2023
ZERO PROTOTYPES
SUMMIT

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MEGARIDE
VI-GRADE
DROMO

The 10 Lessons we Learned from Testing, Analysing and Modelling Vehicle-Road Interaction

FROM THEORY…

“An expert is a person who has made all the mistakes that can be made, in a very narrow field”

— **Niels Bohr**

…TO PRACTICE

“I've missed more than 9000 shots in my career. I've lost almost 300 games. I've failed over and over and over again in my life. And that is why I succeed”

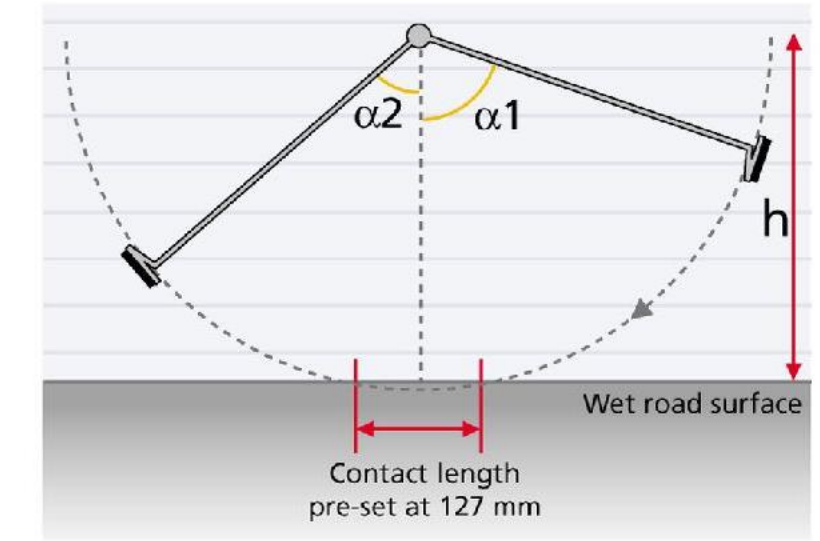
— Michael Jordan

ASK FIRST: "WHAT IS THE GRIP?"

LESSON 1. ASK FIRST: "WHAT IS THE GRIP?"

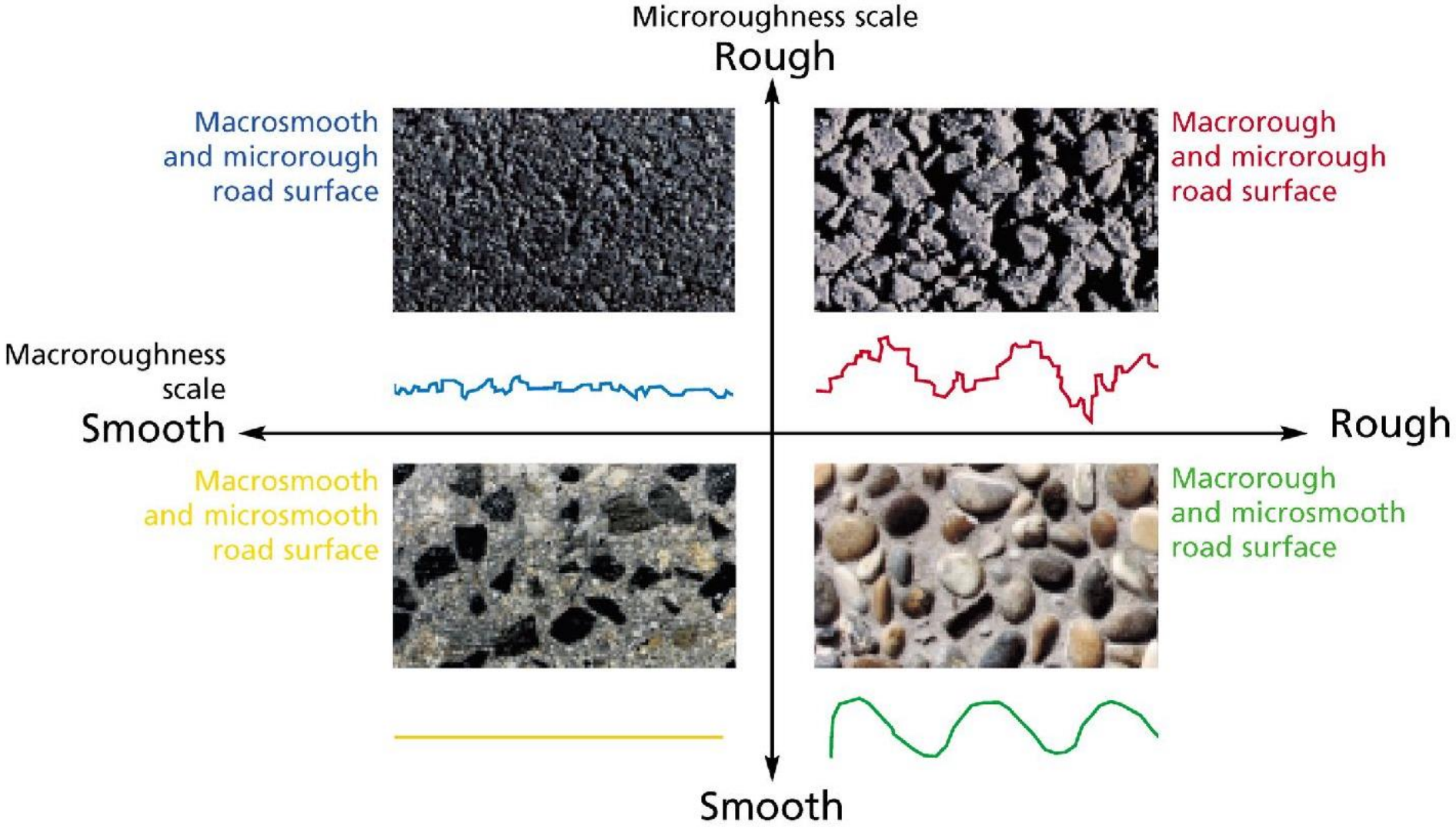
IS IT ABOUT THE ASPHALT YOU HAVE?

LESSON 1. ASK FIRST: "WHAT IS THE GRIP?"

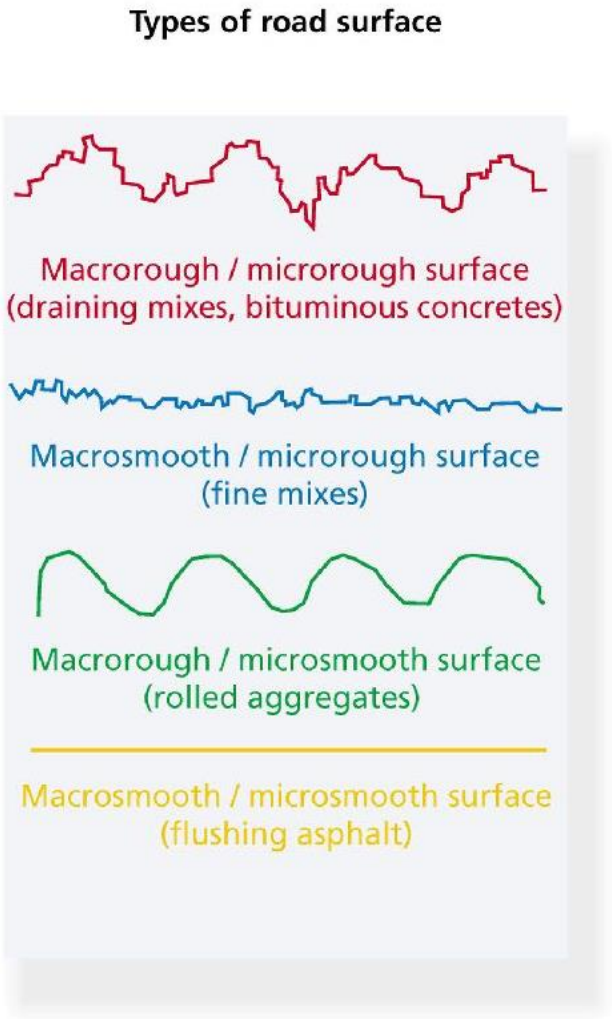


The SRT pendulum is used to determine the characteristic coefficient of friction for a given rubber on a wet surface. The friction of the block on the surface is representative of a slippage speed of 3 m/s.

LESSON 1. ASK FIRST: "WHAT IS THE GRIP?"



LESSON 1. ASK FIRST: "WHAT IS THE GRIP?"




Negative Texture


Positive Texture

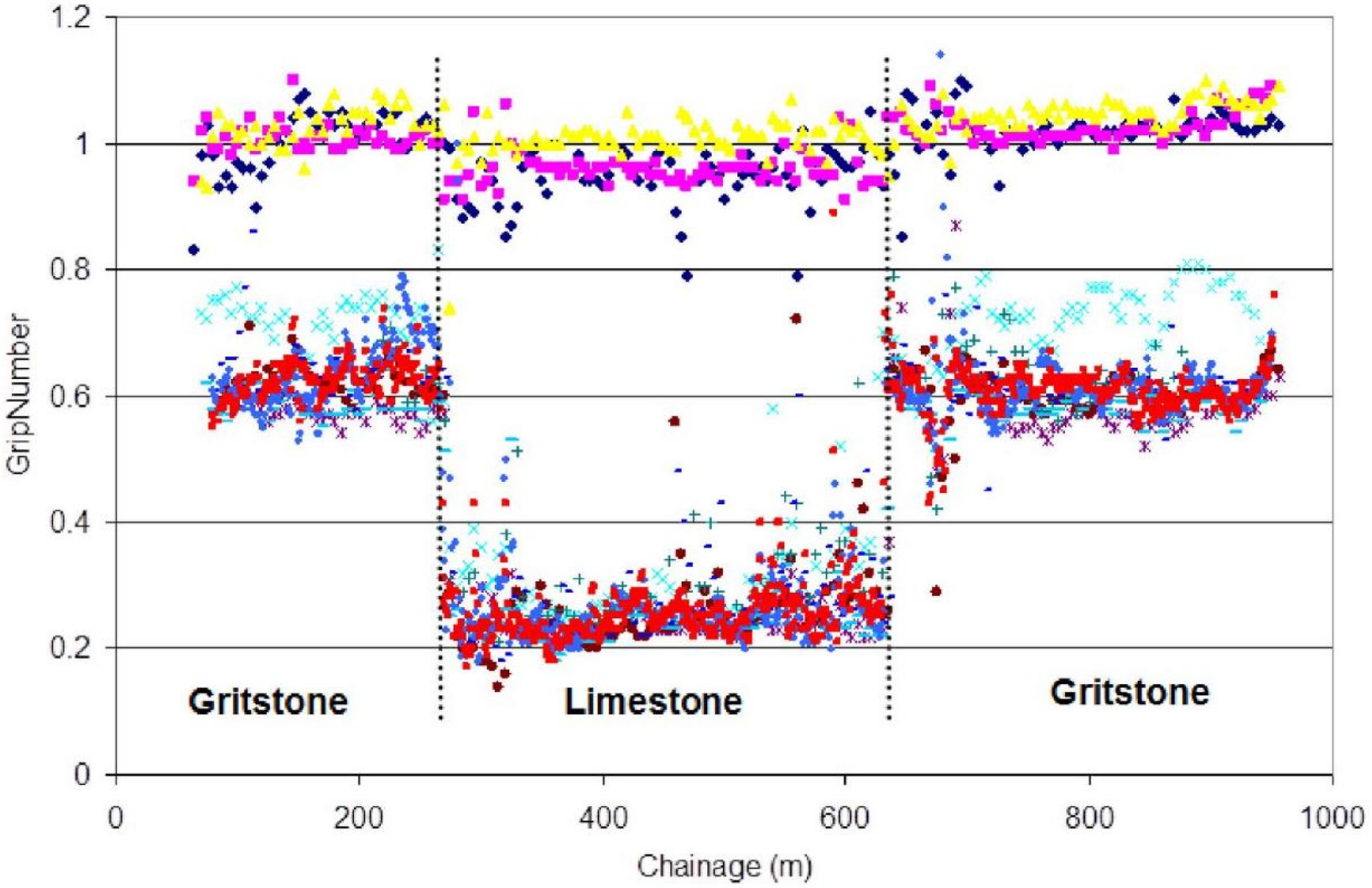
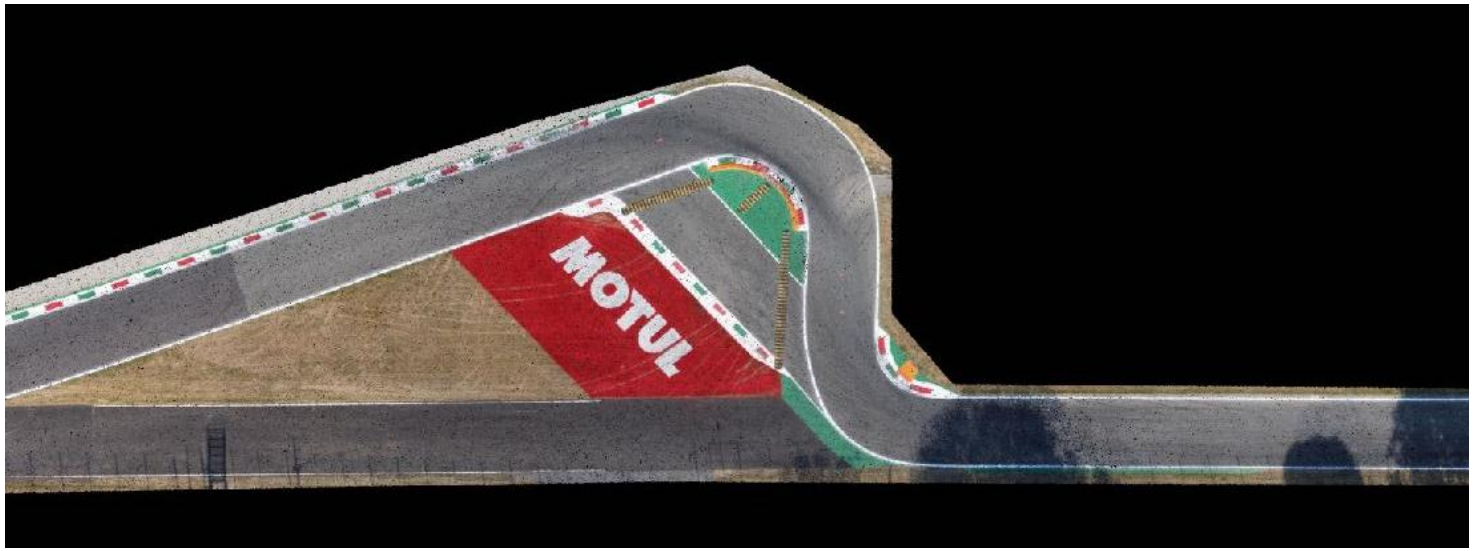
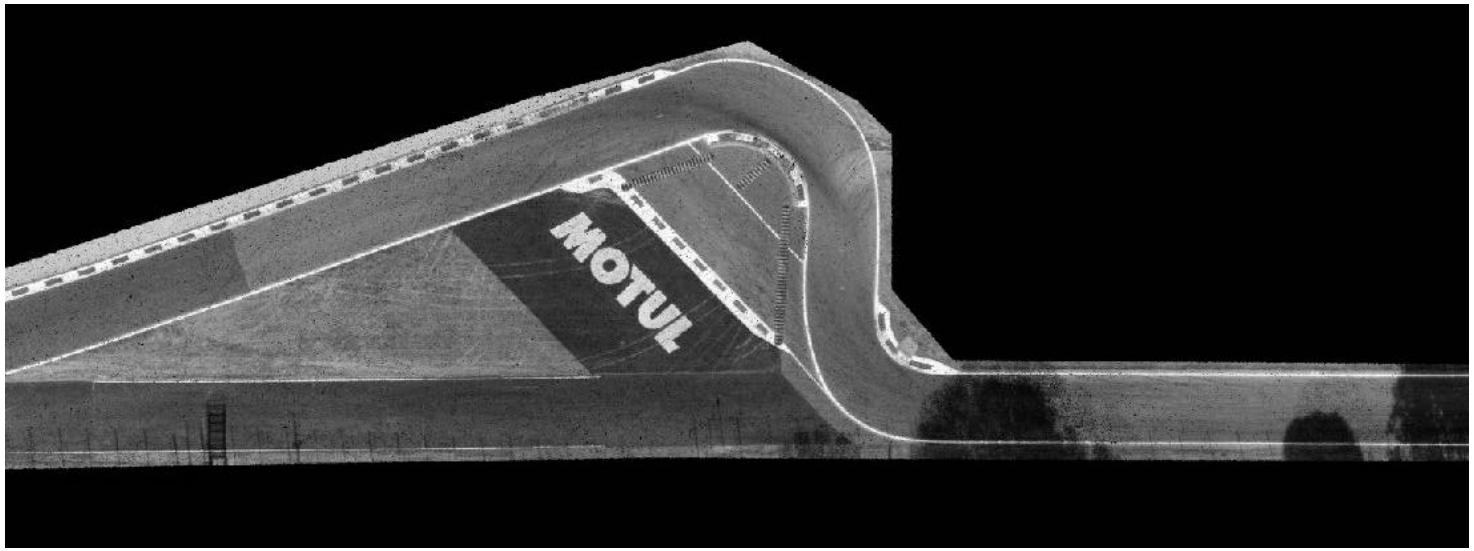
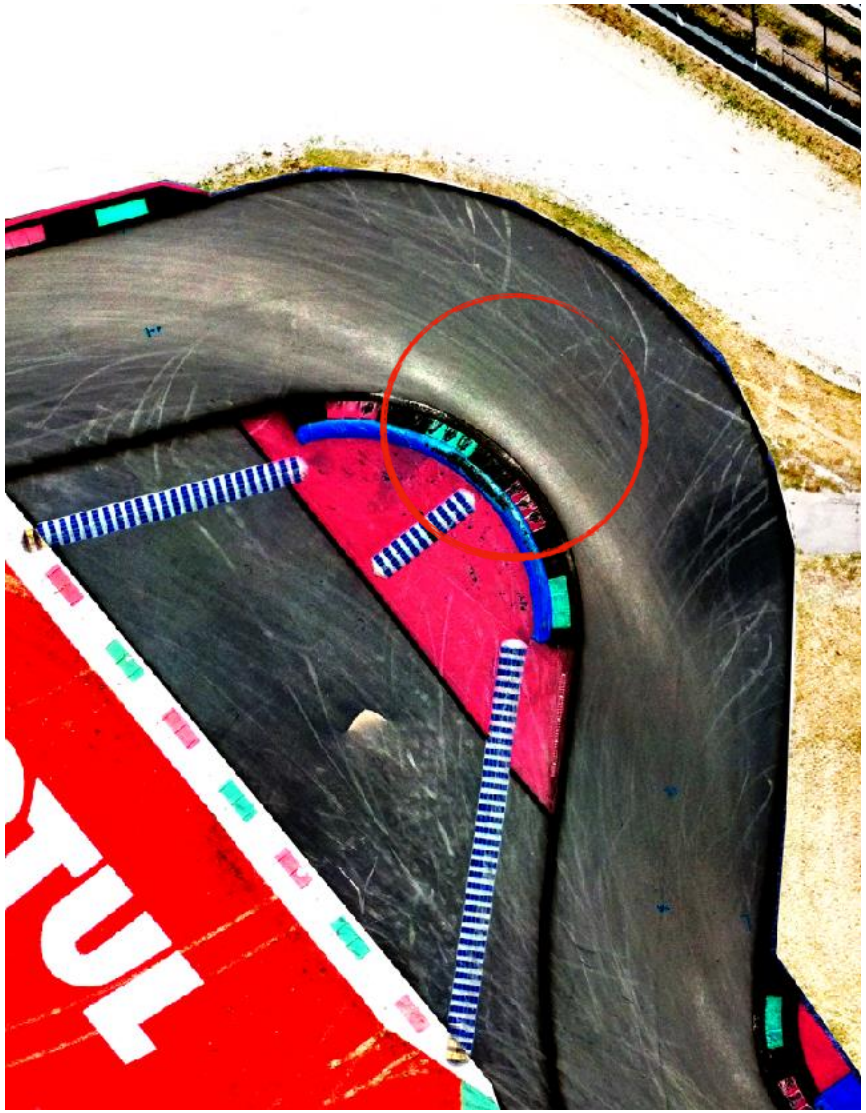


Figure 2 - Example GripTester data showing effect of water application and rock type

WHERE IS THE GRIP?

