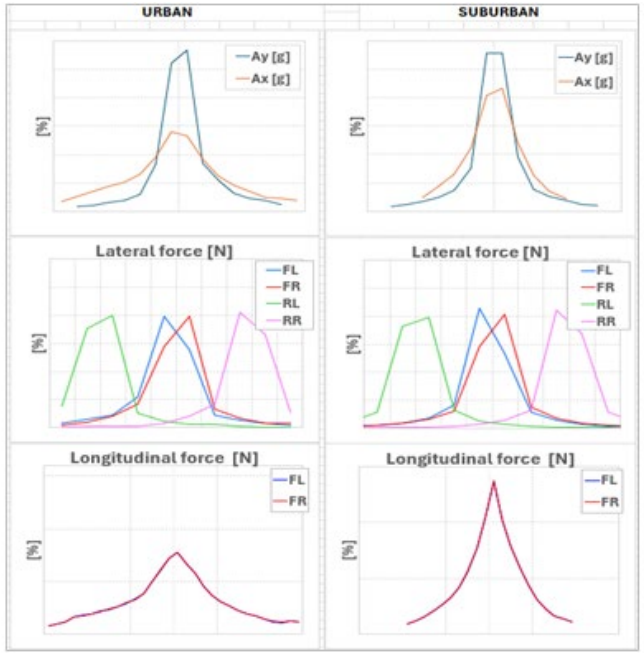
RIDEsuite

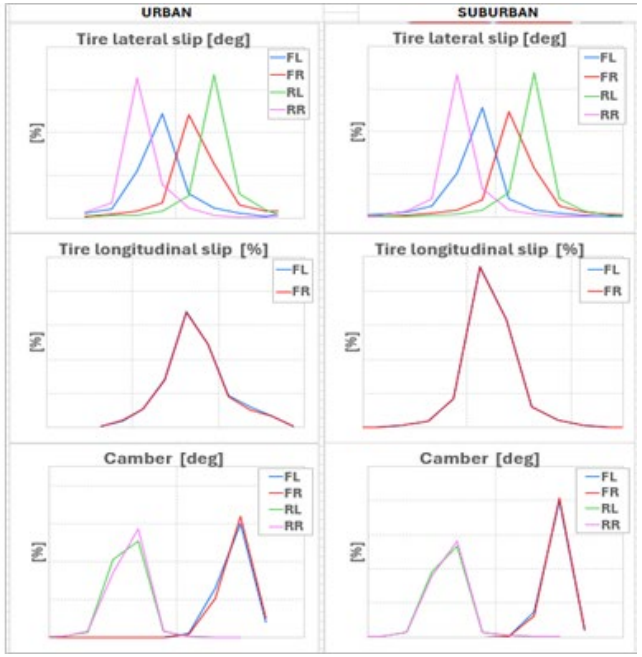
GLOBAL VEHICLE DYNAMICS SIMULATION VS. EXP CHECK



The residual differences are due to the acquired GPS signal, that causes some peaks in the simulated AY/AX. A further correction is done in the following phase of the project

