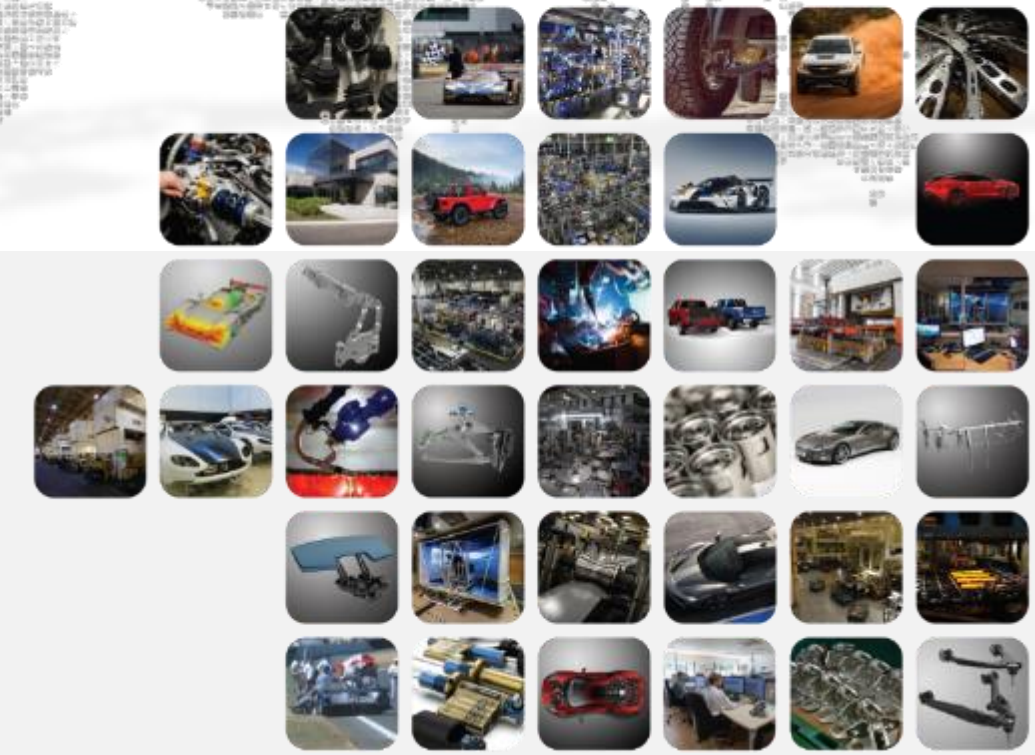
Multimatic



Update on the Application of FTire to Ride Development

2025 Zero Prototypes Summit NA
12 June 2025 – Novi, MI

Tony Yardley, Multimatic
Andre Alvarez, Multimatic

Kyle Markland, Multimatic

Acknowledgements

Cosin

Benjamin Rieff	Cosin Scientific Software

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Multimatic

Tony Yardley	Multimatic
Andre Alvarez	Multimatic
Kyle Markland	Multimatic

MICHELIN

MICHELIN

Multimatic

Industry Leaders in Tire Design, Analysis, and Manufacturing






Globally recognized expertise in tire modeling

Michelin Developed Models

Commercial Tire Models

cosin scientific software

TameTire Powered by Michelin

MFSwift

MFTyre

CDTire

Multimatic

Multimatic delivers manufactured products and engineering services to the global automotive industry… at any volume level.

Low Volume Production → **High Volume Production**

Suspension Products

Structural Products

Mechanism Products

Ford Mustang GTD

One of Multimatic's niche vehicles based on the S650-generation Ford Mustang

In-board rear suspension

Multimatic's ASV (Adaptive Spool Valve), DHR (Dual - Height Rate)

Front Tire 325/30R20

Rear Tire 345/30R20

Tires

MICHELIN

PILOT SPORT CUP 2 R

Exceptional track performance made to last.