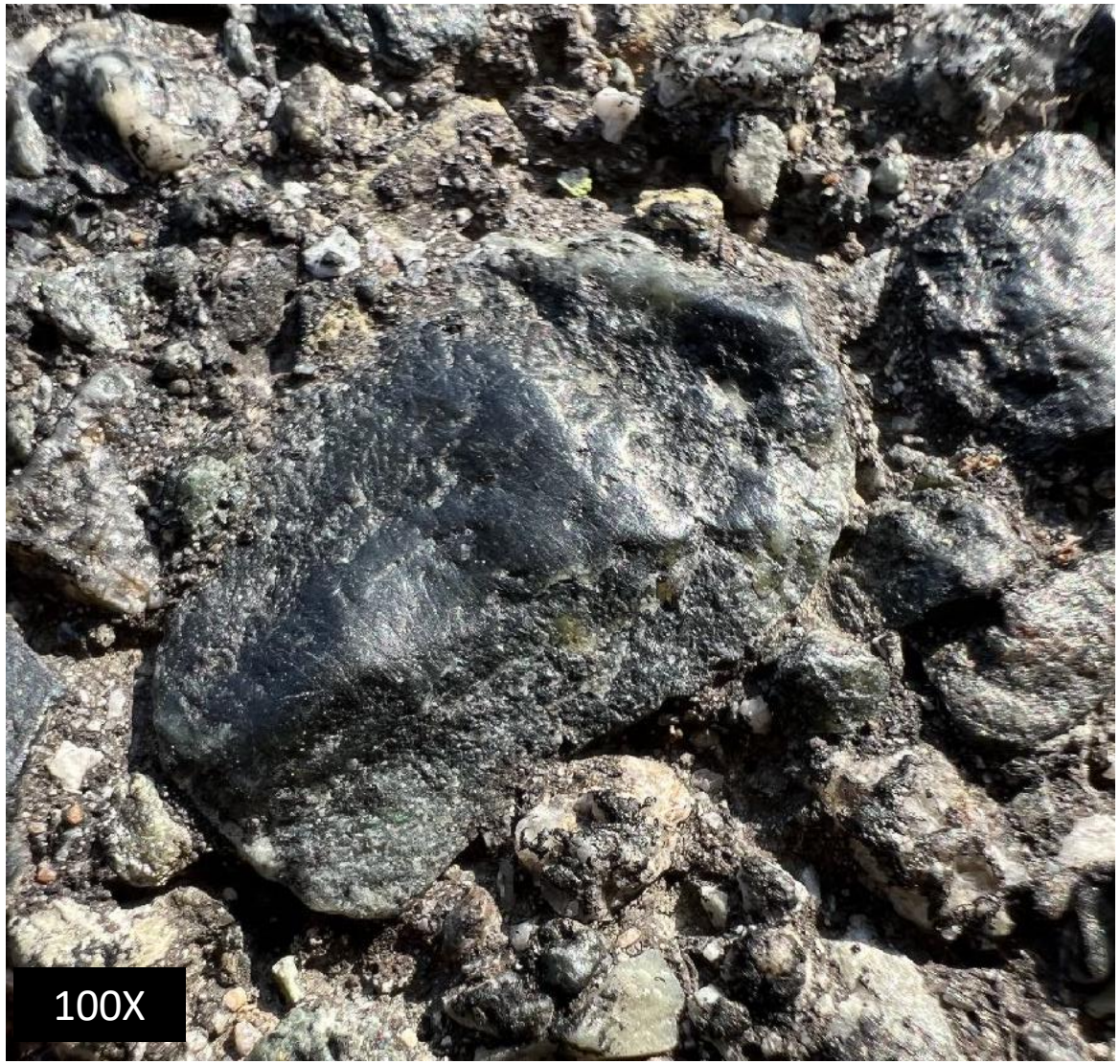


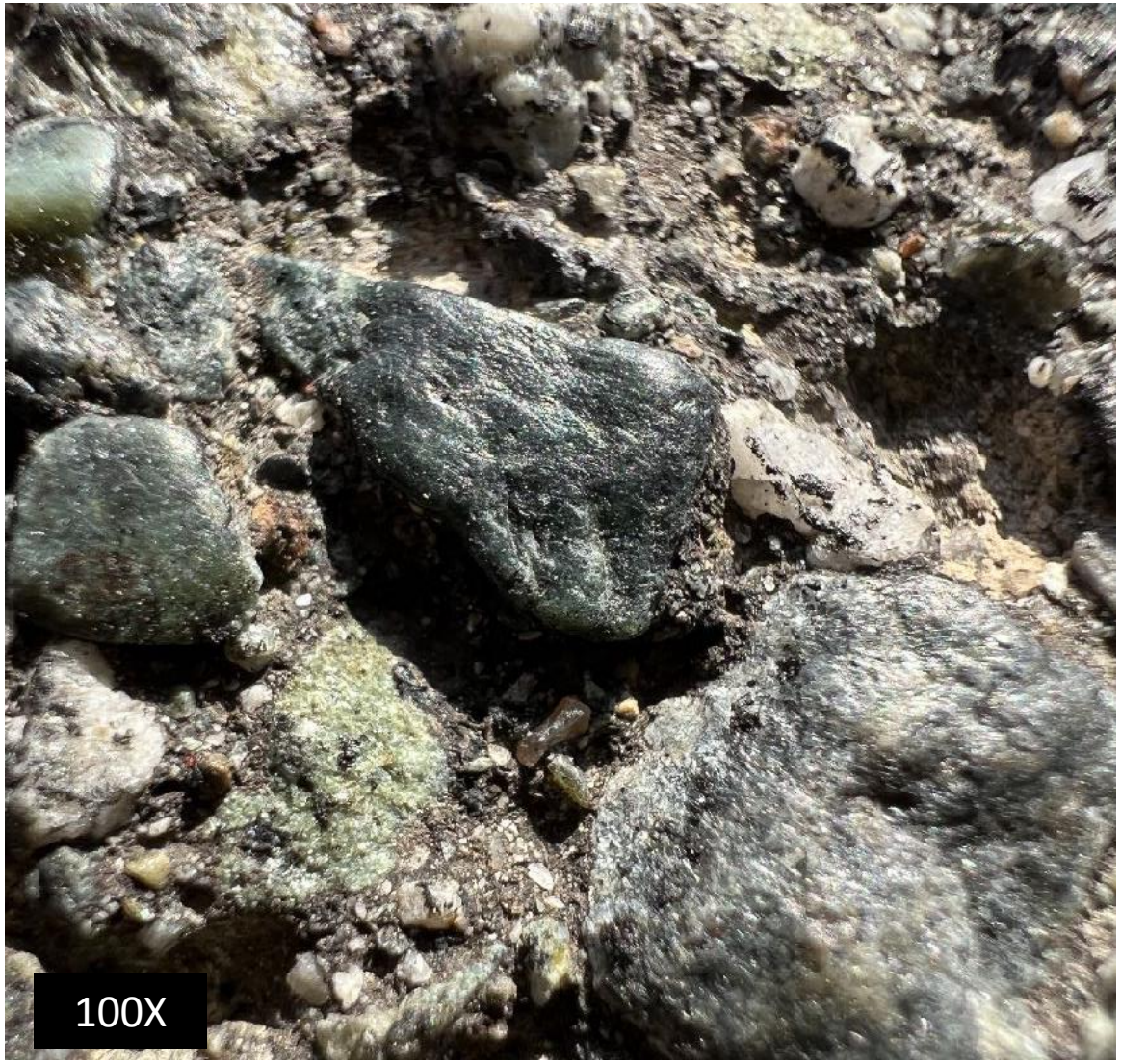




POLISHED ASPHALT

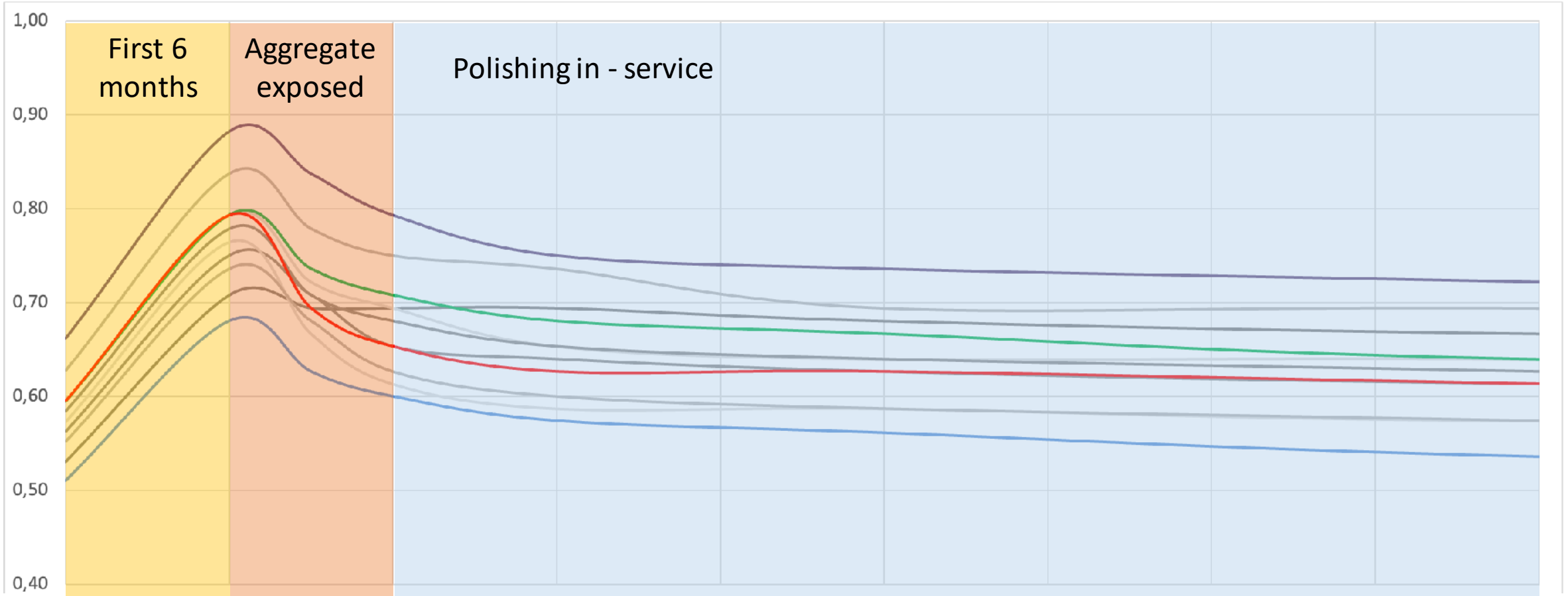
POLISHED ASPHALT





ASPHALT WET GRIP BEHAVIOUR IN THE TIME

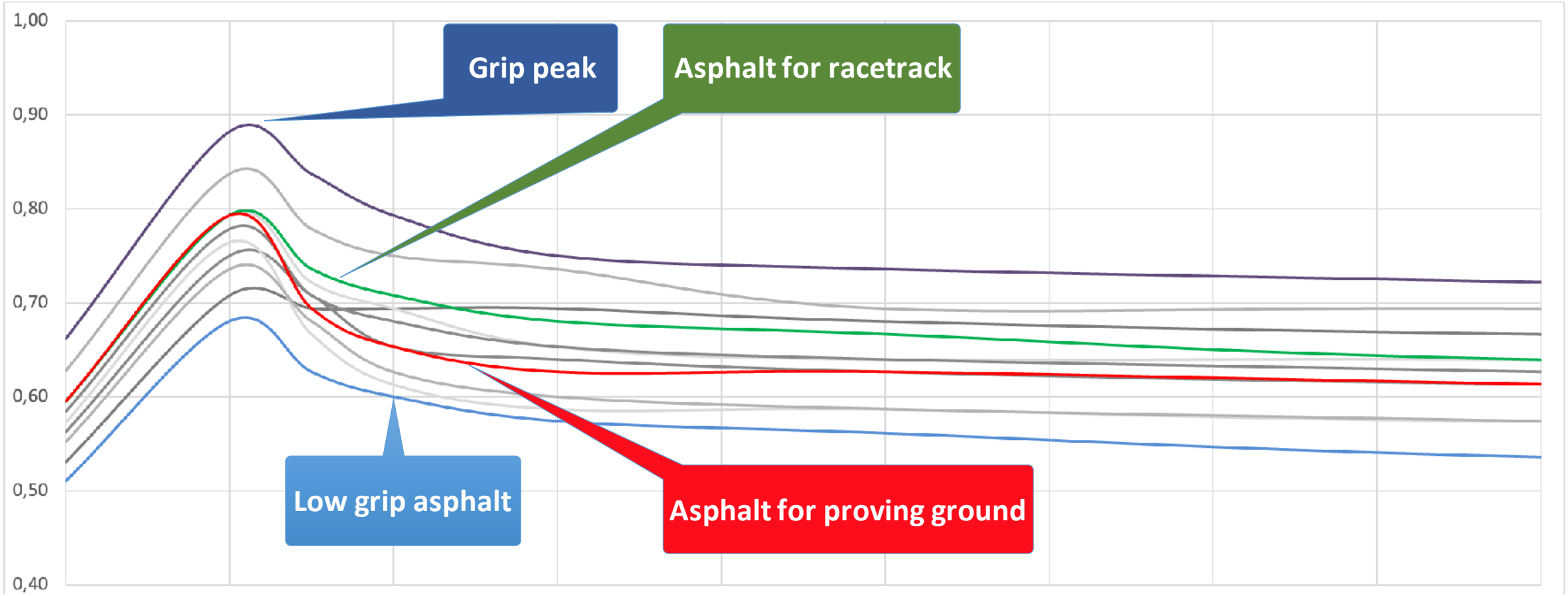
Grip level



Time - - - - >

ASPHALT WET GRIP BEHAVIOUR IN THE TIME

Grip level

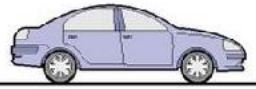


Time - - - - >

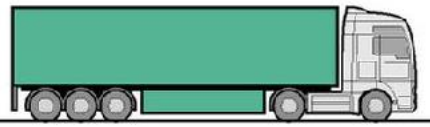
LESSON 1. ASK FIRST: "WHAT IS THE GRIP?"

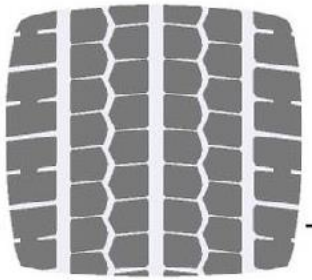
IS IT ABOUT THE TIRE YOU HAVE?

Percentage of contact with the road and pressure in the contact patch



150 cm^2

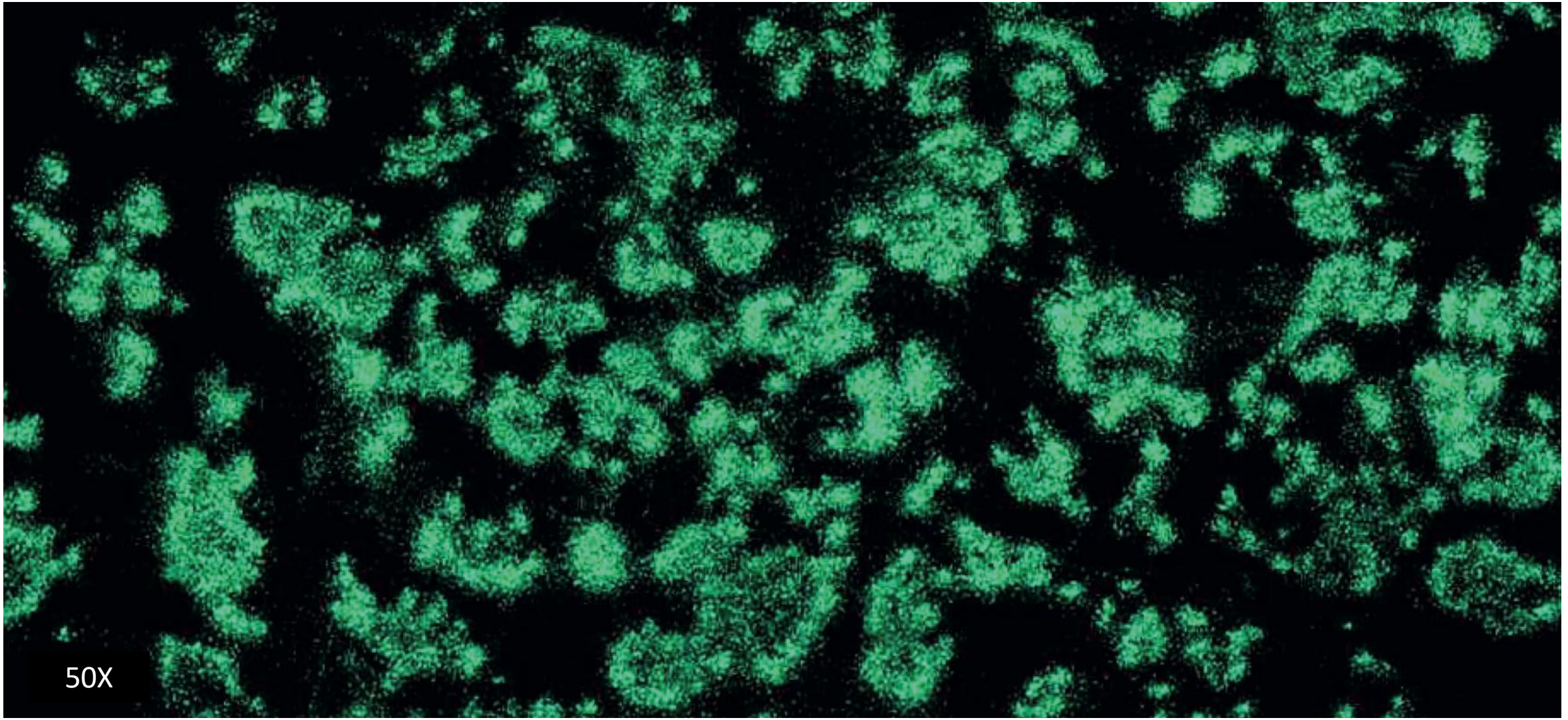




500 cm^2

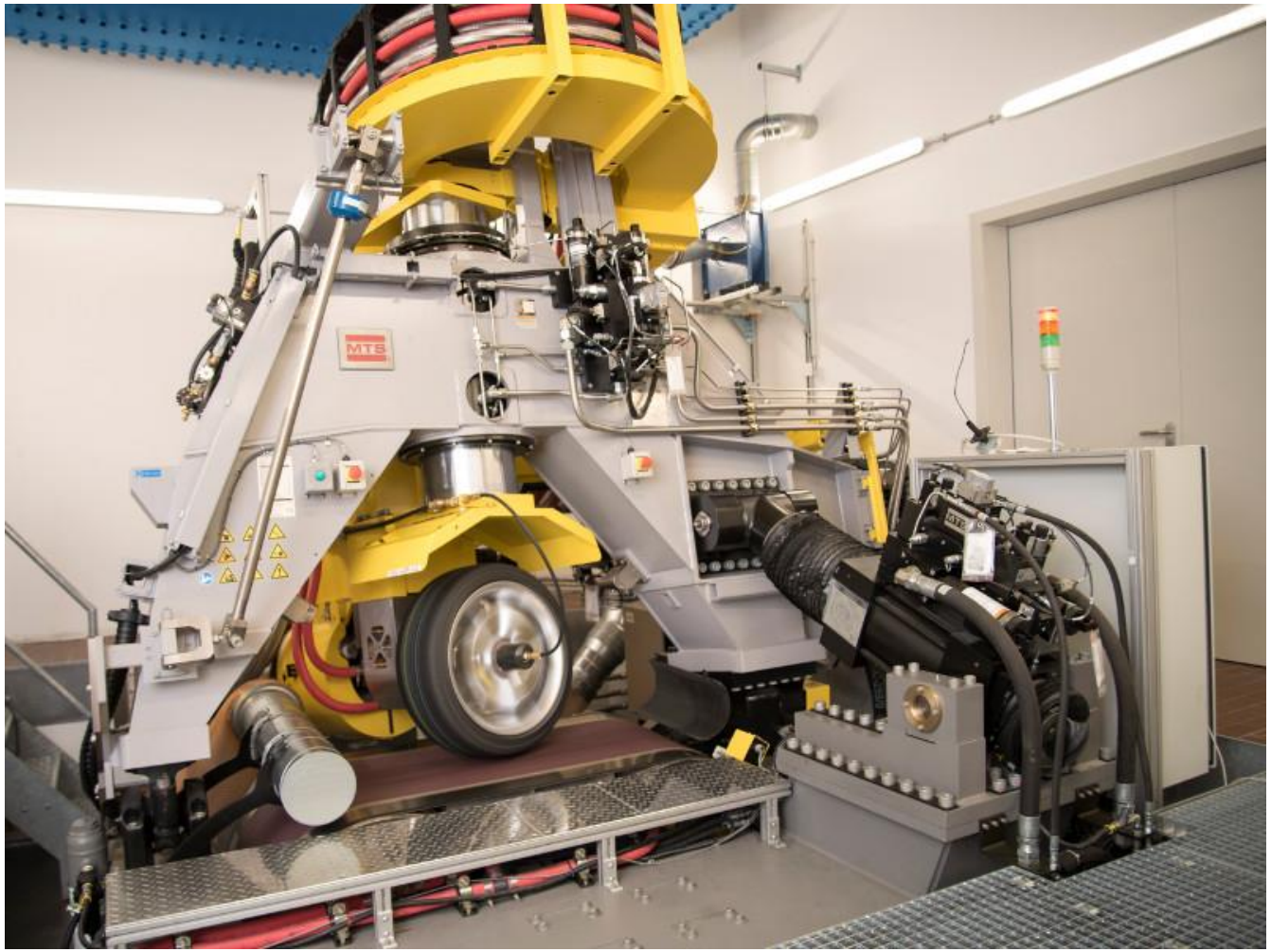
Inflation pressure	2 bars		8 bars	
Rubber/void percentage	30 %		30 %	
Mean pressure in the contact patch	3 bars		11 bars	
Percentage of rubber in contact with the road (load bearing surface)	on very rough surfaces  **7%**	on slightly rough surfaces  **60%**	on very rough surfaces  **7%**	on slightly rough surfaces  **60%**
Local pressure on rough spots (mean value)	43 bars	5 bars	157 bars	18 bars

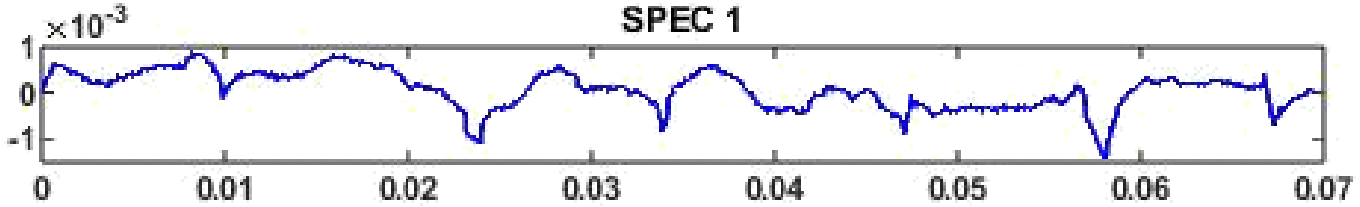
MOTOGP FRONT TIRE PATCH ON RACETRACK ASPHALT - 35%