VERTICAL LOAD, CAMBER, LONGITUDINAL / LATERAL SLIP ESTIMATION ON EACH WHEEL





3 SETS OF MISSION SIMULATION DATA AVAILABLE FOR THE TIRE WEARING HYBRID ESTIMATION

TIRE TREAD VESEVO ANALYSIS

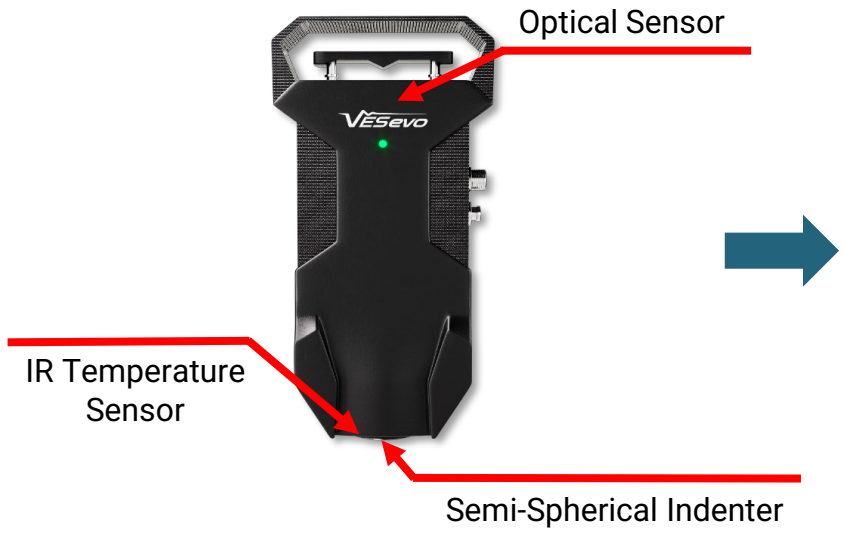
VI-CRT TEST CASES ANALYSIS

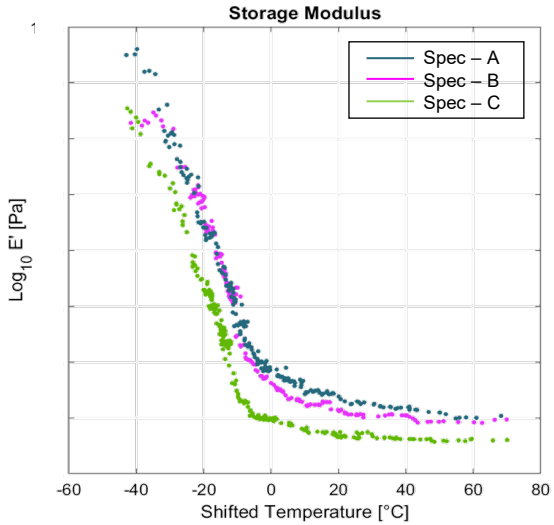
NON-DESTRUCTIVE CHARACTERIZATION PROCESS