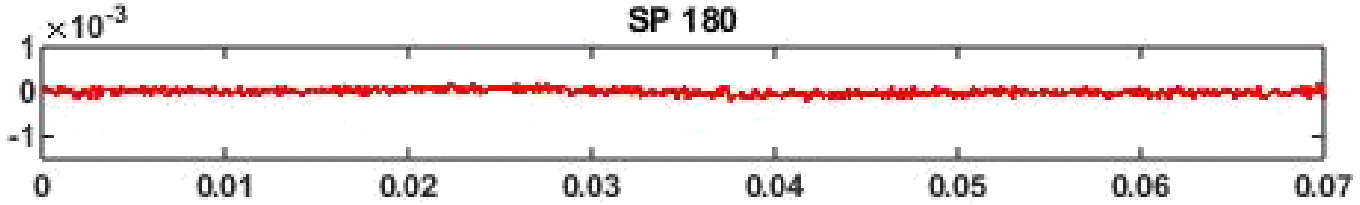
SANDPAPER IS NOT REAL ROAD

LESSON 2. SANDPAPER IS NOT REAL ROAD

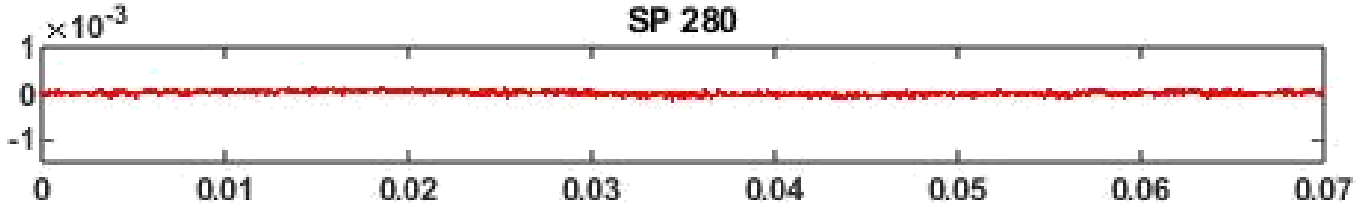




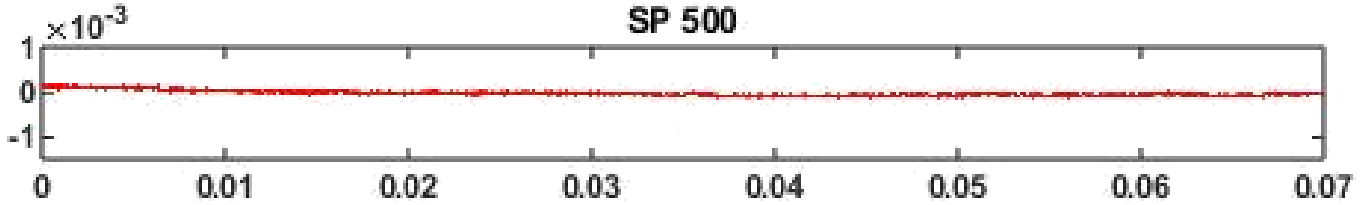
35%



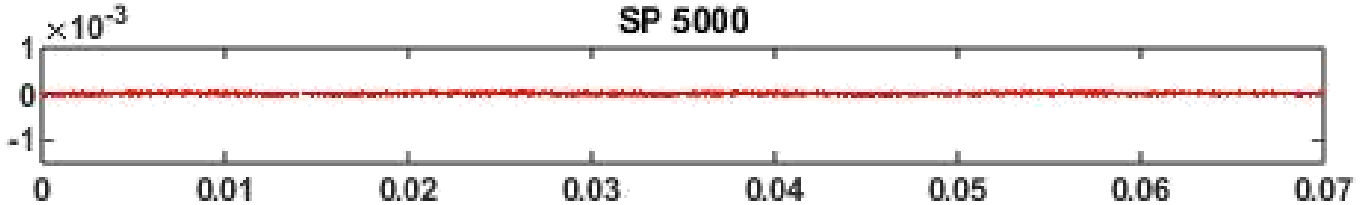
92%



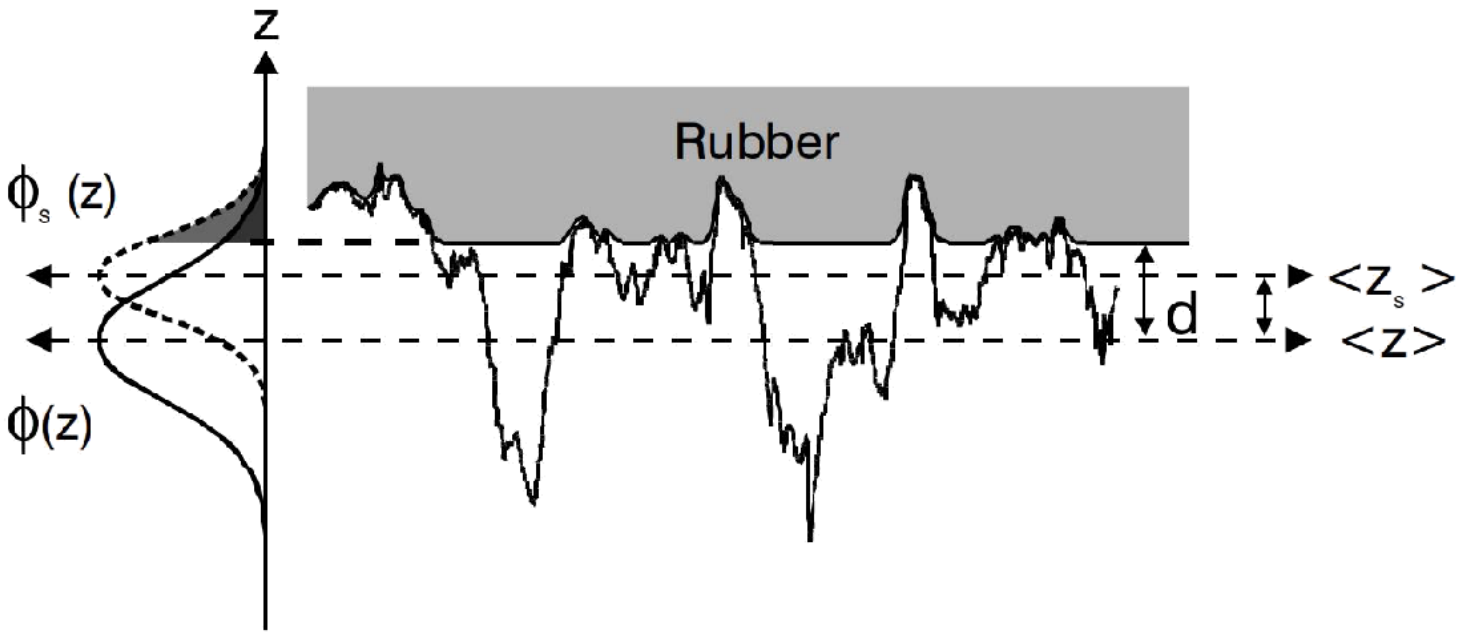
95%

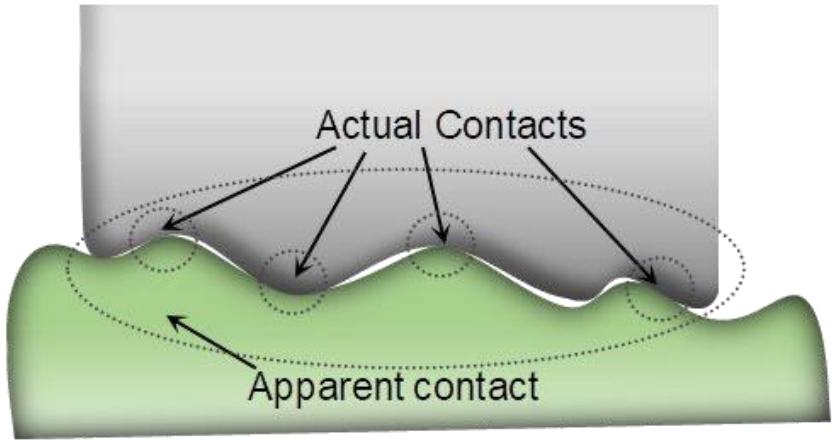


99%

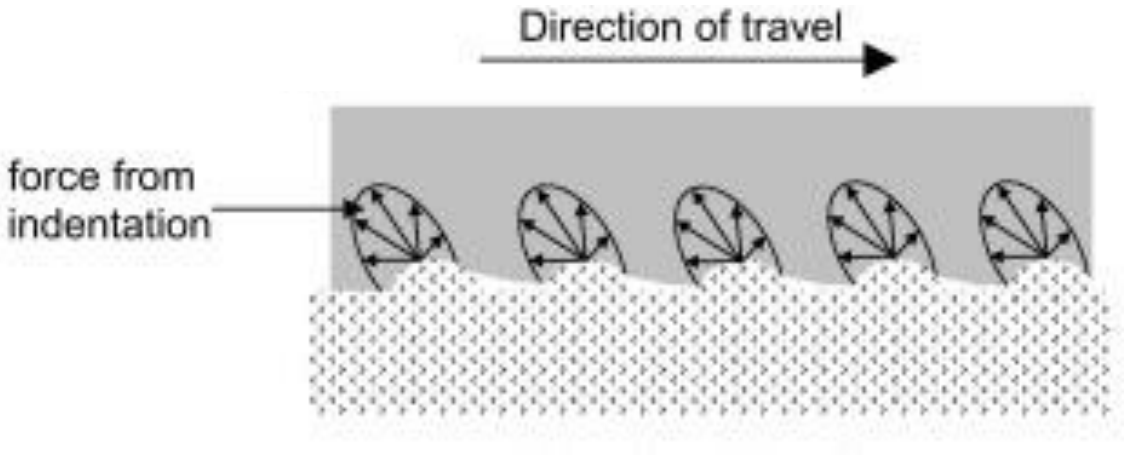


100%

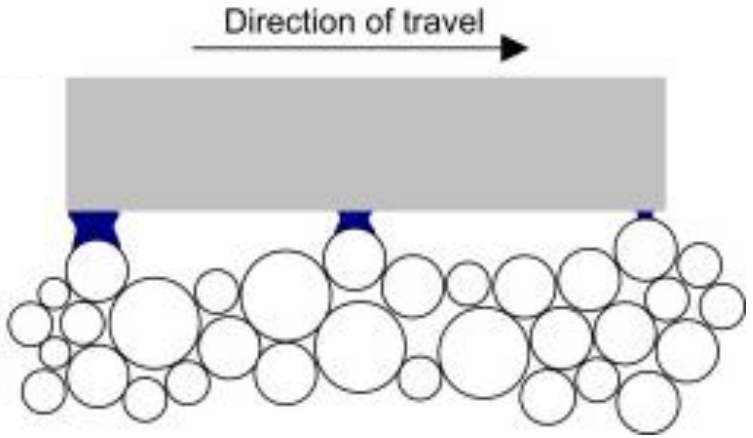




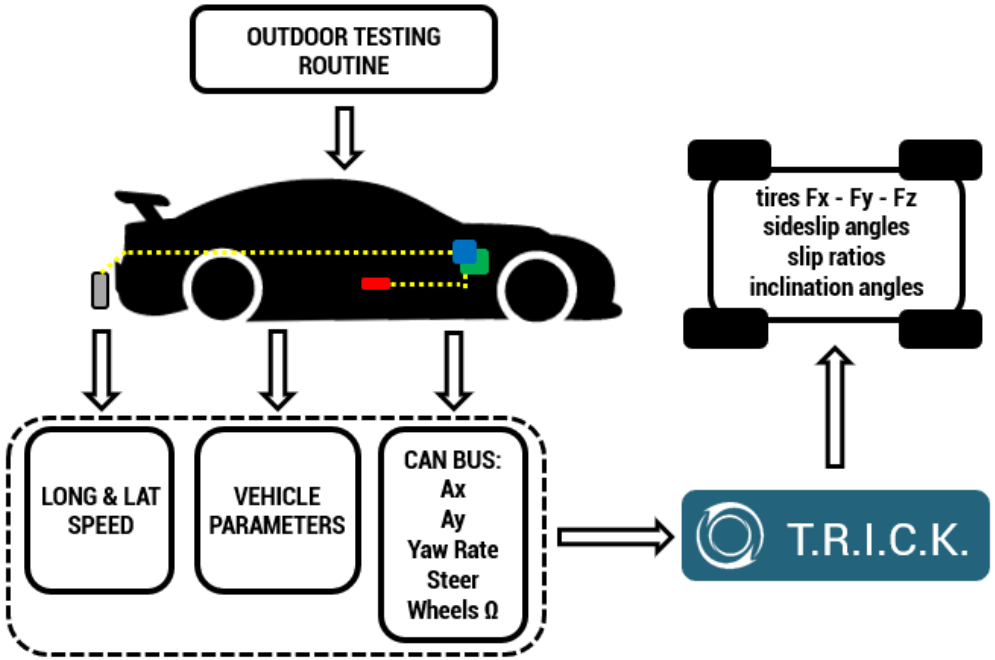
HYSTERETIC GRIP



ADHESIVE GRIP



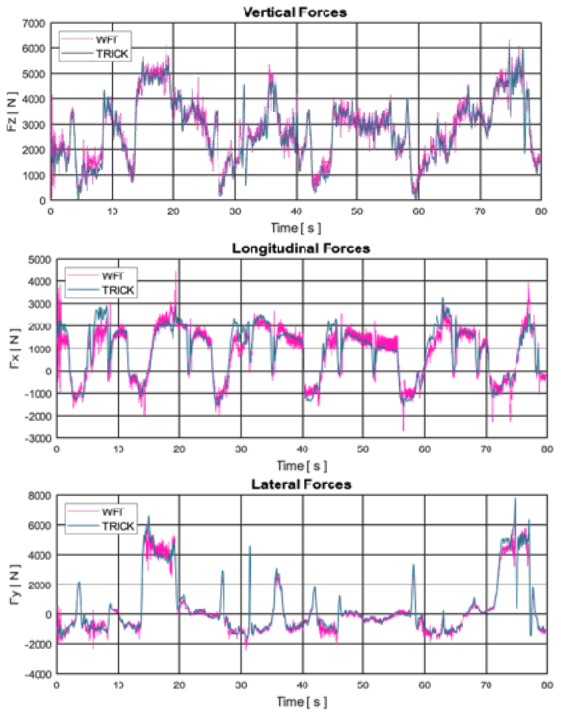
LESSON 2. SANDPAPER IS NOT REAL ROAD

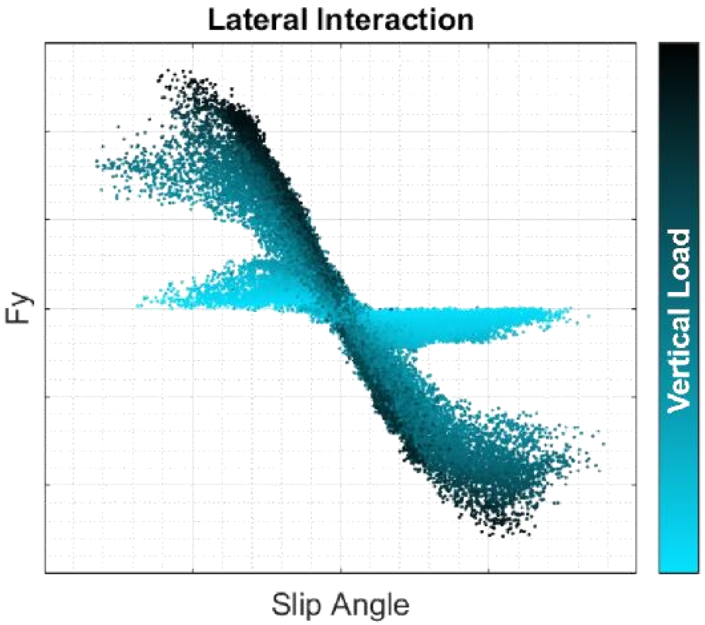


- **T.R.I.C.K.: Tire-Road Interaction Characterization & Knowledge**
- **characterize the vehichle system using it as a «moving lab»**

Target:

- **objectivation of tire and driving performance during testing**
- **achievement of tire-road interaction experimental curves**





*** for further info:**
F. Farroni – T.R.I.C.K.: Tire/Road Interaction Characterization & Knowledge – A tool for the evaluation of tire and vehicle performances in outdoor test sessions – Mechanical Systems and Signal Processing – 72-73 808-831 (2016)

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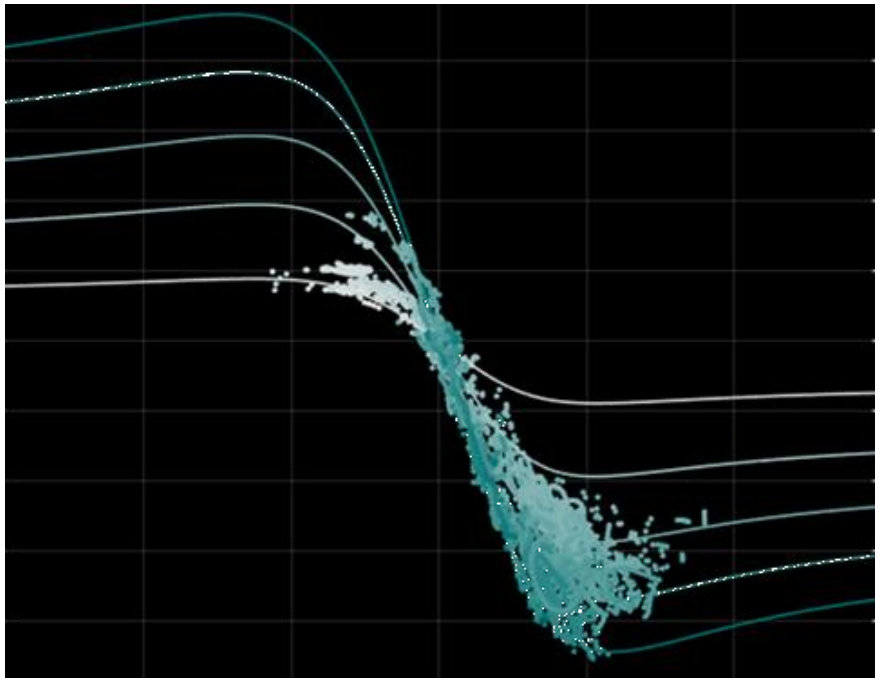
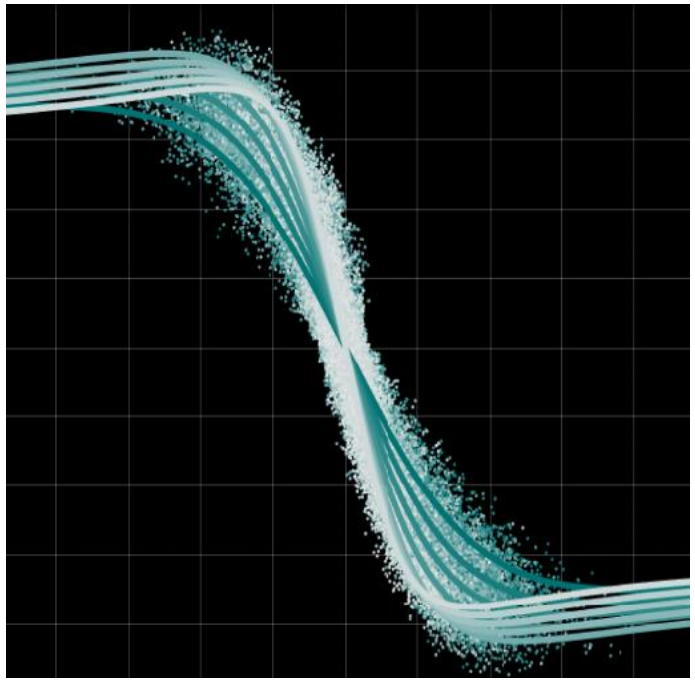
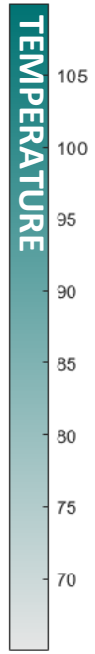
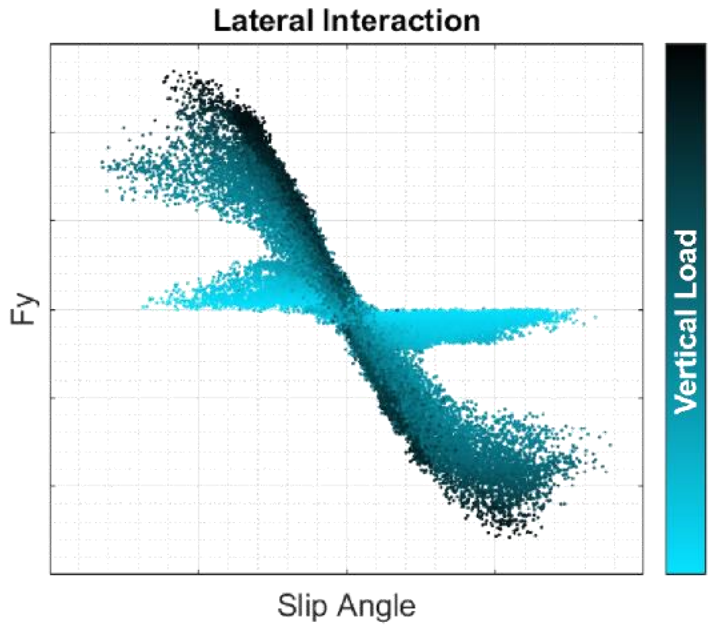




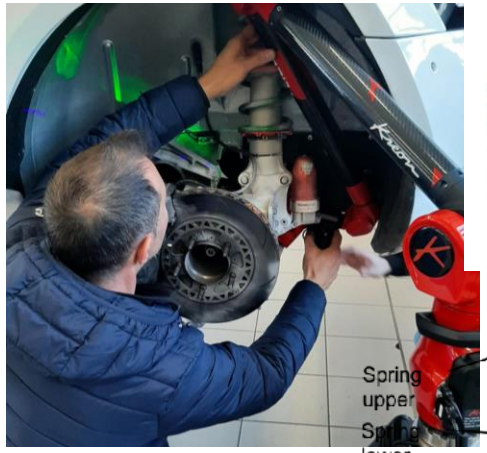


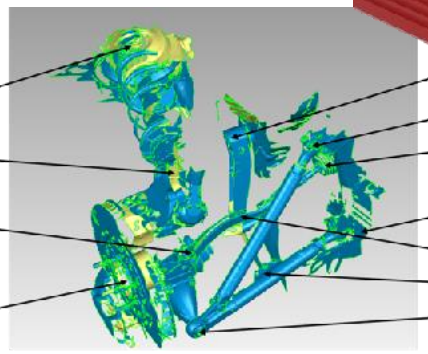


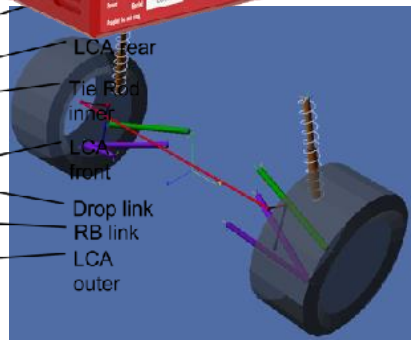
IDENTIFICATION OF MULTI-PHYSICAL TIRE MODELS ON DATA ACQUIRED FROM REAL TIRES, ON REAL ASPHALT, EXERTED IN REAL WORKING CONDITIONS