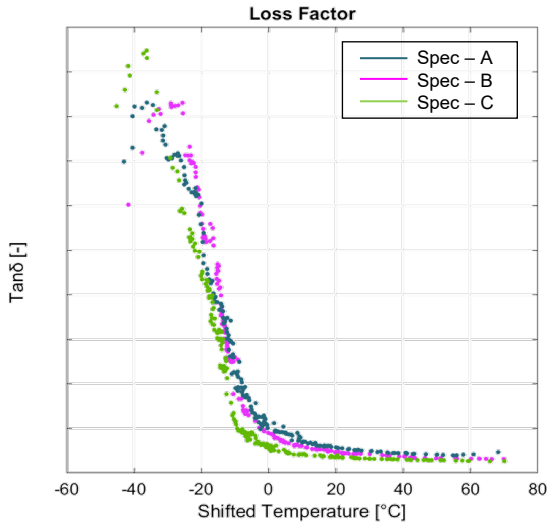
WEAR EVALUATION

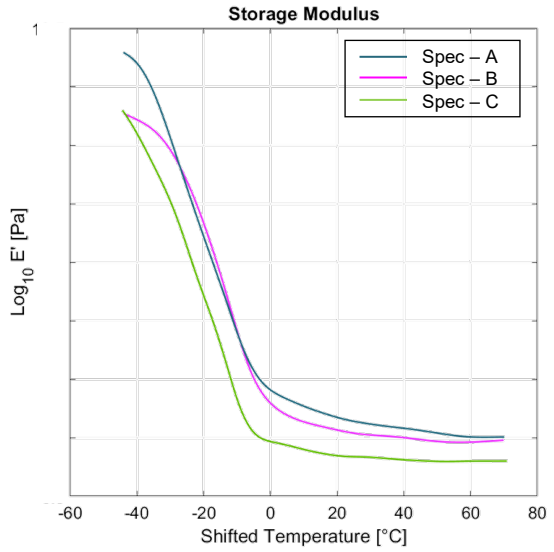
RIDEsuite

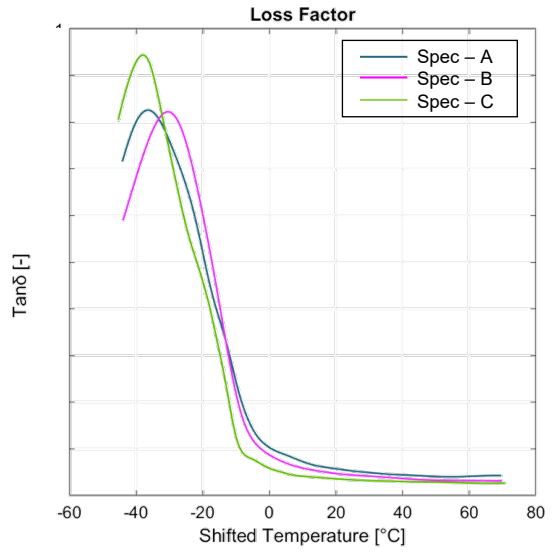
- Non-destructive viscoelastic tread testing device
- Portable, easy to use, less of 1.5 seconds for each acquisition
- Objective data for physical grip and wear models
- Test executed on the three different spec of this PoC











TIRE STRUCTURAL CHARACTERIZATION

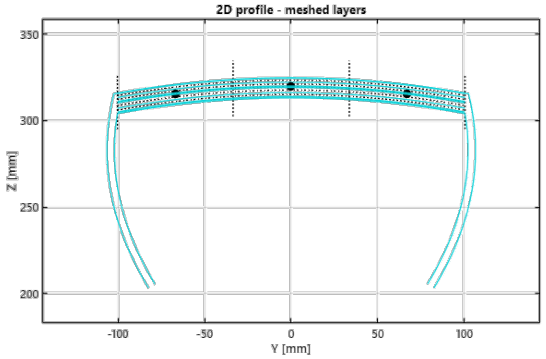
VI-CRT TEST CASES ANALYSIS

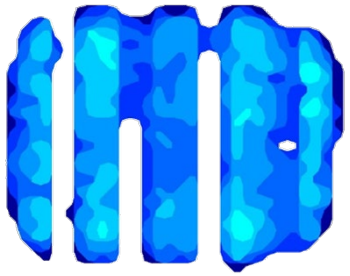
NON-DESTRUCTIVE CHARACTERIZATION PROCESS

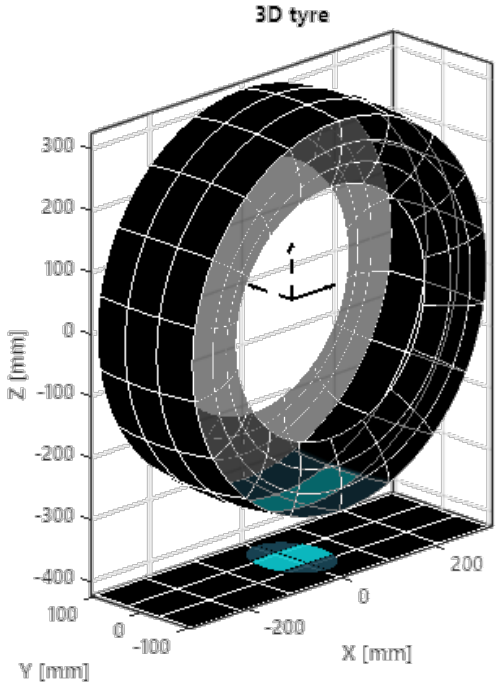
WEAR EVALUATION

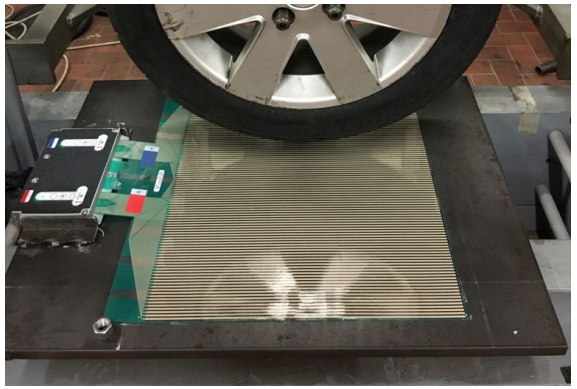
RIDEsuite

Tire structural parameterization consists in processing information related to tire geometric, inertial and contact patch properties in order to faithfully reproduce its behavior. **RIDEtool** has been used to parameterize the tire in a user-friendly environment.