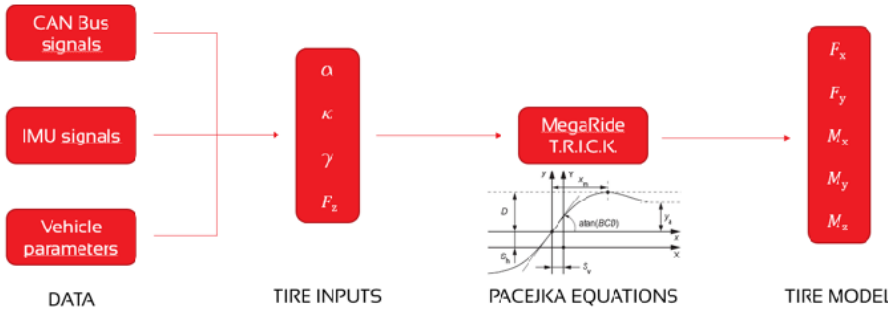
FROM REAL TO VIRTUAL, A GAP TO RE-BRIDGE

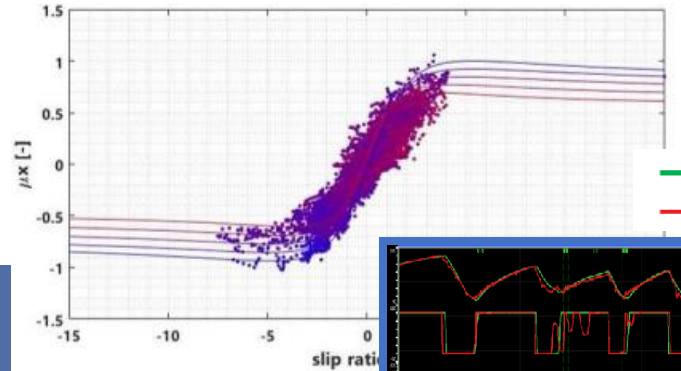
LESSON 3. FROM REAL TO VIRTUAL, A GAP TO RE-BRIDGE

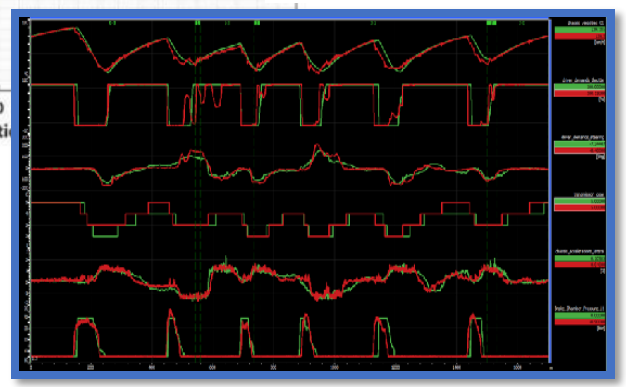




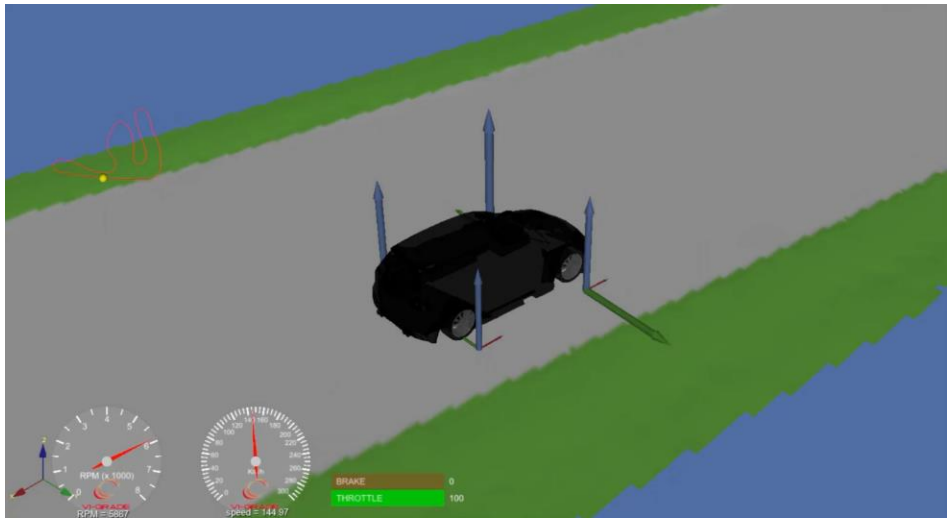








LESSON 3. FROM REAL TO VIRTUAL, A GAP TO RE-BRIDGE



LESSON 3. FROM REAL TO VIRTUAL, A GAP TO RE-BRIDGE

SUSPENSION JOUNCE

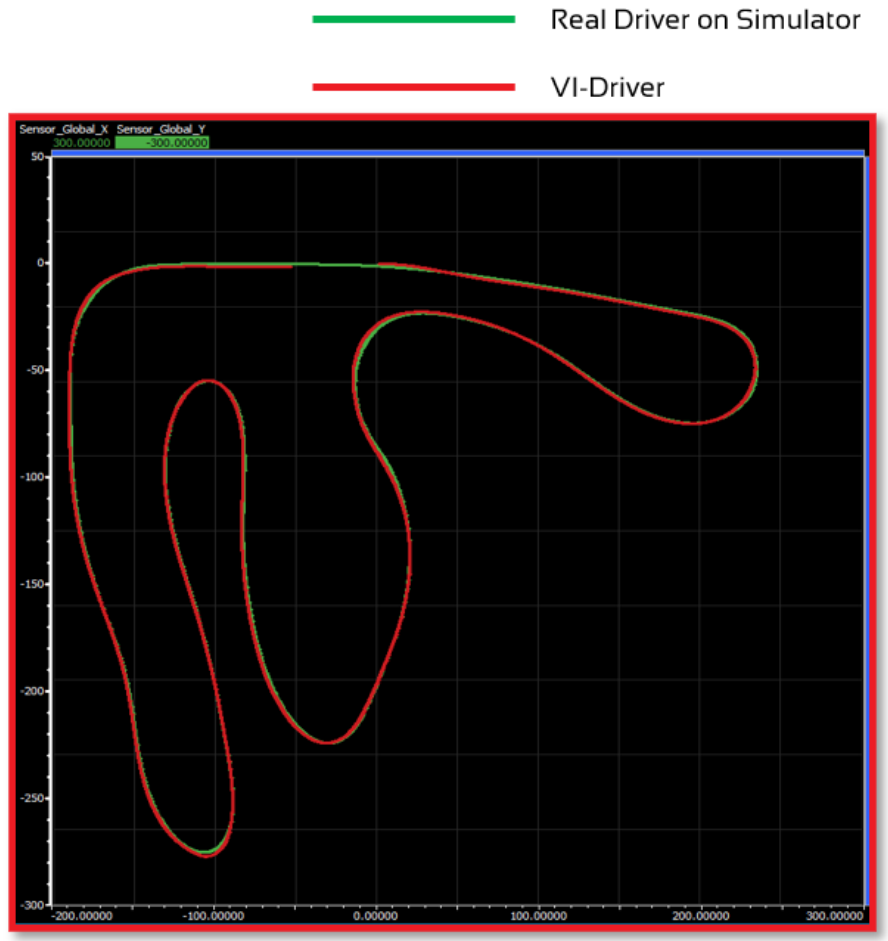
- Several set-ups were tested during the driving simulator sessions.
- Front suspensions look a little softer in the real vehicle.
- Very good overlap of the rear suspensions data.

LESSON 3. FROM REAL TO VIRTUAL, A GAP TO RE-BRIDGE

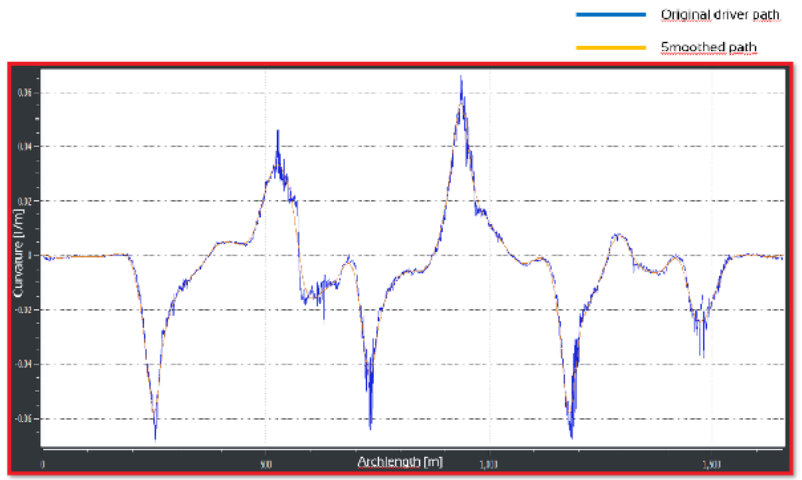
- VI-Driver can use real driver trajectory on the sim

- Curvature profile can be smoothed and adjusted

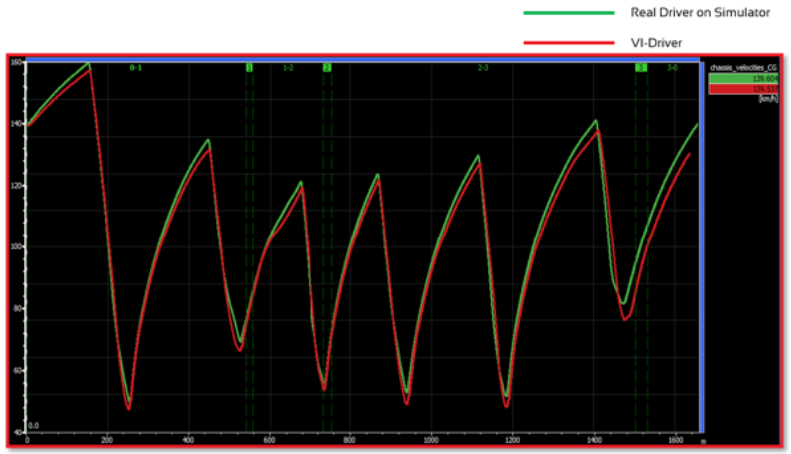
- Speed profile could be auto-generated using Maxperformance



Real driver trajectory can be taken as input for the VI-Driver



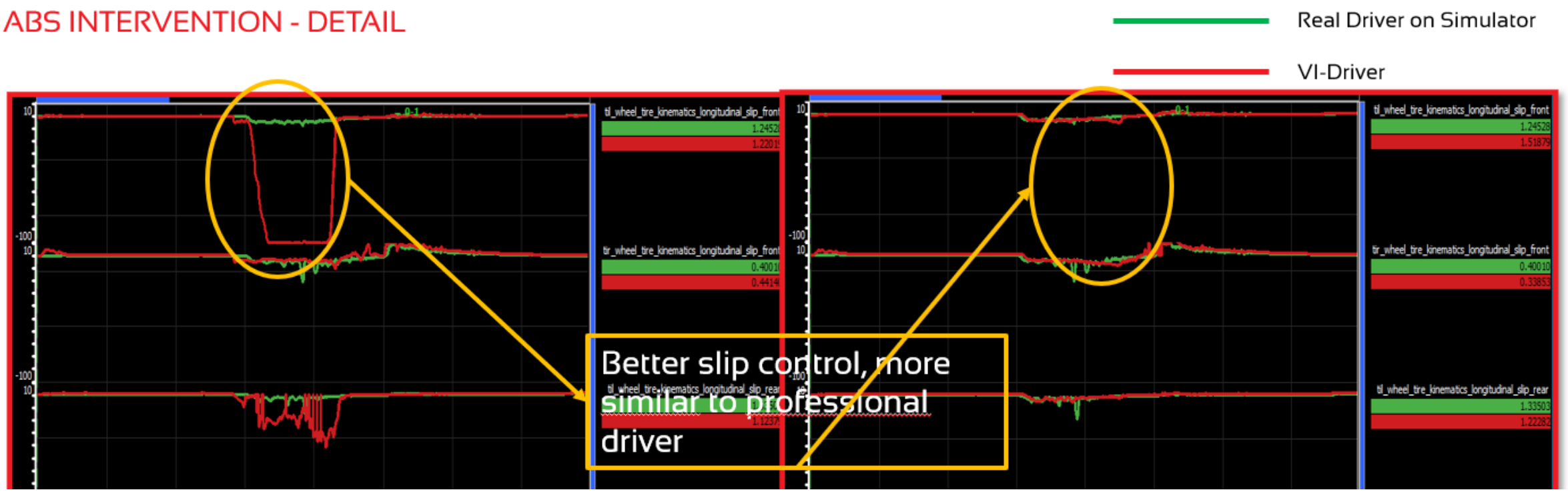
VI-Road path smoothing to improve VI-Driver behavior



Possibility to track the real driver speed profile in a file driven event.

LESSON 3. FROM REAL TO VIRTUAL, A GAP TO RE-BRIDGE

ABS INTERVENTION - DETAIL

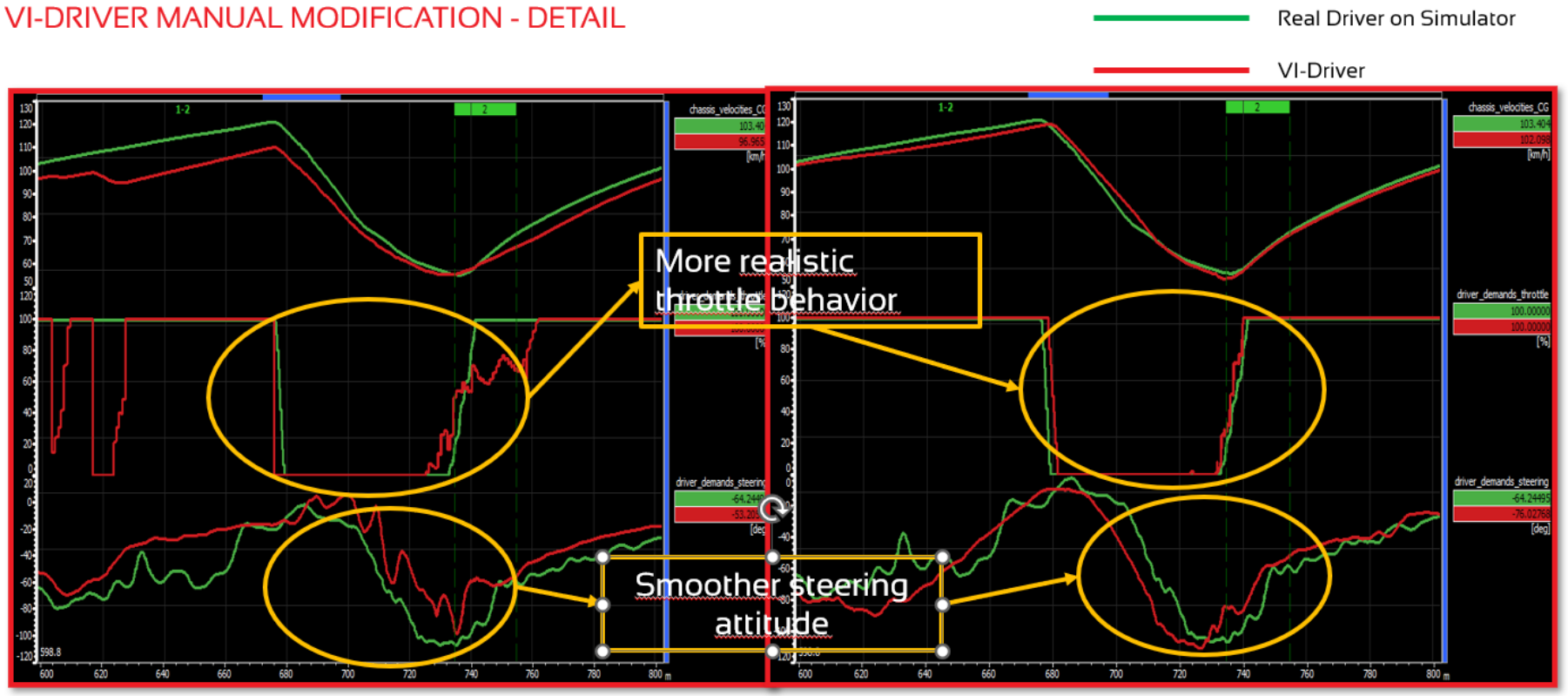


- VI-Driver does not avoid wheel spin and locking during extreme actions

  TC and ABS intervention can help better reproducing professional driver behavior

LESSON 3. FROM REAL TO VIRTUAL, A GAP TO RE-BRIDGE

VI-DRIVER MANUAL MODIFICATION - DETAIL



Original VI-Driver behavior

After VI-Driver modification with vdf file

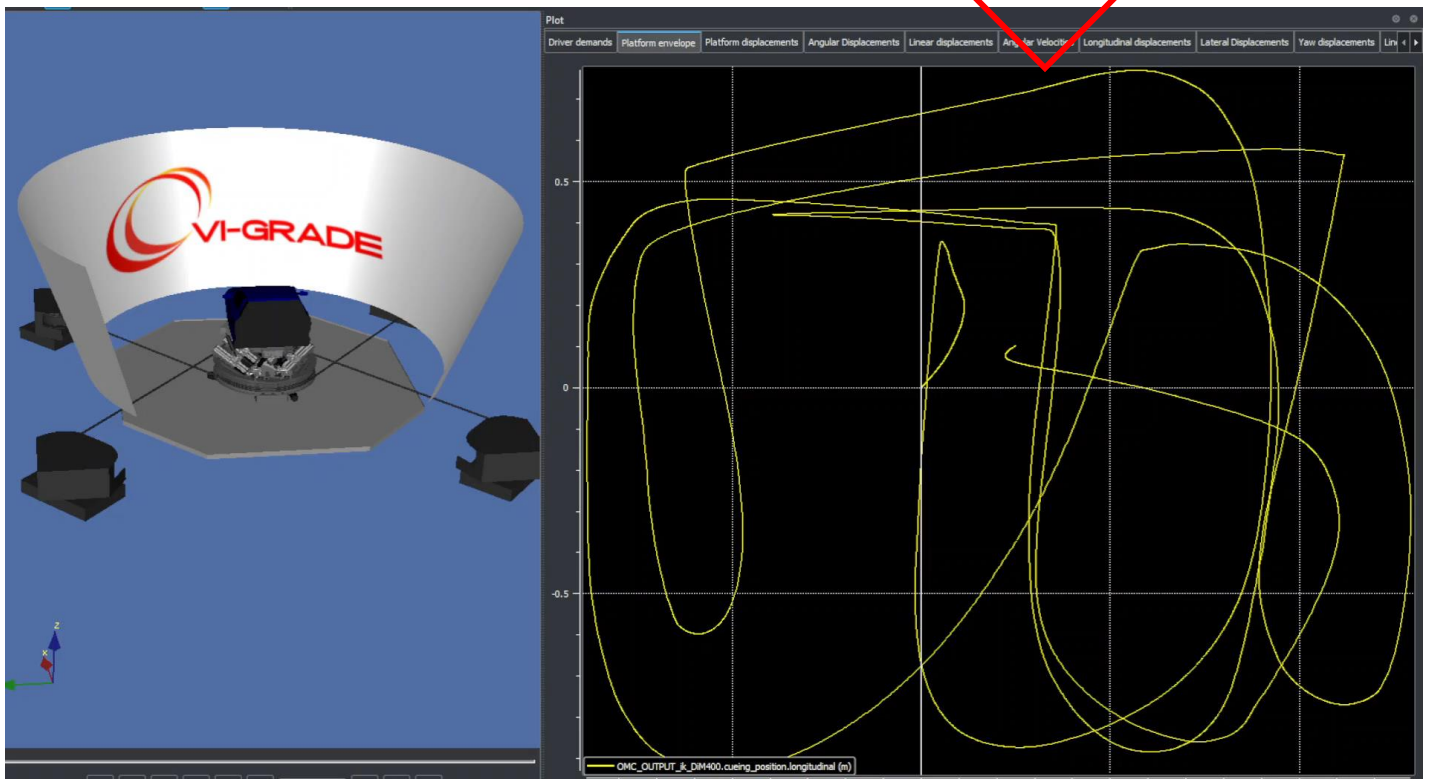
- VI-Driver has robotic throttle and steering attitudes

With using several parameters in the EventBuilder or VDF file it is possible to better represent the behaviour of a real driver

LESSON 3. A GAP TO RE-BRIDGE

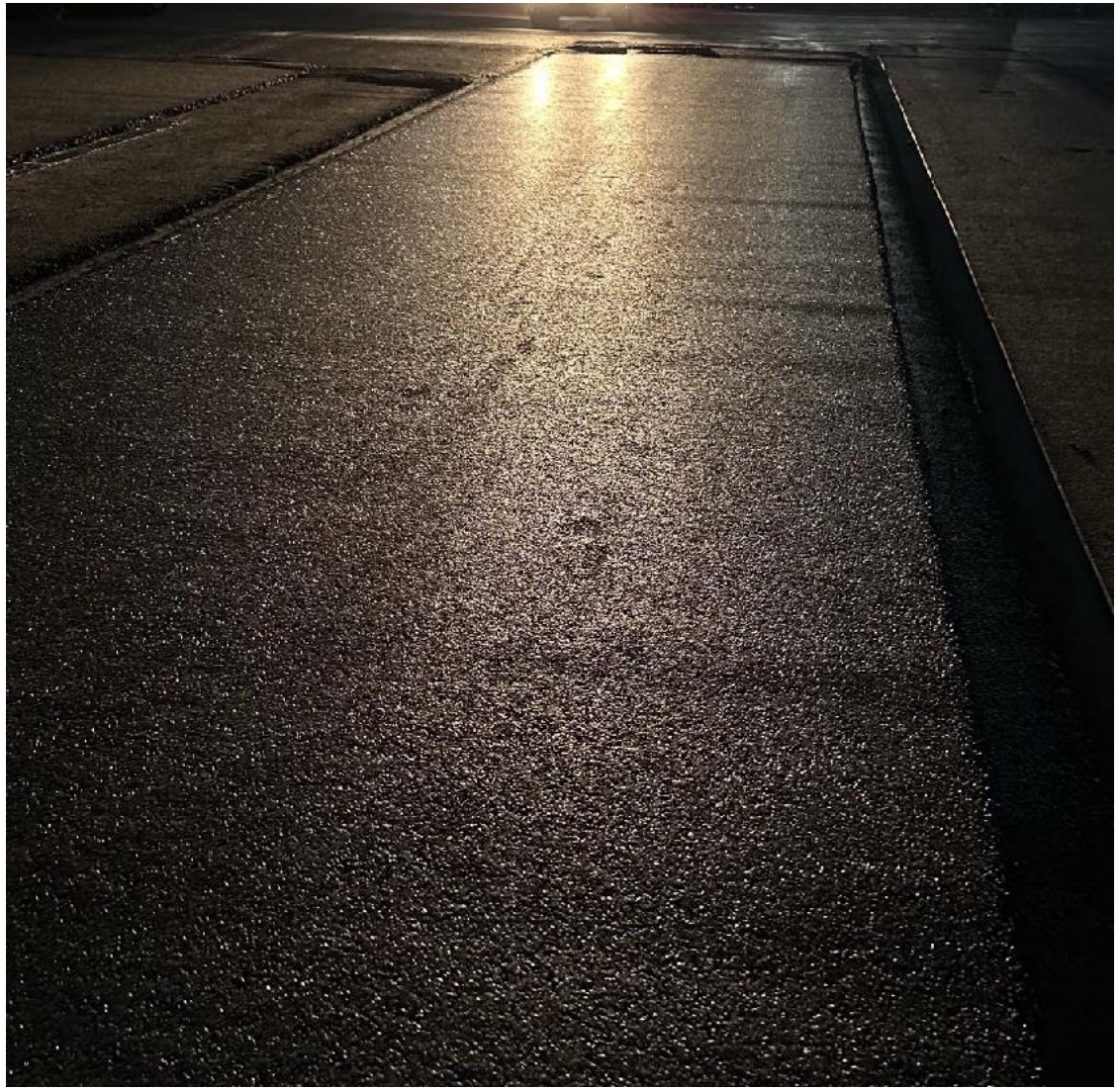
Extraction of Real Driver on Simulator results (WINTAX) to be used within VI-OfflineMotionCueing