VI-CRT TEST CASES ANALYSIS

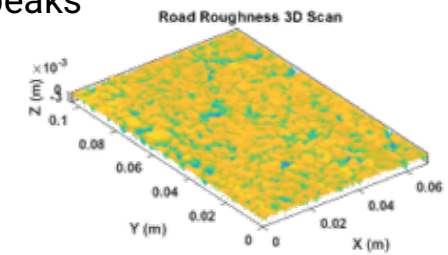
NON-DESTRUCTIVE CHARACTERIZATION PROCESS

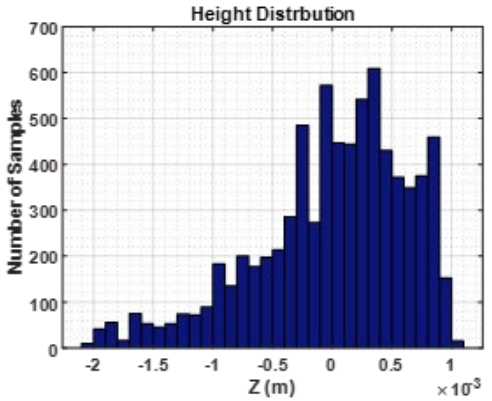
WEAR EVALUATION

ROAD ROUGHNESS PROPERTIES CHARACTERIZATION

Surface roughness is reconstructed from 2D/3D laser measurements (for this project, they were taken from georeferenced companies' database). The analysis of the surface profiles allows to extract standard and proprietary parameters such as:

- Ra (macro / micro): representing the average roughness amplitude
- λ (macro / micro): the characteristic wavelength between peaks





WAVELENGTH

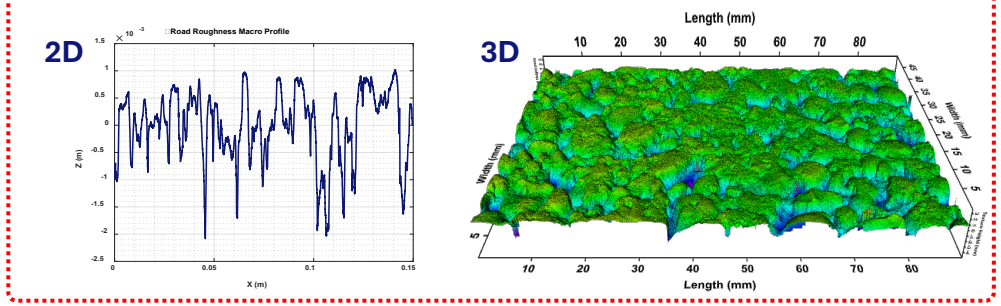
$$\lambda = \frac{2\pi \int_0^L Z(x)dx}{\int_0^L Z'(x)dx}$$

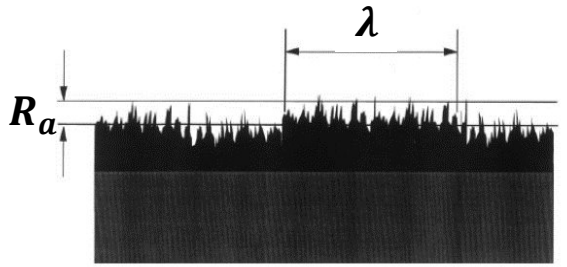
CENTER LINE AVERAGE

$$R_a = \frac{1}{L}\int_0^L |Z - m|dx$$

2D

3D





* Given the need for practicality and streamlining in the project, the part relating to road characterization was subject to simplifying assumptions.