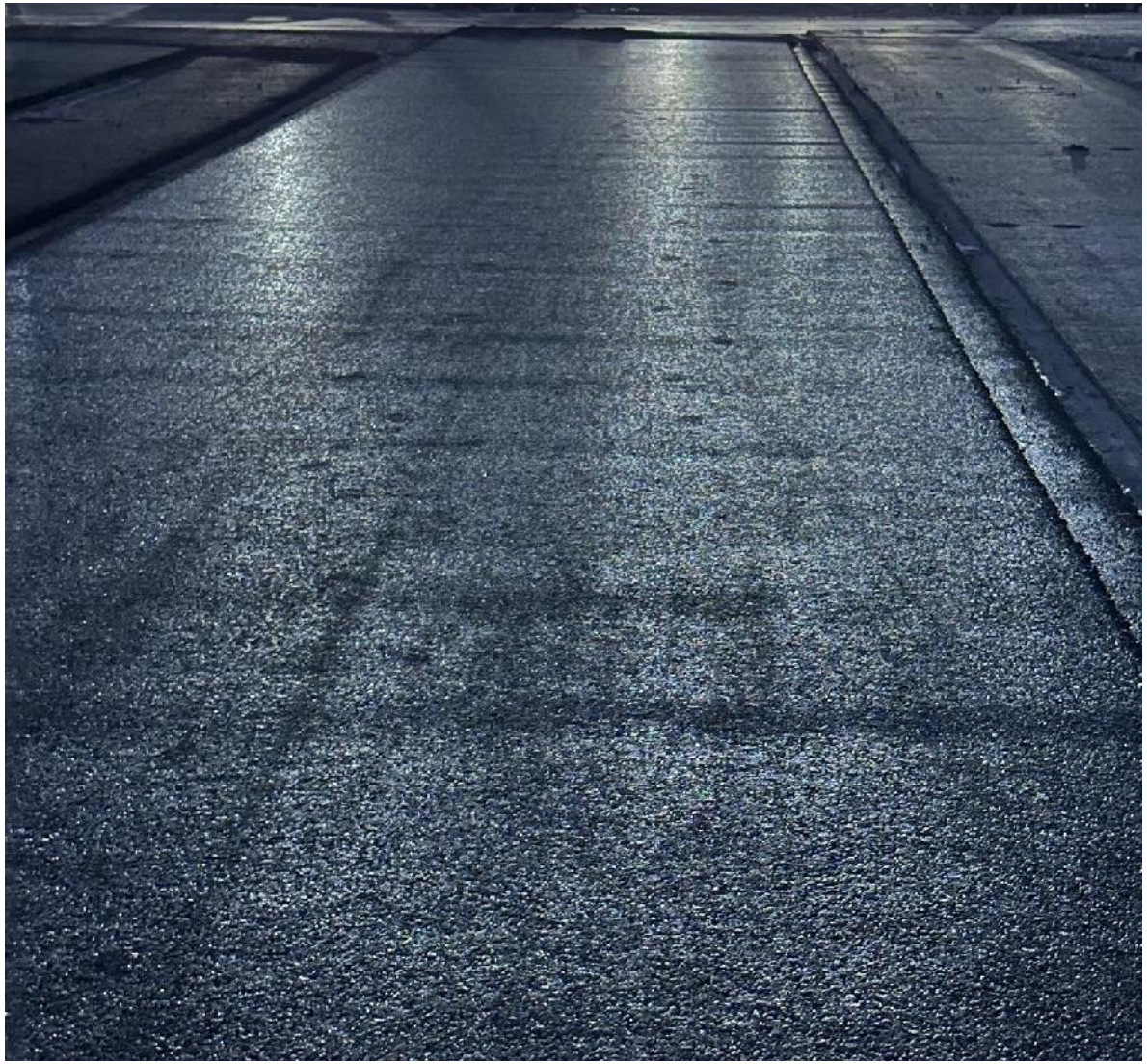
- A result file from Maxperformance or from a driving session could be used for MotionCueing preparation
- The driver should be comfortable and drive without discontinuities on the simulator to get “on pace” as soon as possible
- Possible driver’s action correction could be taken into account simulating them off-line thus avoiding session interruptions
- Possible driver’s request for MotionCueing adjustments could be tested off-line



BUMPS ARE NOT GENERATED BY VEHICLES

LESSON 4. BUMPS ARE NOT GENERATED BY VEHICLES





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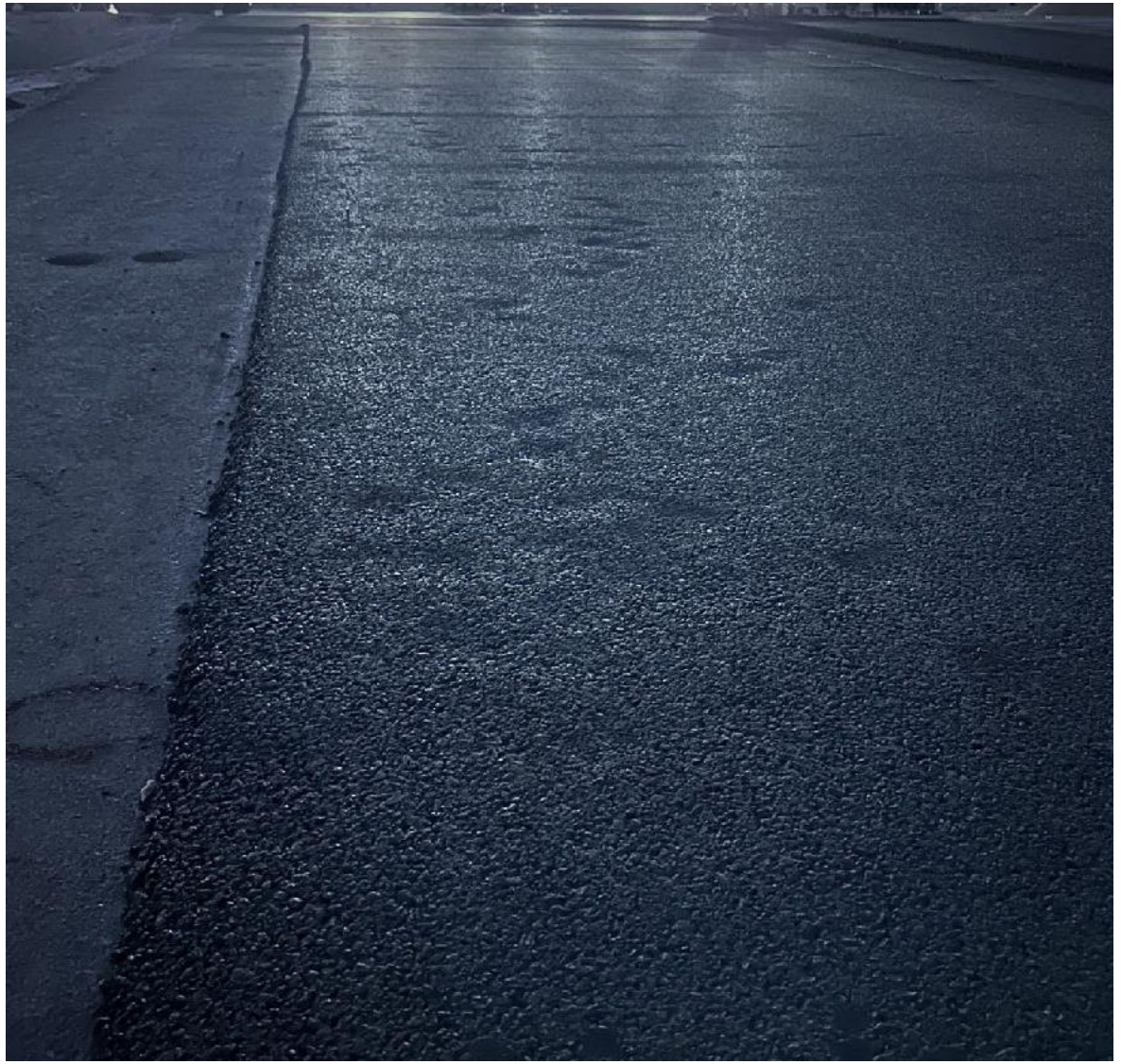
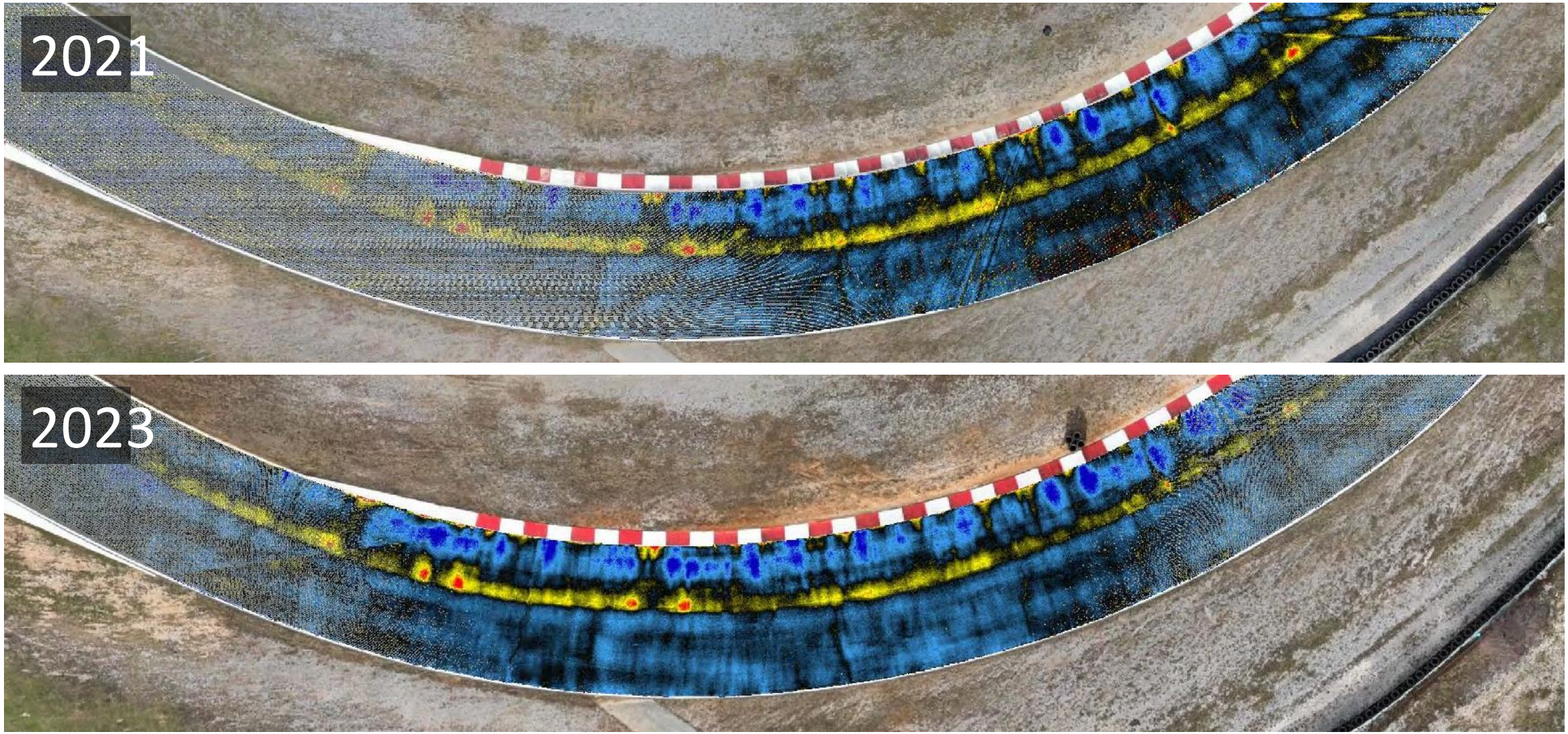


LESSON 4. BUMPS ARE NOT GENERATED BY VEHICLES



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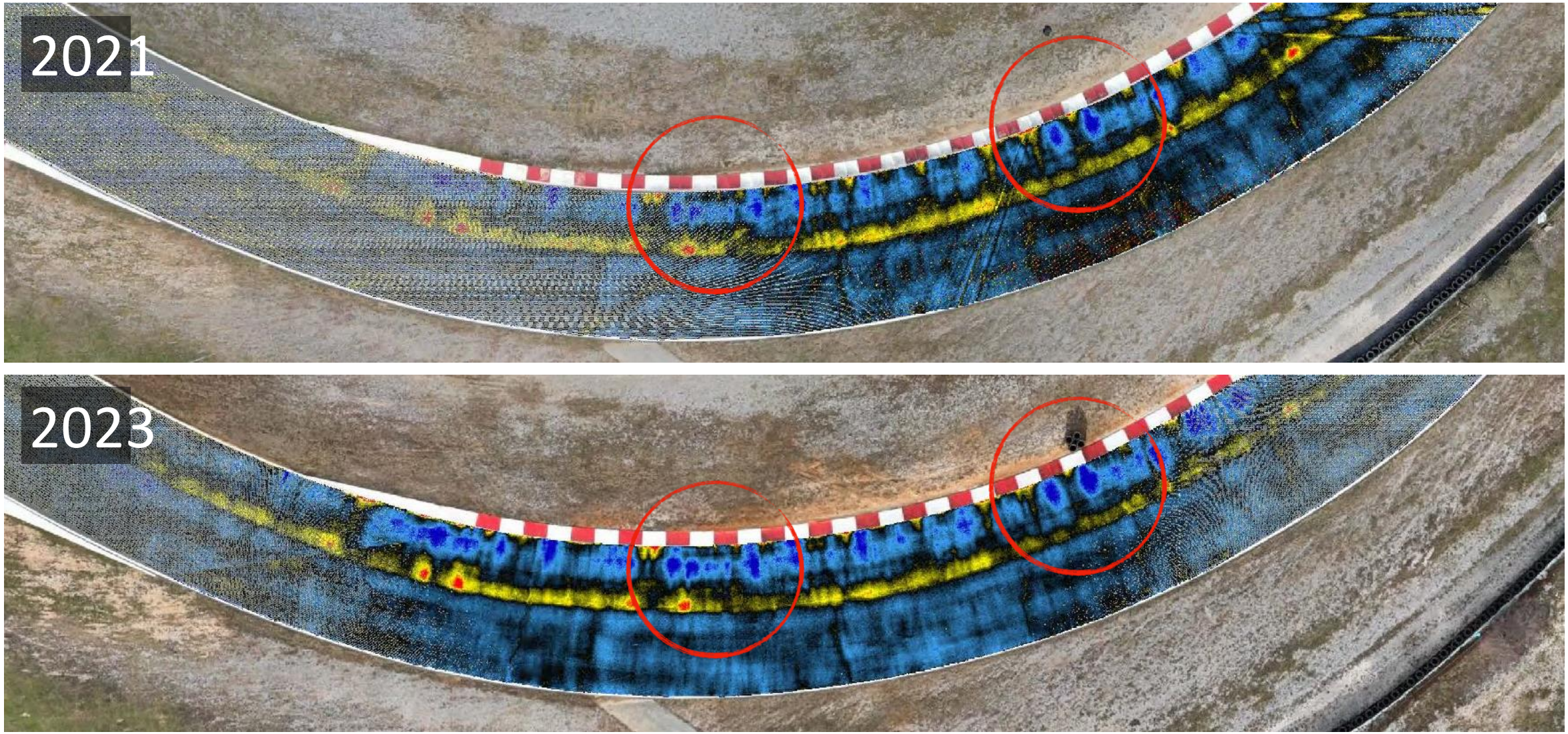
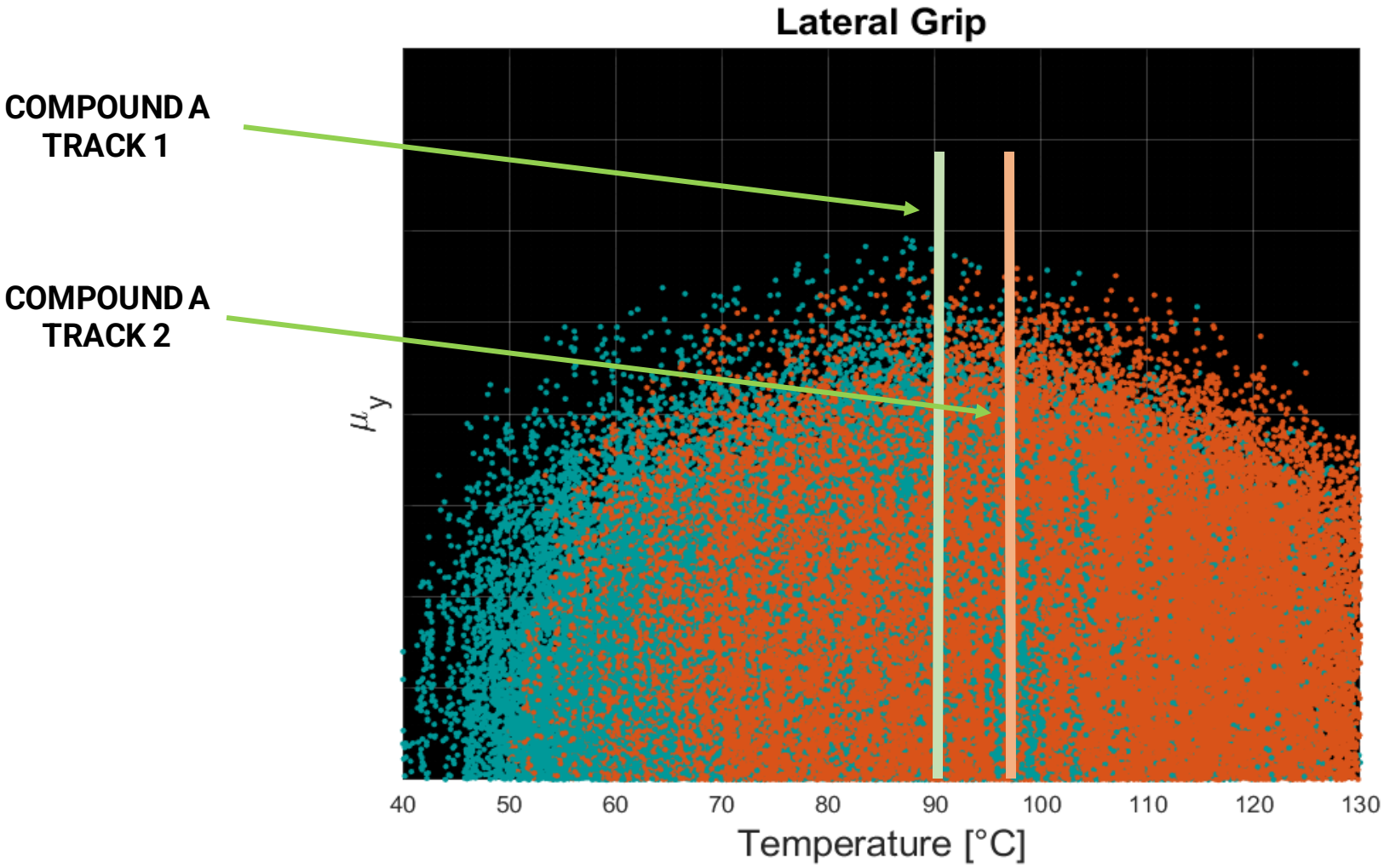
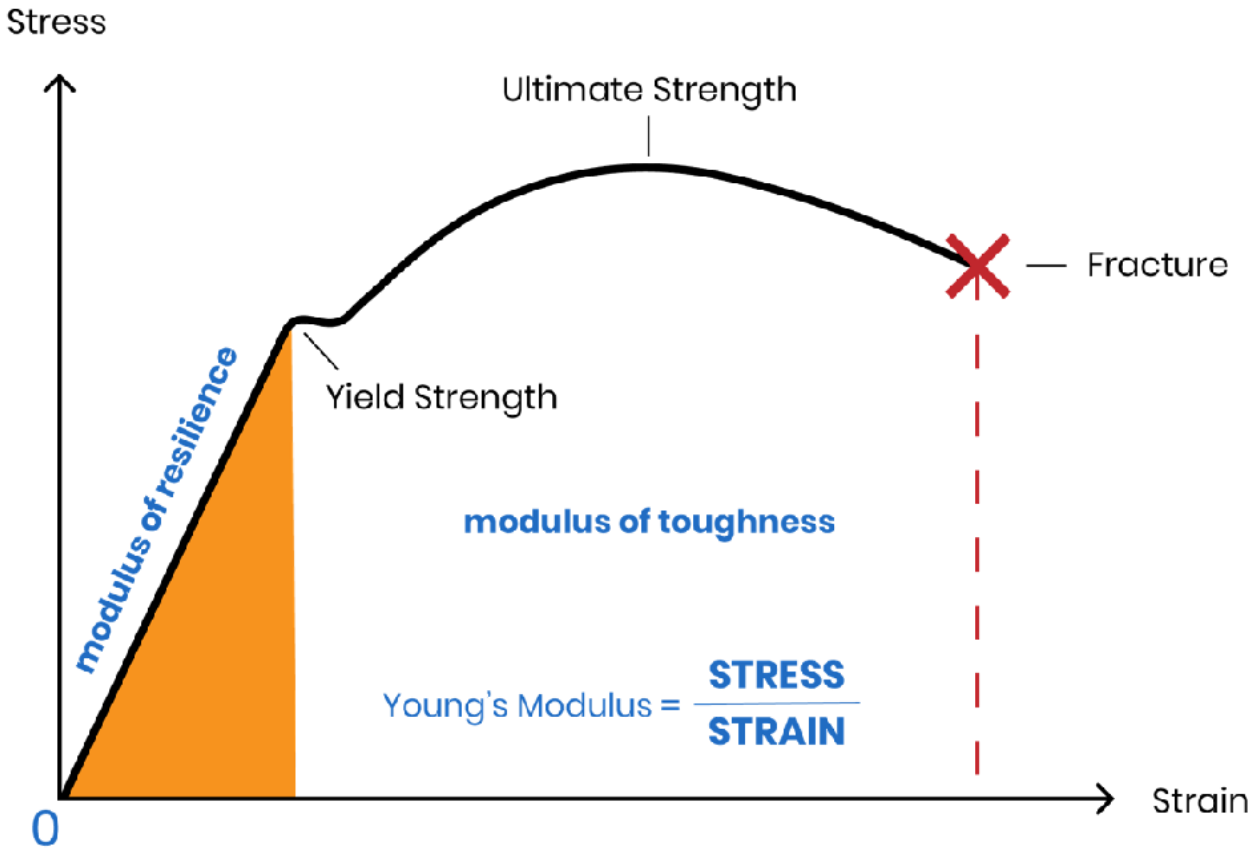