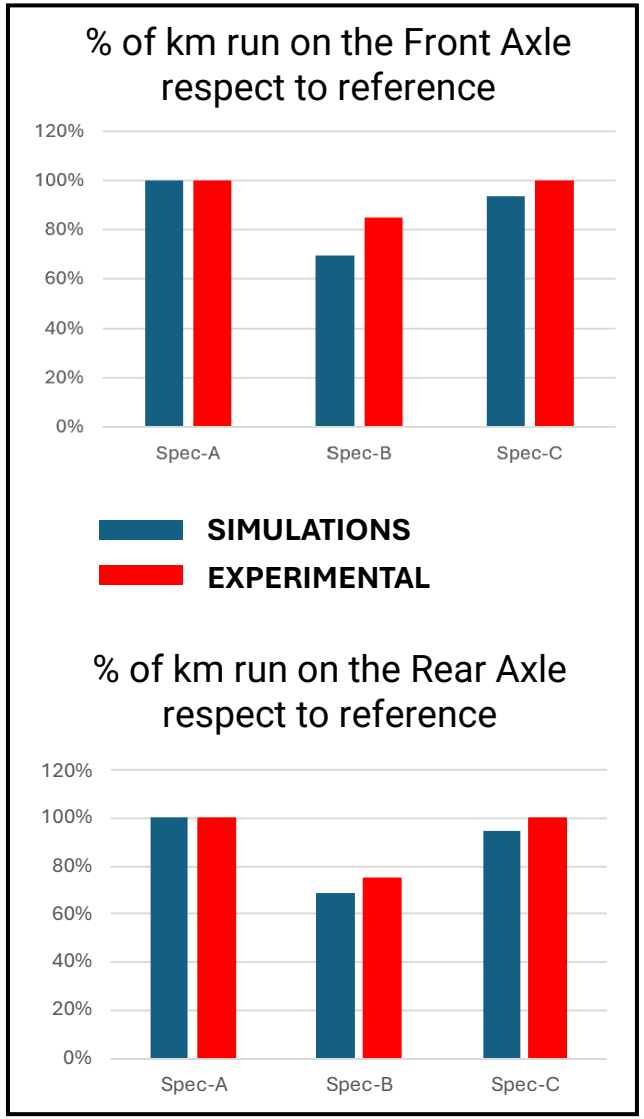
RESULTS OF WEAR MODEL SIMULATIONS – OVERALL MILEAGE

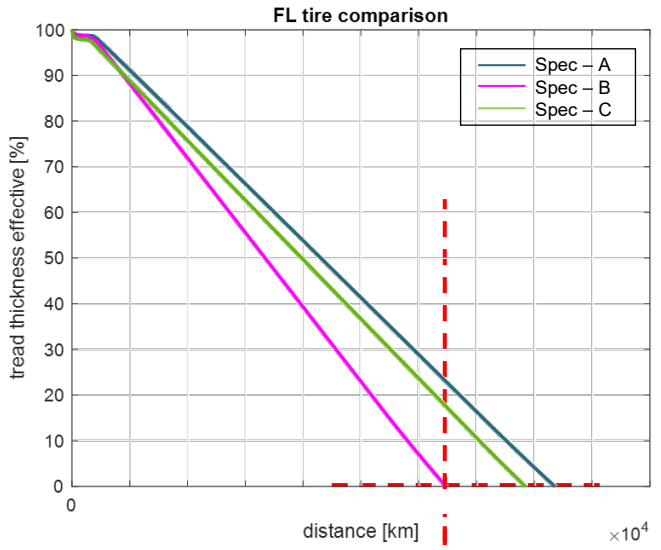
VI-CRT TEST CASES ANALYSIS

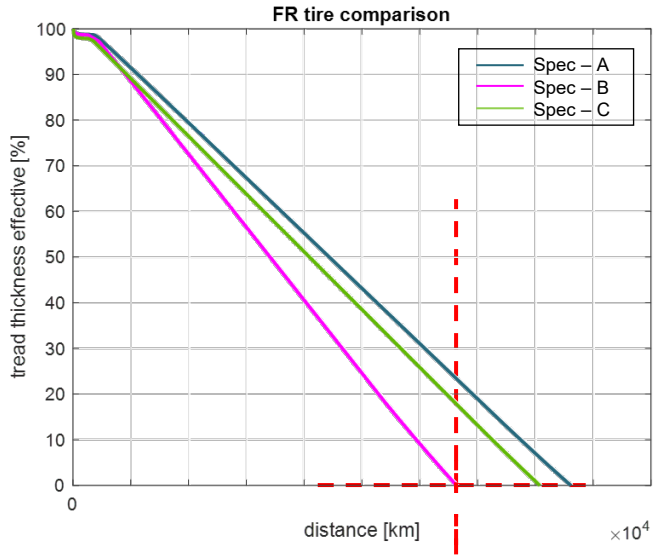
NON-DESTRUCTIVE CHARACTERIZATION PROCESS