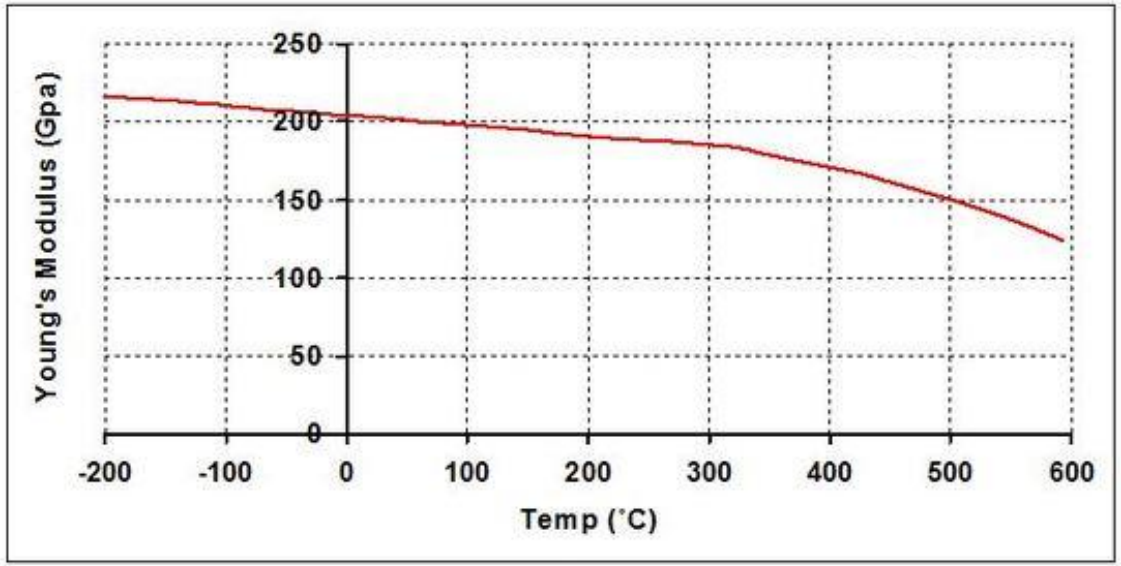
SAME TIRE, DIFFERENT TRACK
=>
DIFFERENT OPTIMAL TEMPERATURE

5. SAME TIRE, DIFFERENT TRACK ⇨ DIFFERENT OPTIMAL TEMPERATURE



5. SAME TIRE, DIFFERENT TRACK ⇨ DIFFERENT OPTIMAL TEMPERATURE

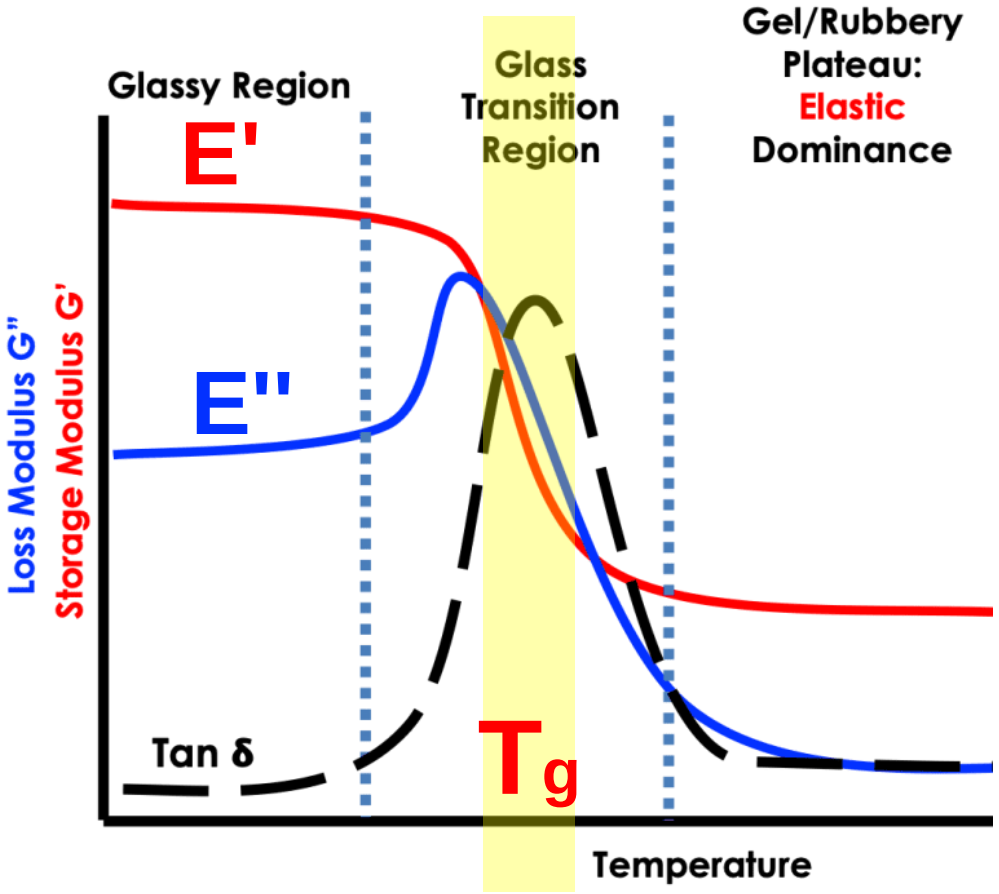


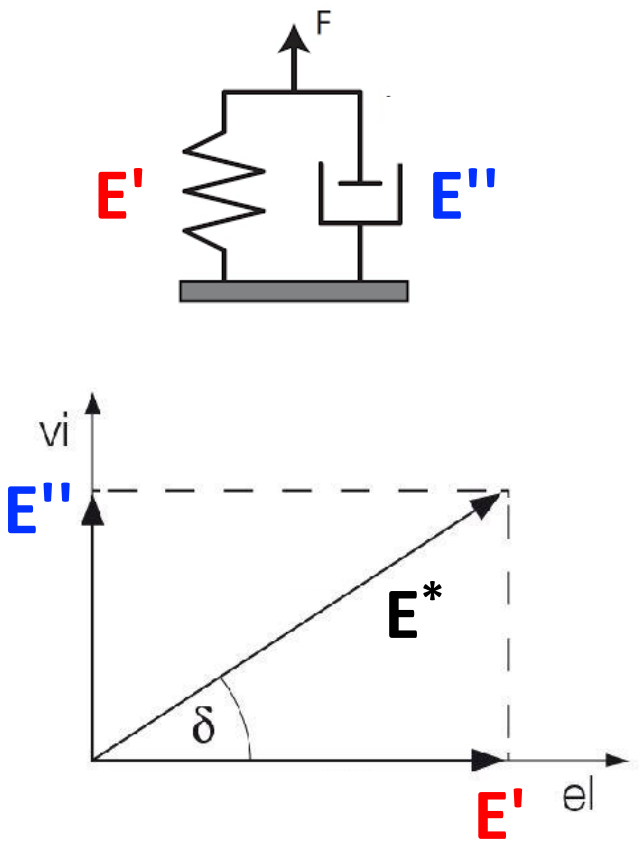


Young's Modulus vs. Temperature for Steel

ELASTIC MATERIALS BEHAVIOUR

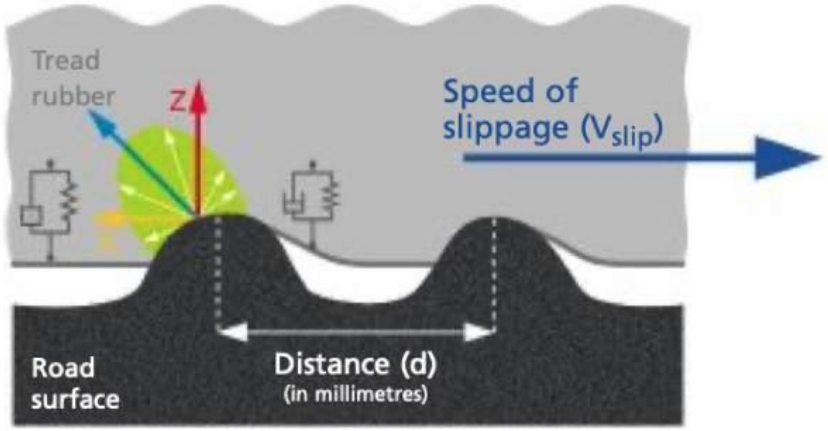
5. SAME TIRE, DIFFERENT TRACK ⇨ DIFFERENT OPTIMAL TEMPERATURE



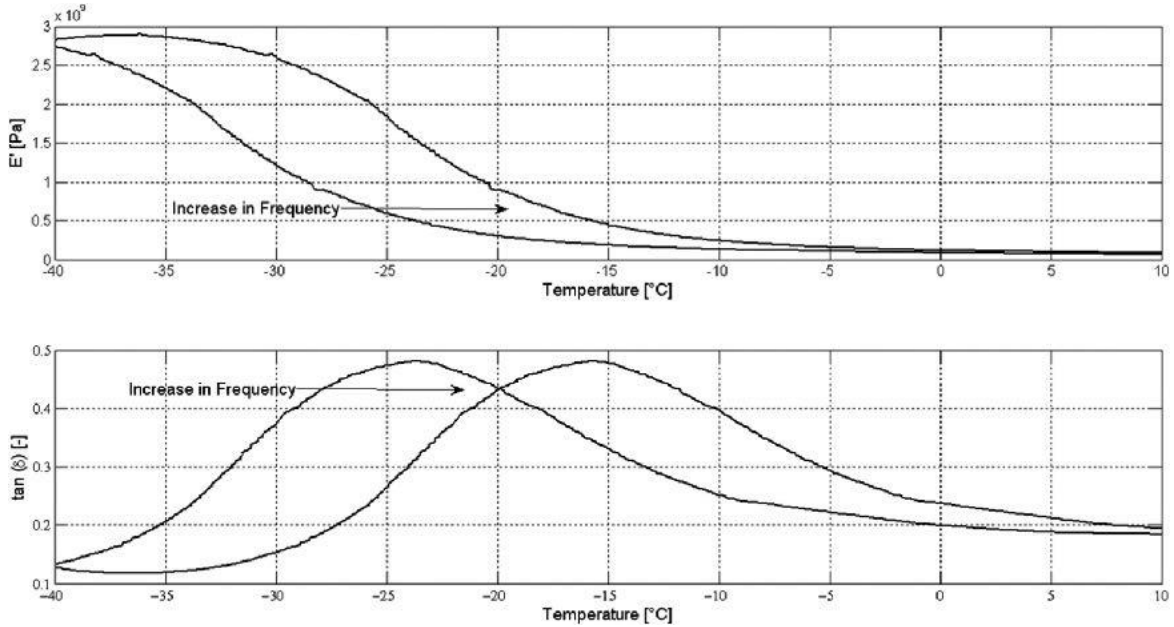


VISCO-ELASTIC MATERIALS BEHAVIOR

5. SAME TIRE, DIFFERENT TRACK ⇨ DIFFERENT OPTIMAL TEMPERATURE



f [Hz] = Vs / d



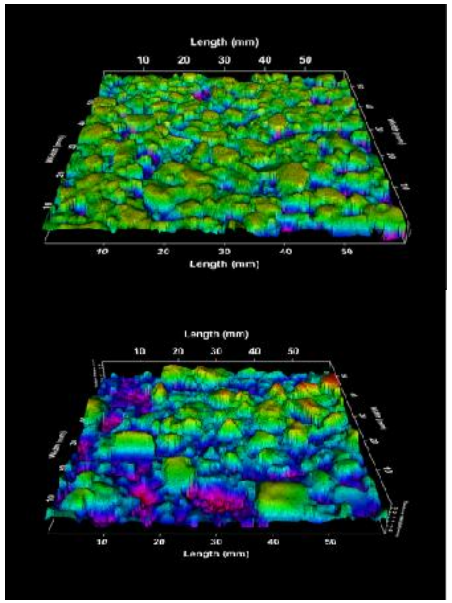
$$\log(a_T) = \frac{-C_1(T - T_r)}{C_2 + (T - T_r)} \Rightarrow \log\left(\frac{f_2}{f_1}\right) = \frac{T^* - T_1}{\Delta T}$$

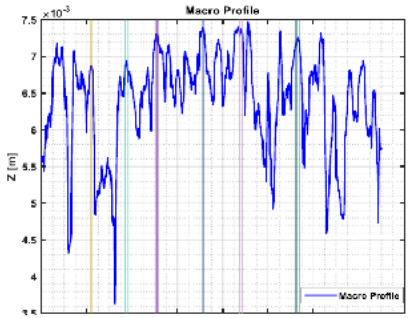
$$E(f_1, T_1) = E[f_2, \alpha(T_1)]$$

(Williams, Landel & Ferry Law)