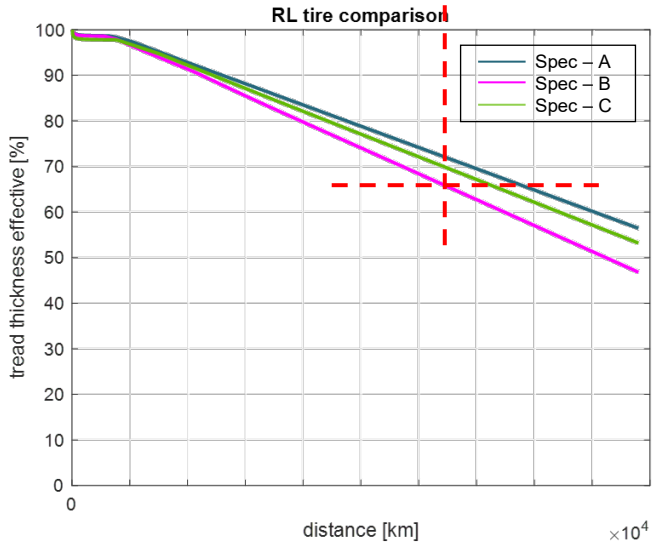
WEAR EVALUATION

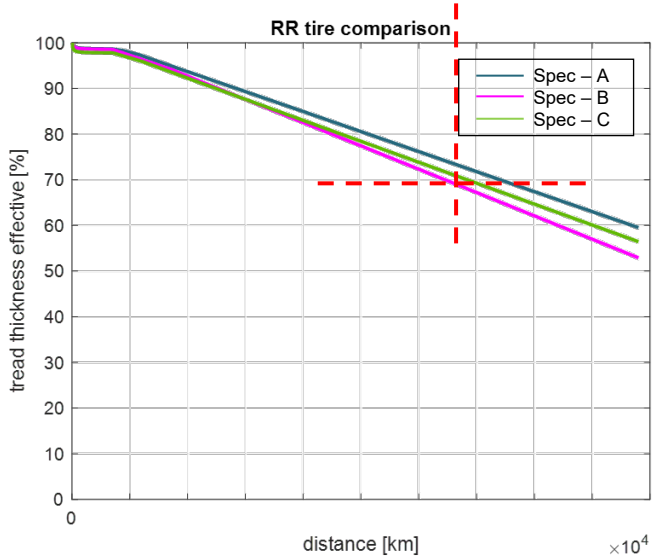
RIDEsuite











RESULTS OF WEAR MODEL SIMULATIONS – WORN PROFILE

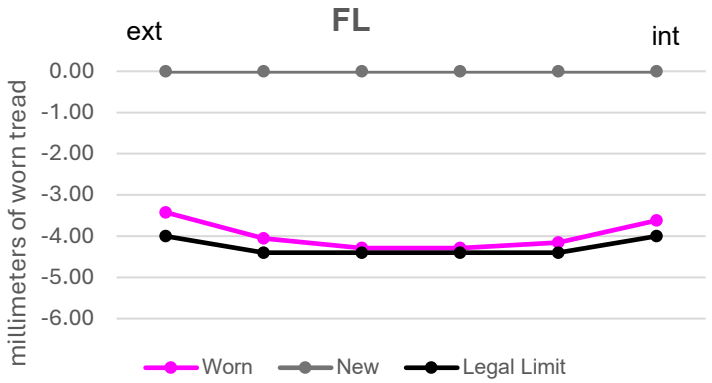
VI-CRT TEST CASES ANALYSIS

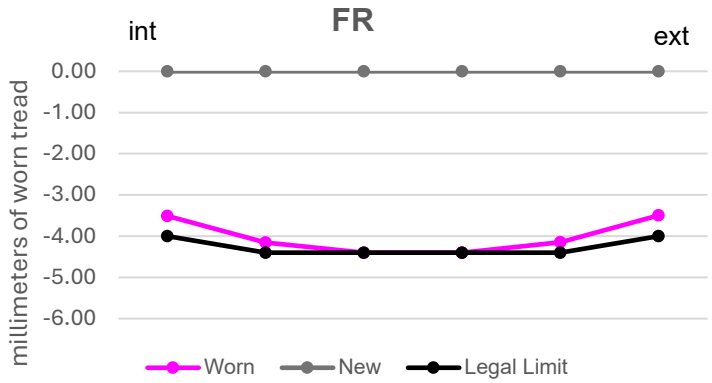
NON-DESTRUCTIVE CHARACTERIZATION PROCESS

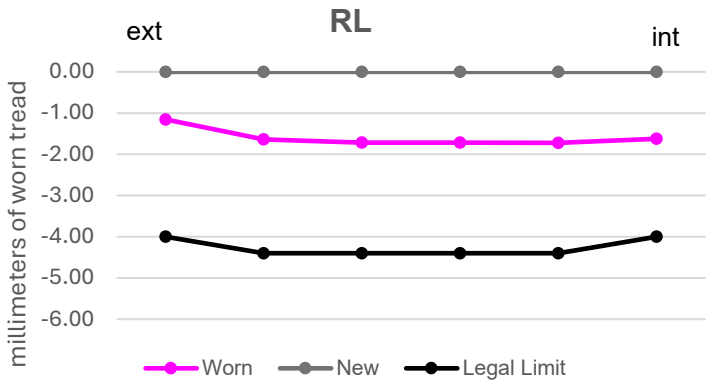
WEAR EVALUATION

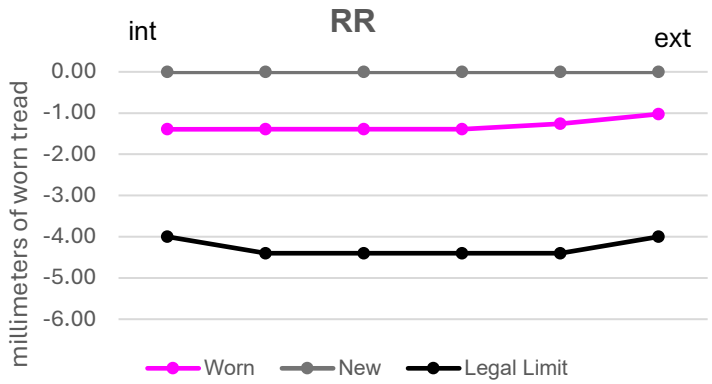
RIDEsuite

Transversal tire wear of a single spec (Spec-B), expressed in millimeters of worn tread, simulated by MegaRide