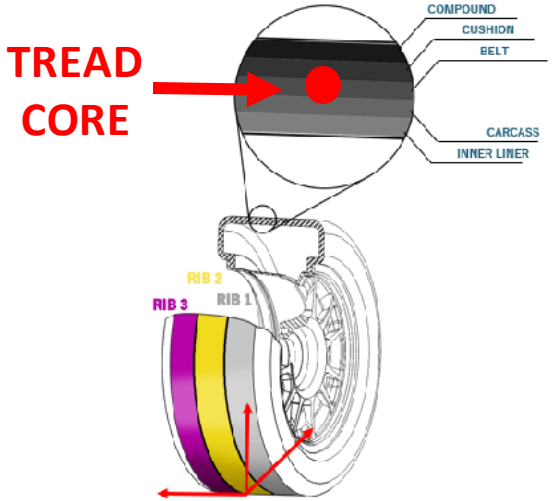
TEMPERATURE/FREQUENCY SUPERPOSITION

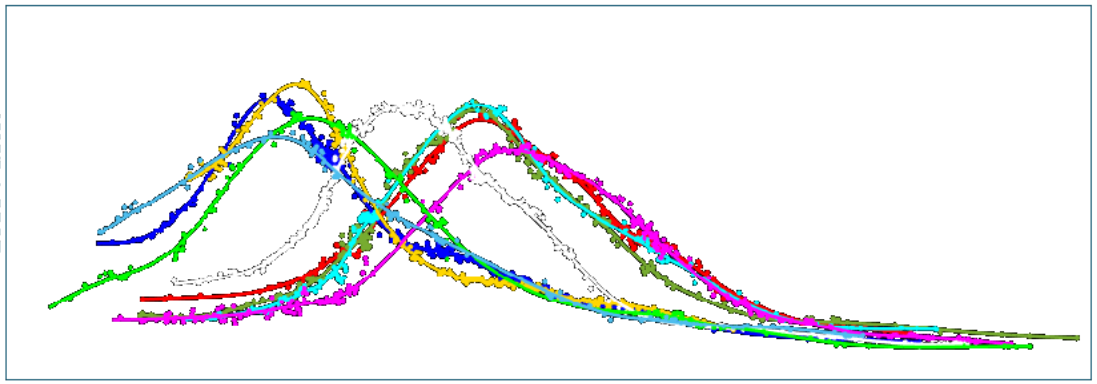
5. SAME TIRE, DIFFERENT TRACK ⇨ DIFFERENT OPTIMAL TEMPERATURE





KNOWLEDGE ON TARMAC MACRO/MICROROUGHNESS

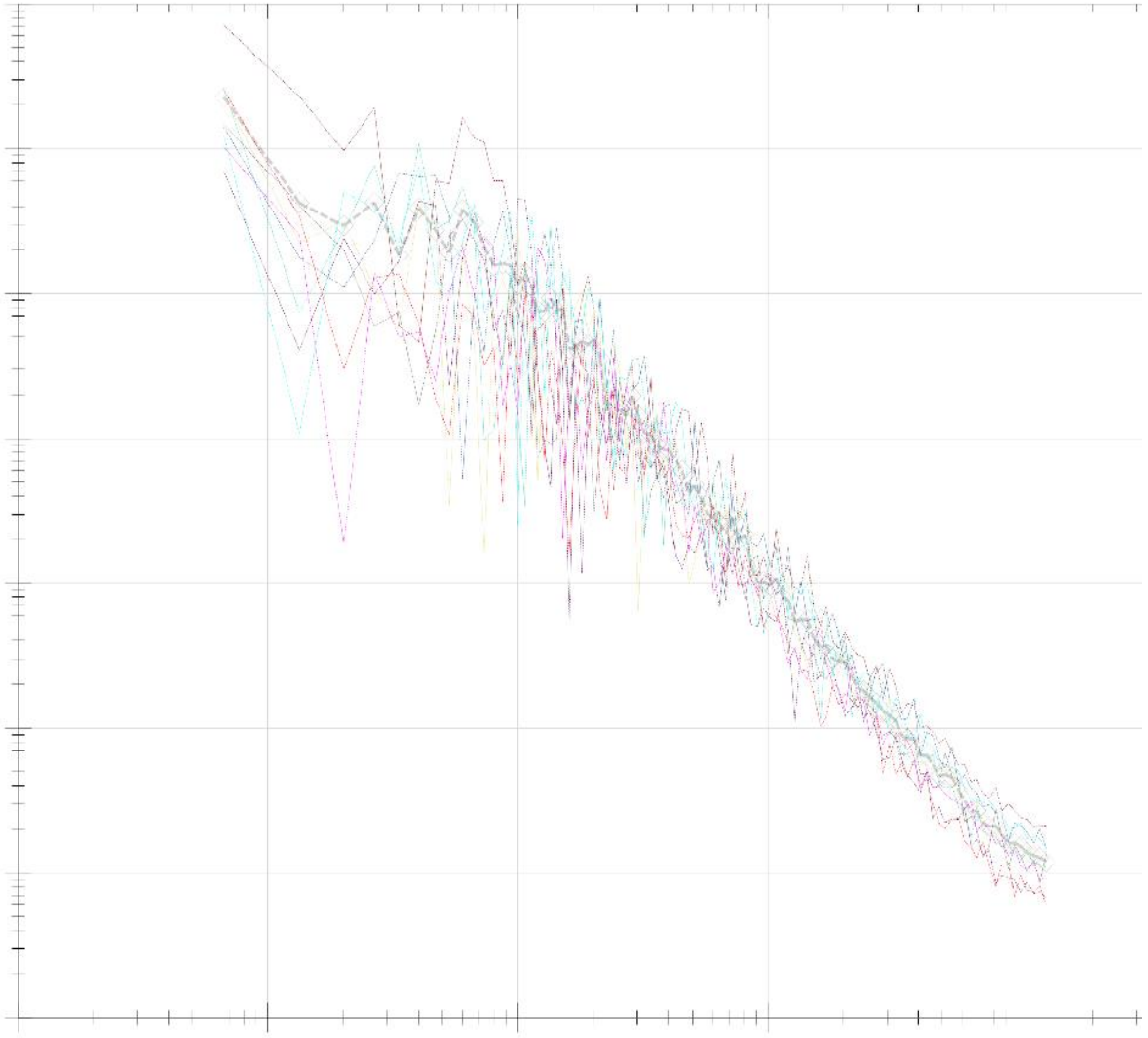


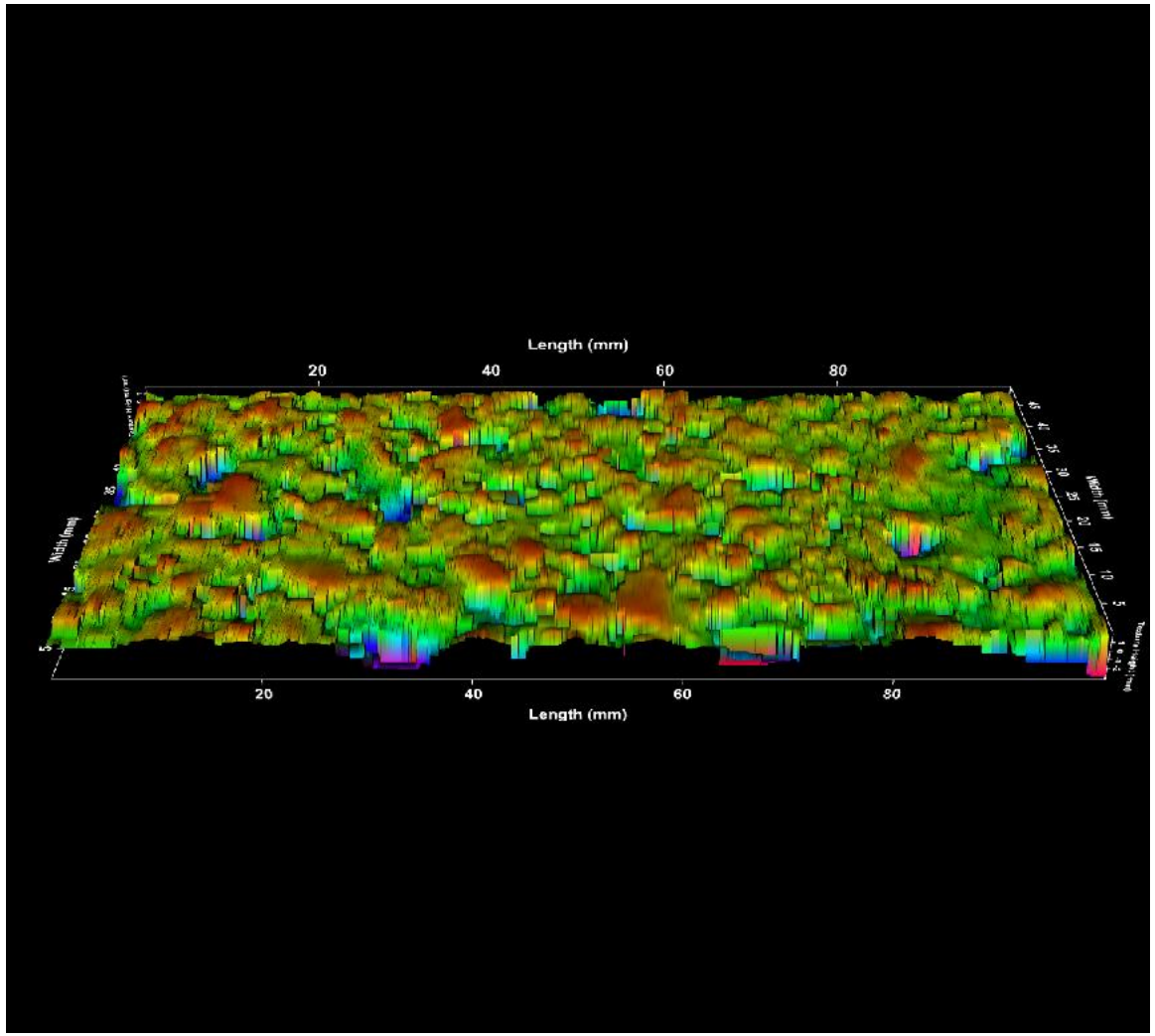


KNOWLEDGE ON TIRES VISCOELASTICITY

GRIP IS NOT INFLUENCED BY VOLUMETRICS…

SURFACE COURSE - LIDAR ANALYSIS - PSD





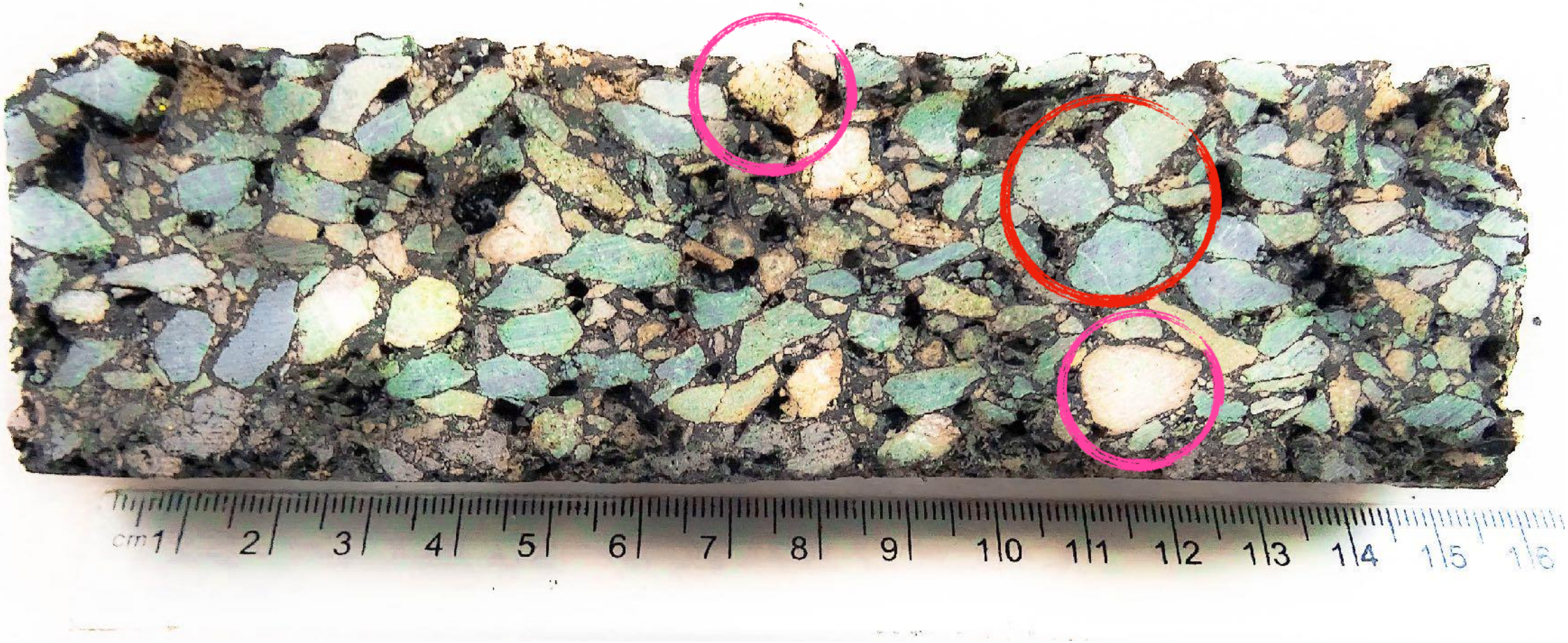
CORES ANALYSIS



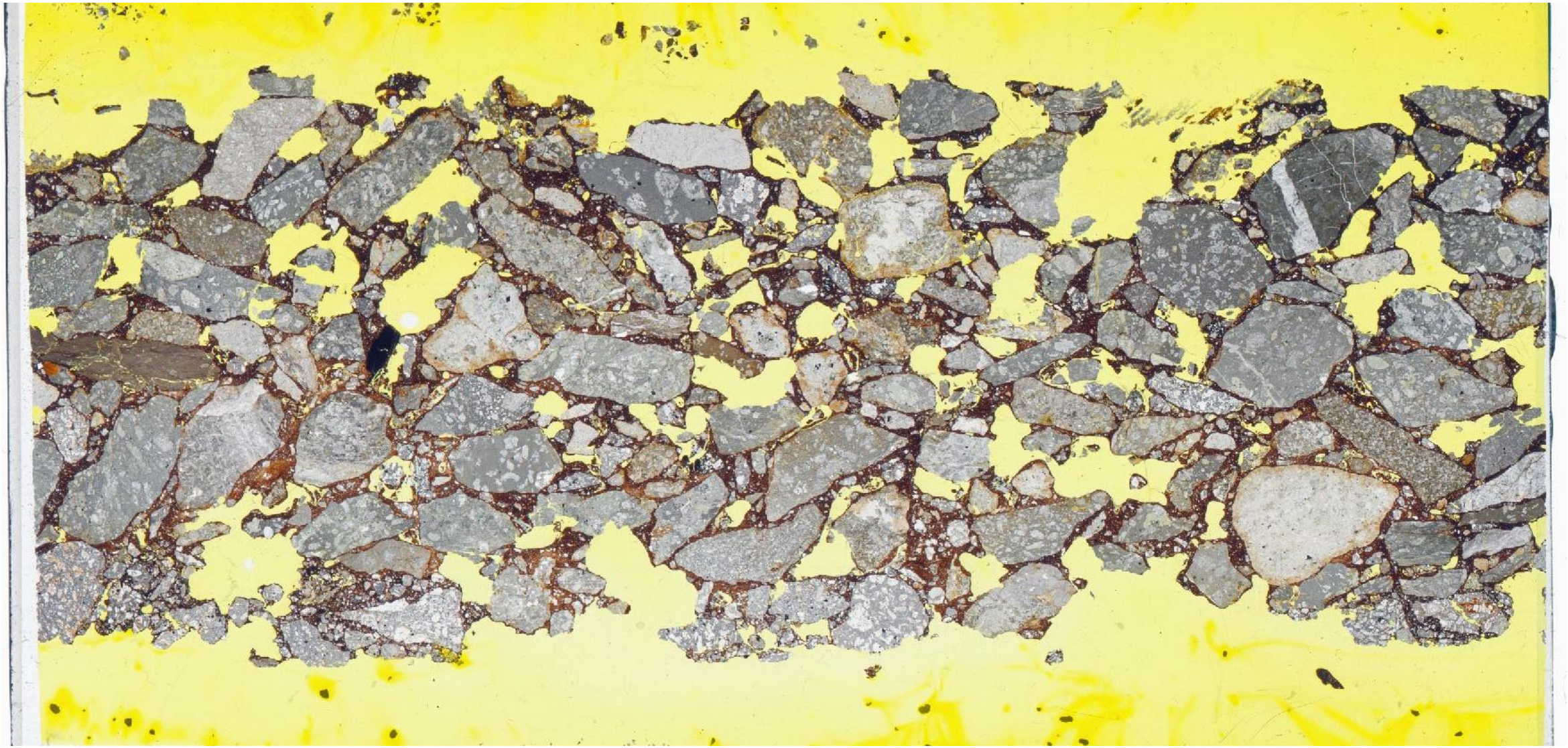

SMA 2021 - T15L

SMA 2021 - T15L - VOIDS 14,5%

SMA 2021 - T15L - PETROLOGY - 2 DIFFERENT TYPES



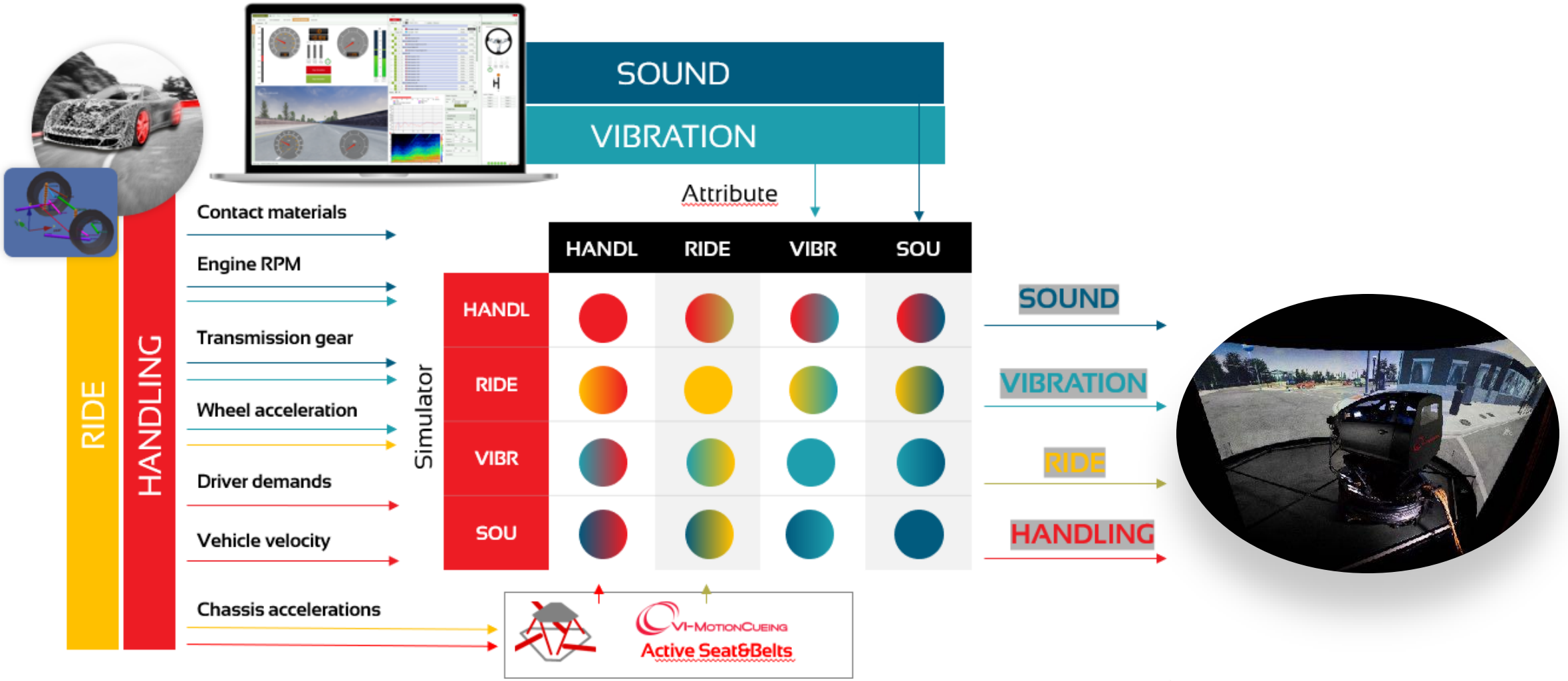
SMA 2021 - THIN SLICE



GRIP IS NOT INFLUENCED BY VOLUMETRICS…
…BUT THE NOISE IS!

HANDLING, RIDE, VIBRATION, SOUND INTEGRATION AS WHOLE

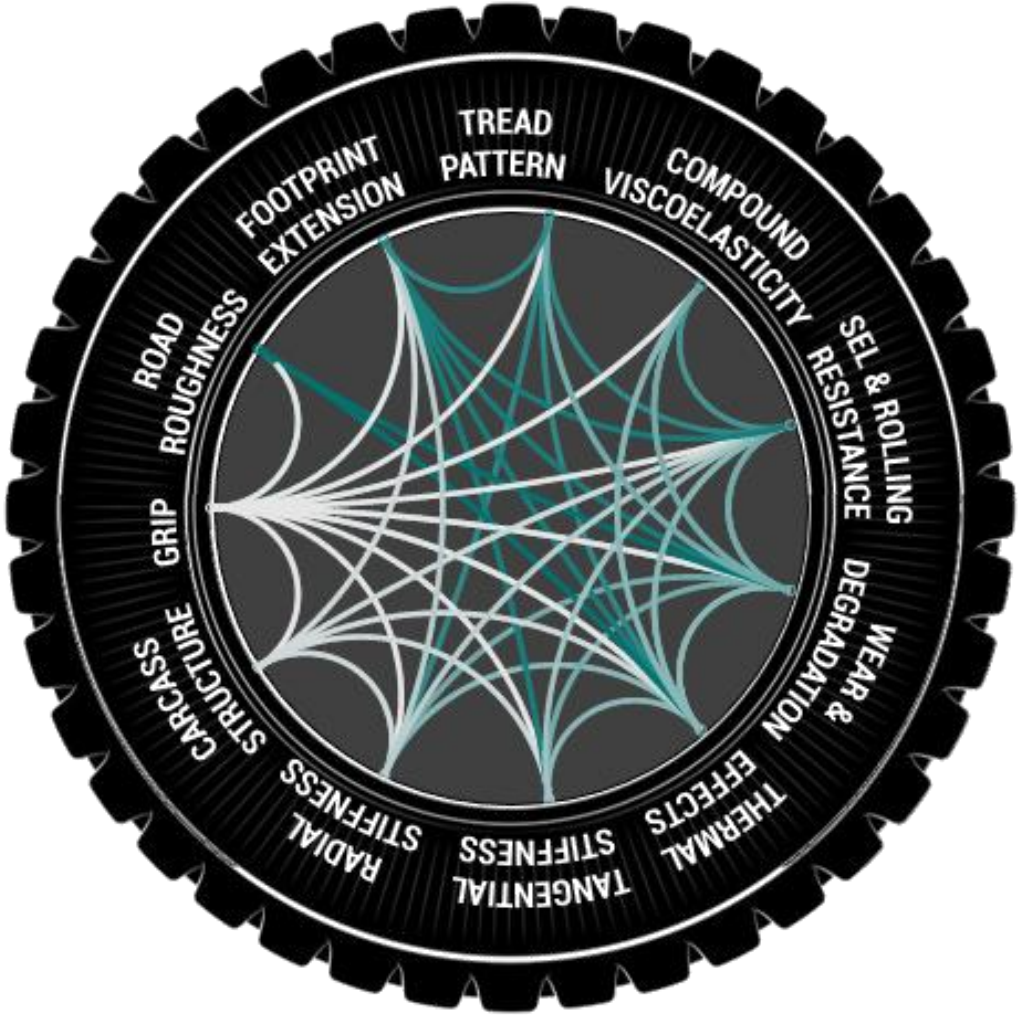
7. HANDLING, RIDE, VIBRATION, SOUND INTEGRATION AS WHOLE



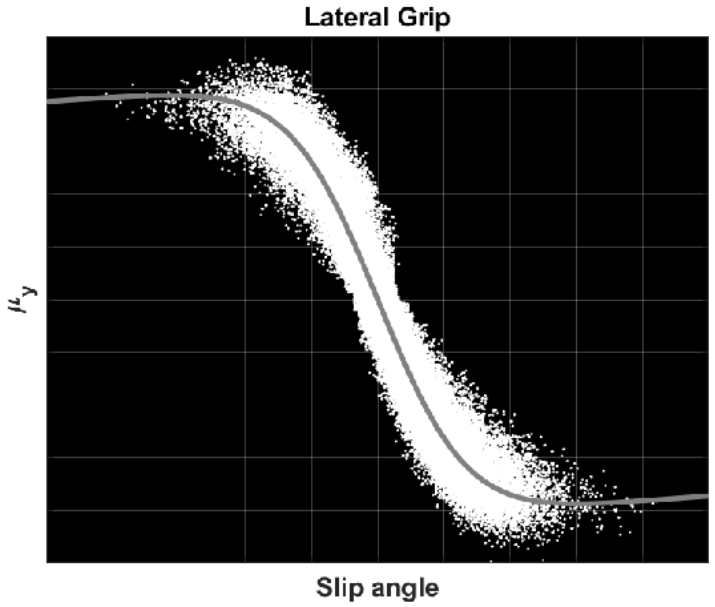
“PANTA REI"
APPLIED TO VEHICLE DYNAMICS

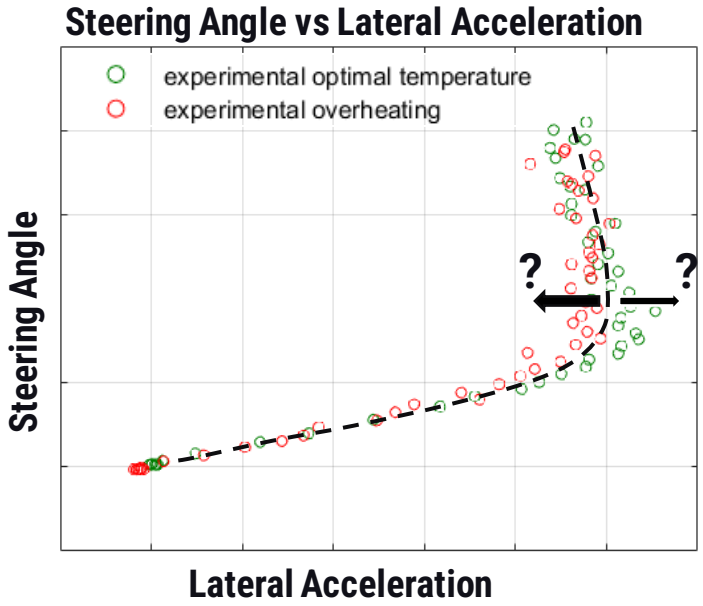
8. "PANTA REI" APPLIED TO VEHICLE DYNAMICS

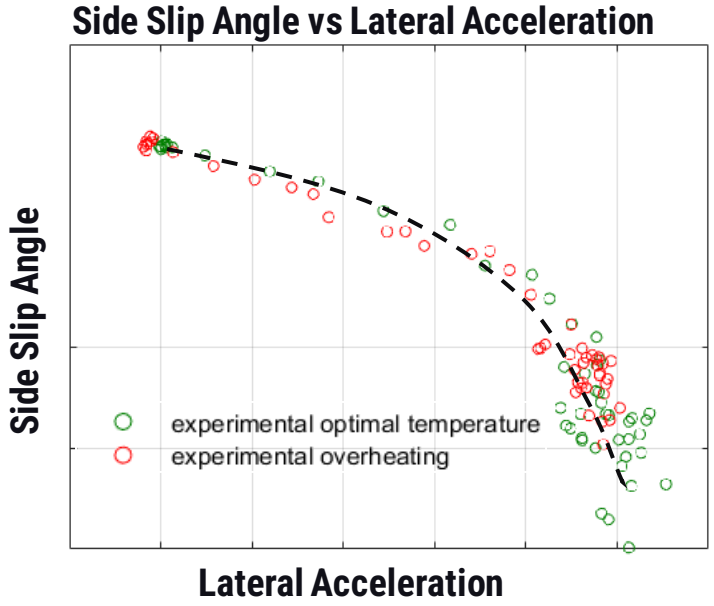
"IT IS NOT POSSIBLE TO STEP TWICE INTO THE SAME RIVER, IT IS NOT POSSIBLE TO RUN TWICE THE SAME TIRE"



8. "PANTA REI" APPLIED TO VEHICLE DYNAMICS

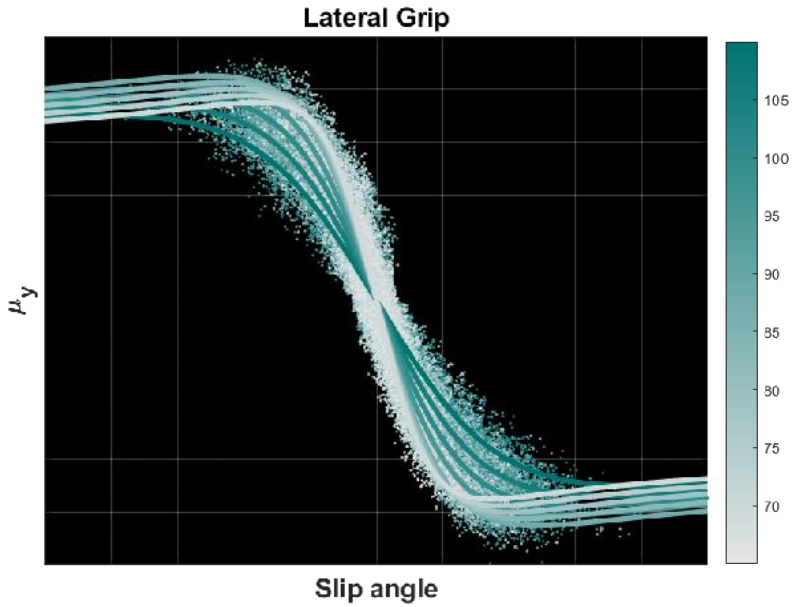


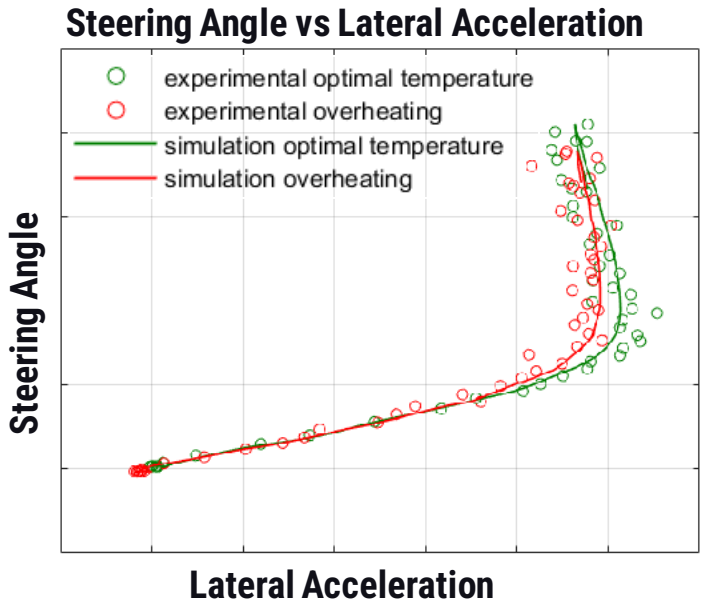


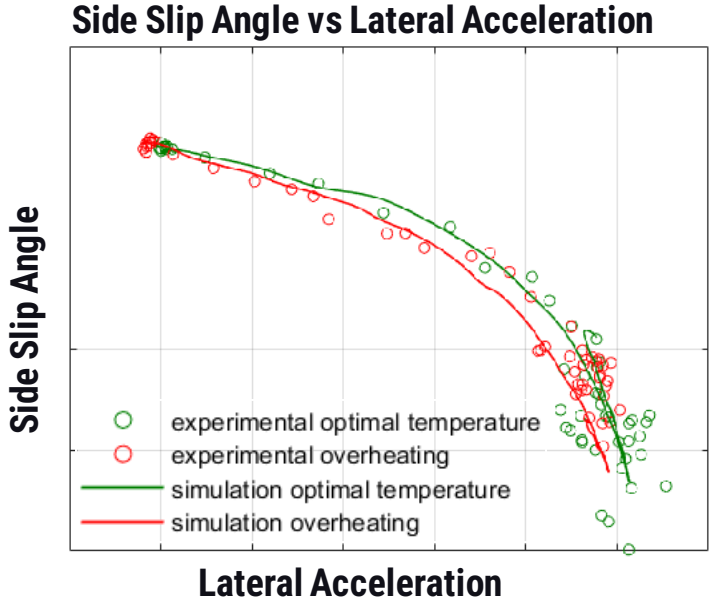


WHAT IF WE ASSUME A CONSTANT CORNERING STIFFNESS AT A REFERENCE TEMPERATURE?

8. "PANTA REI" APPLIED TO VEHICLE DYNAMICS

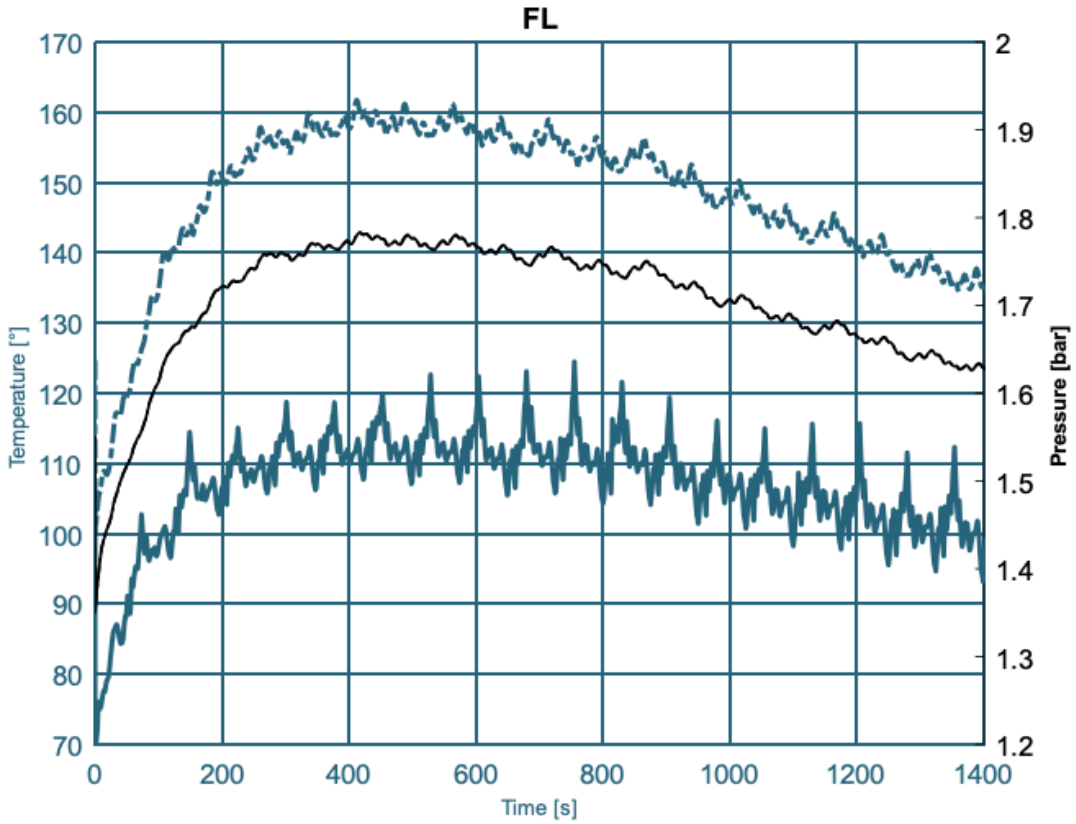






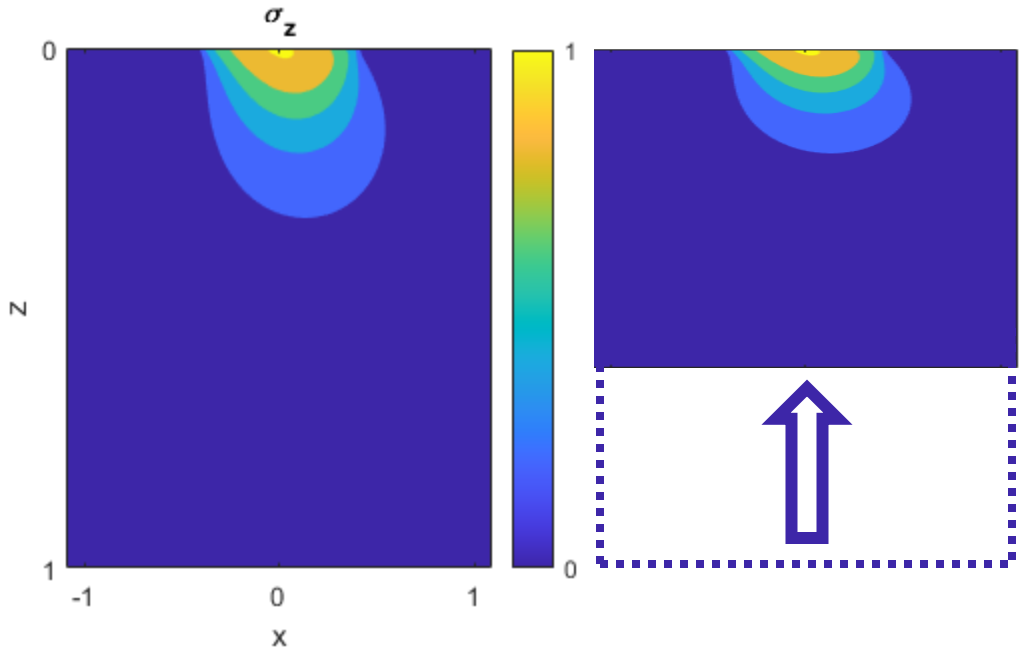
WHAT IF WE ASSUME A CONSTANT CORNERING STIFFNESS AT A REFERENCE TEMPERATURE?

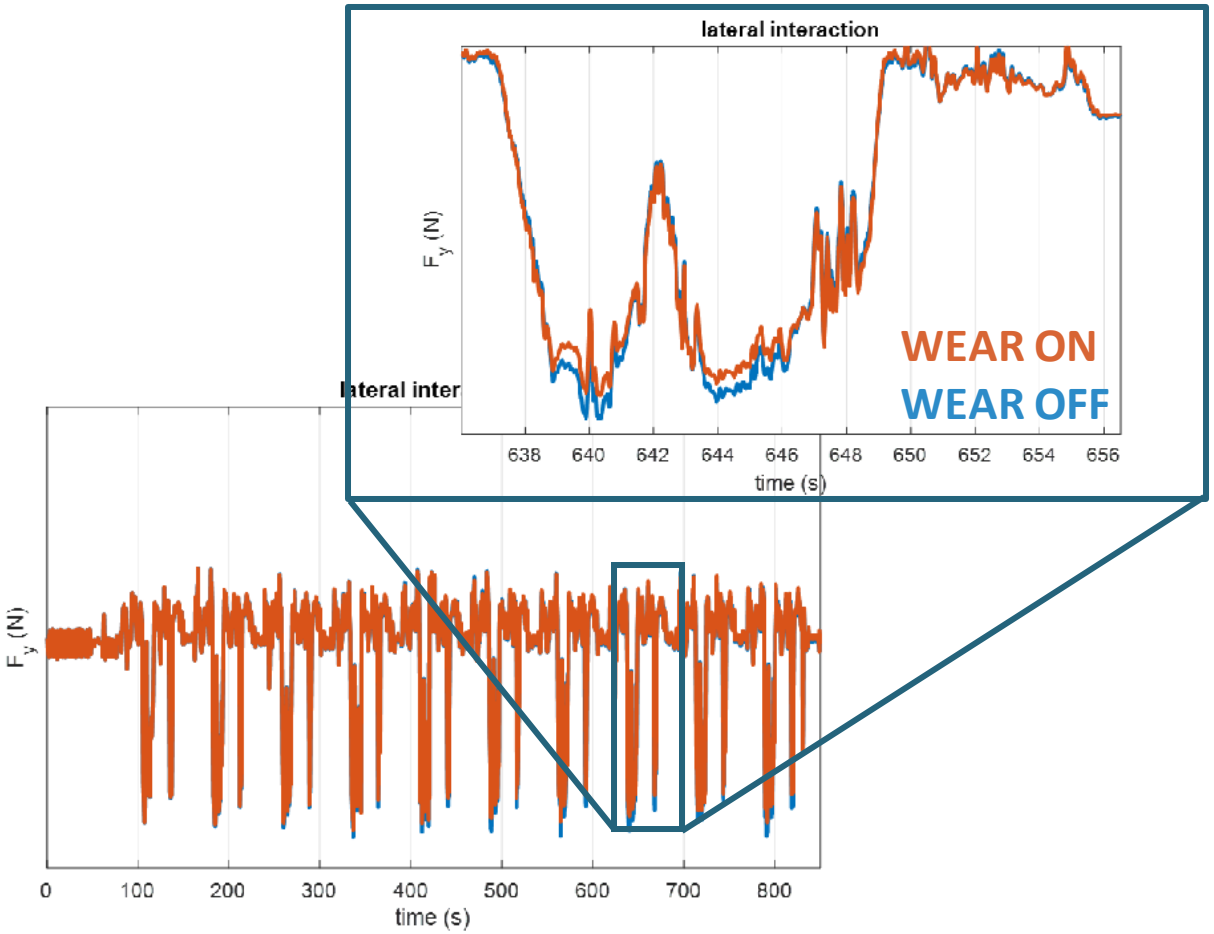
8. "PANTA REI" APPLIED TO VEHICLE DYNAMICS



WHAT IF WE ASSUME THE TREAD THICKNESS CONSTANT DURING A WHOLE RUN?

8. "PANTA REI" APPLIED TO VEHICLE DYNAMICS





WHAT IF WE ASSUME THE TREAD THICKNESS CONSTANT DURING A WHOLE RUN?

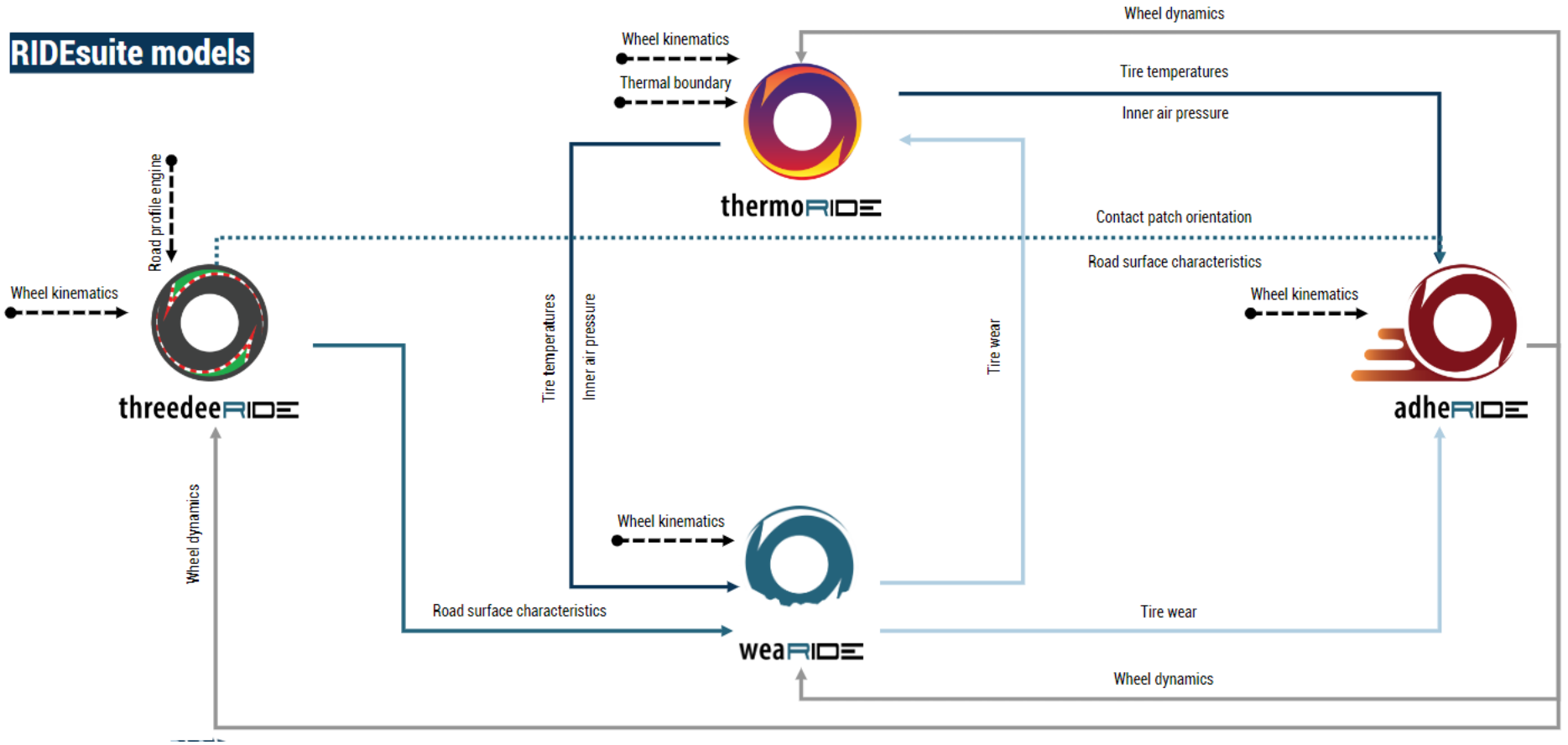
8. "PANTA REI" APPLIED TO VEHICLE DYNAMICS

01 adheRIDE
MF-EVO module an infrastructure consisting of an evolved MF model

02 thermoRIDE
Thermal module a real-time thermodynamic model

03 threedeeRIDE
Multicontact module a multi-contact ride model

04 weaRIDE
Wear module a model for the prediction and analysis of wear



WE NEED A MULTI-PHYSICAL LANGUAGE FOR MULTI-PHYSICAL PHENOMENA

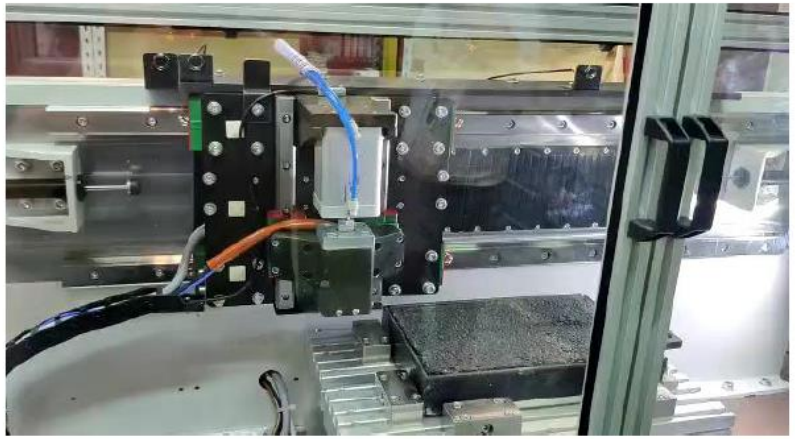
MULTIATTRIBUTE-MULTICUEING-ZEROLATENCY

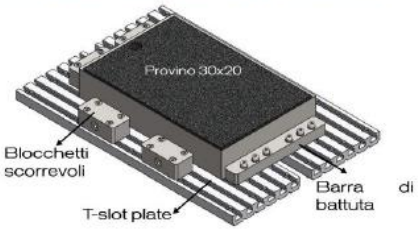
9. MULTIATTRIBUTE-MULTICUEING-ZEROLATENCY

Simulation/Simulator	Cueing Off-line/On-line	MultiAttribute	Harmonize
Use off-line and on-line Simulation in a sinergic way with the Simulator	Use off-line MotionCeuing and MultiCueing on the Simulator for consistent platform motion and active seat and belts complementary actions	Introduce MultiAttribute Simulation paradigm as early as possible to include consistently a whole sensorial perception	Harmonize Driving Simulator subsystems outputs to reduce absolute latencies and eliminate relative differences

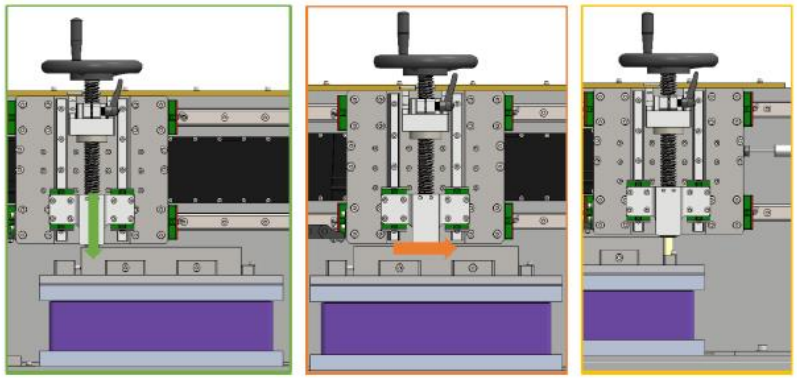
THERE'S STILL A LOT TO KNOW ABOUT GRIP

LESSON 10.

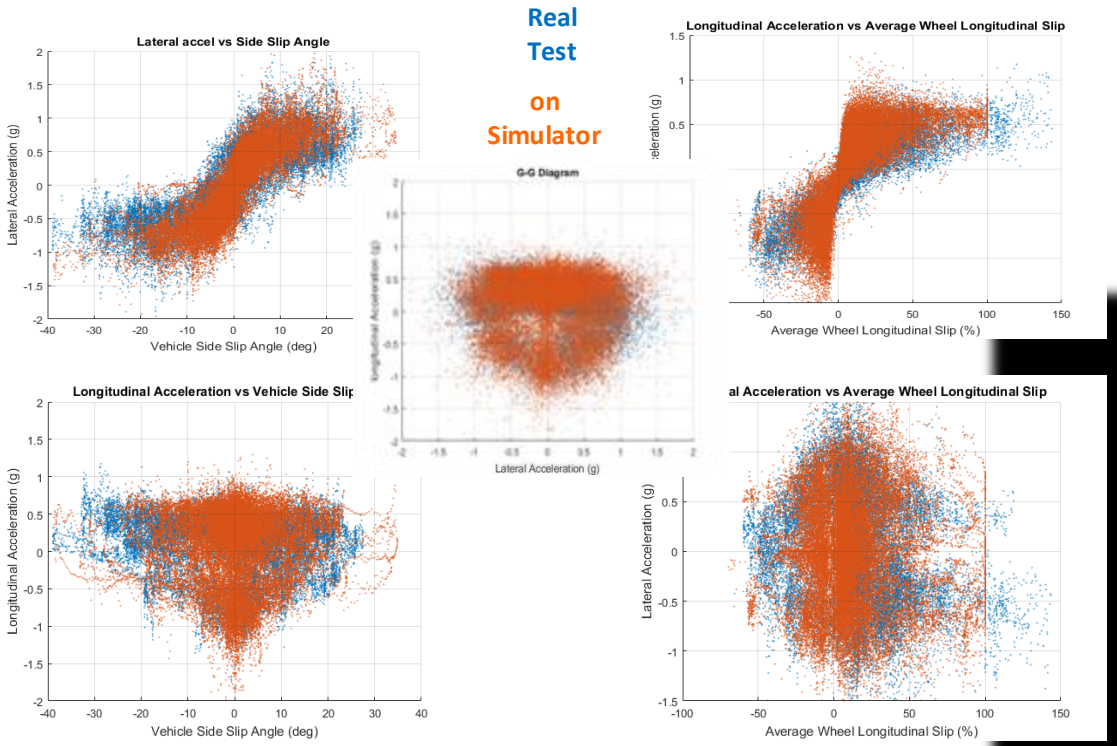



Provino 30x20
Blocchetti scorrevoli
Barra battuta
T-slot plate

di



LESSON 10.



GRIP ON GRAVEL? MUCH TO LEARN ON A SIMULATOR!

MEGARIDE VI-GRADE DROMO

THANK YOU