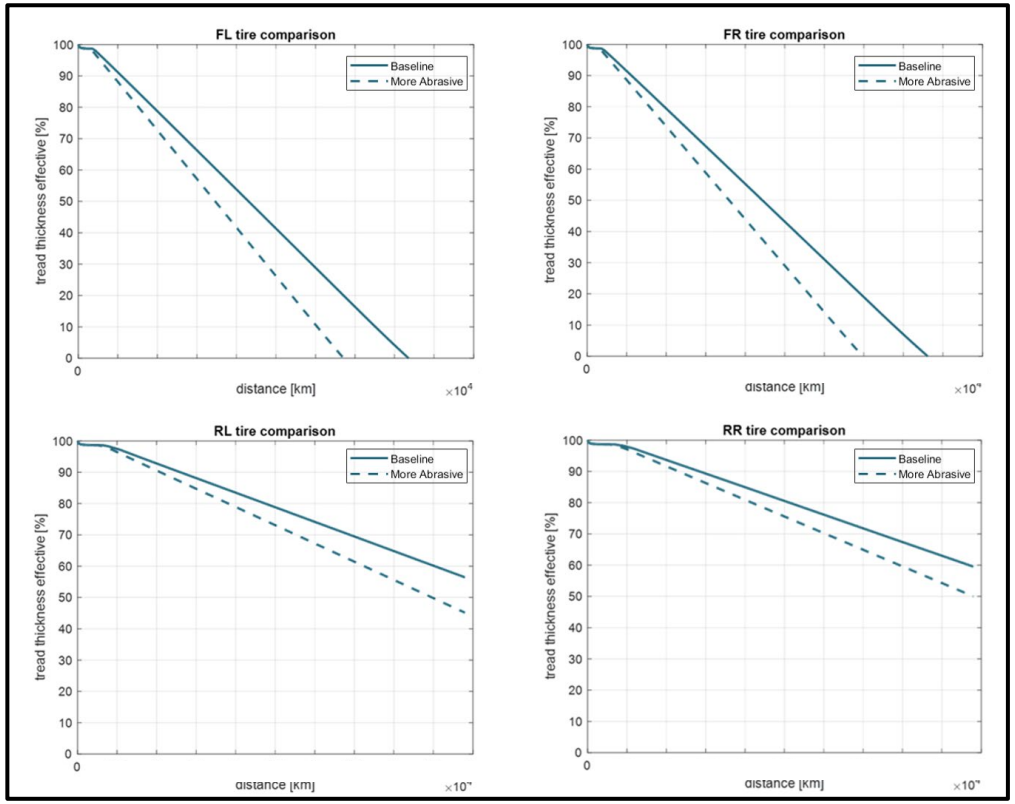
SUMMARY

- A methodology aimed at **virtual predictive assessment of tires wear**, employing Stellantis vehicle modelling procedures, MegaRide tire physical models and Car Real Time simulation environment, has been developed, based on tire models' parameterization by **non-destructive and fast testing**

- The results of an activity involving 3 test cases, running an **urban + highway route**, reported a good capability to predict the relative expected wear among tire specs, with coherent physical sensitivities

- The project demonstrated the preliminary feasibility of applying **weaRIDE** model, originally developed for racing, within a **passenger tire** context

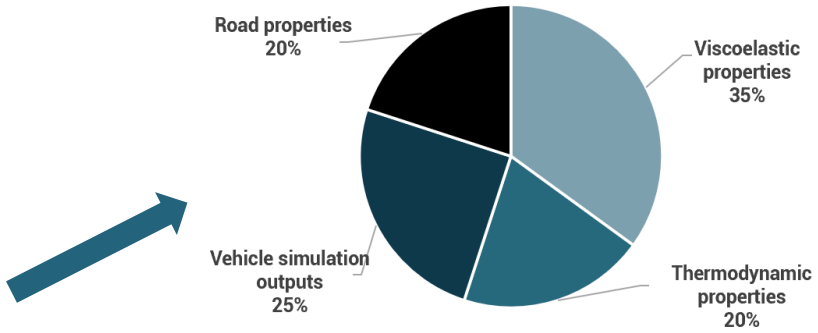
- Basic assumptions have to be considered and progressively removed, such as aspects related to actual **road roughness, tread viscoelasticity degradation and specific weather conditions**



NEXT STEPS

- The project demonstrated the preliminary feasibility of the proposed methodology. **Additional test cases** are in plan, with potential extension to **EURO7** estimations.

- In the presented project tire **thermodynamic** characterization and **road roughness** were parameterized from MegaRide database information. Next steps will involve direct measurements, for improvement in balancing physical effects



- Real-time capabilities of thermal, wear and interaction tire models will lead to further activities involving **DiL environments**, in which drivers feel the direct effects related to progressive tread wear, affecting **vehicle behavior and driving style**.

- Following activities will be part of a **PhD path** jointly coordinated by Stellantis, MegaRide and UniNa, globally aimed at adopting tire multiphysical models in simulation activities for various scopes.

2026
SMART PROTOTYPES
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THANKS FOR ATTENTION

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