MICHELIN Pilot Sport Cup 2 R track tires are designed for ultra-high performance for sports and hypersport cars, with sensational times.[1]

- MICHELIN Semi-Slick high performance track tyres, road approved
- The best lap times on the track[1]
- In the dry, extreme lateral grip and driving precision[1]
- Mounted on the most powerful cars, such as Porsche, Ferrari, Mercedes-AMG, Koenigsegg and Corvette

Tire Constructions

Development of the Mustang GTD in 2024 spawned several tire construction iterations.

Of interest in this study are two constructions codenamed “CC” and a later iteration “LN.”

The LN tire was developed to meet program needs at the expense of ride quality relative to the CC tire.

Multimatic’s simulation capability and high-fidelity Mustang GTD vehicle model enabled virtual testing to “close the loop” on developments made on-vehicle.

As a continuation of Multimatic’s tire modeling efforts last year, FTire was identified as a tool to virtually capture and study the differences in these constructions.

Project Scope

Performed by Michelin

Measure CC and LN tire constructions in the lab

Generate FTire models of each construction

Performed by Multimatic

Perform offline simulations and quantify differences using Multimatic's Ride Metrics

Perform subjective evaluation on Full Spectrum Simulator (FSS)

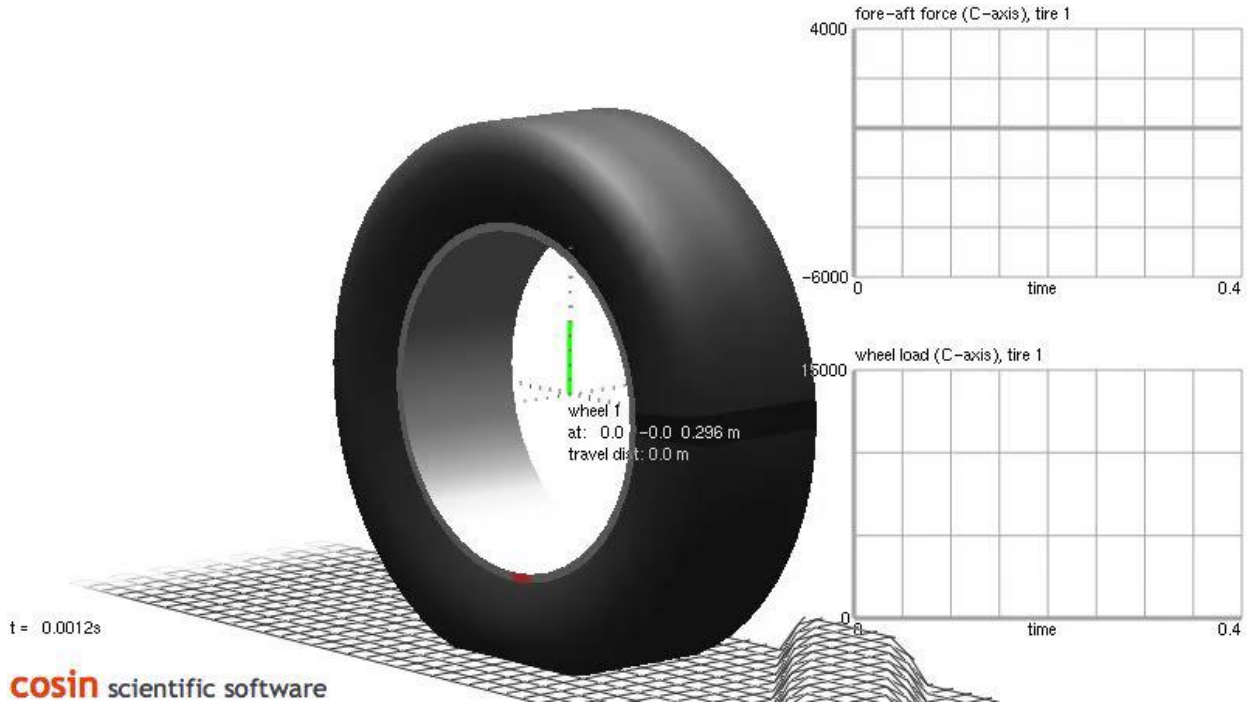
Tire Simulation Models

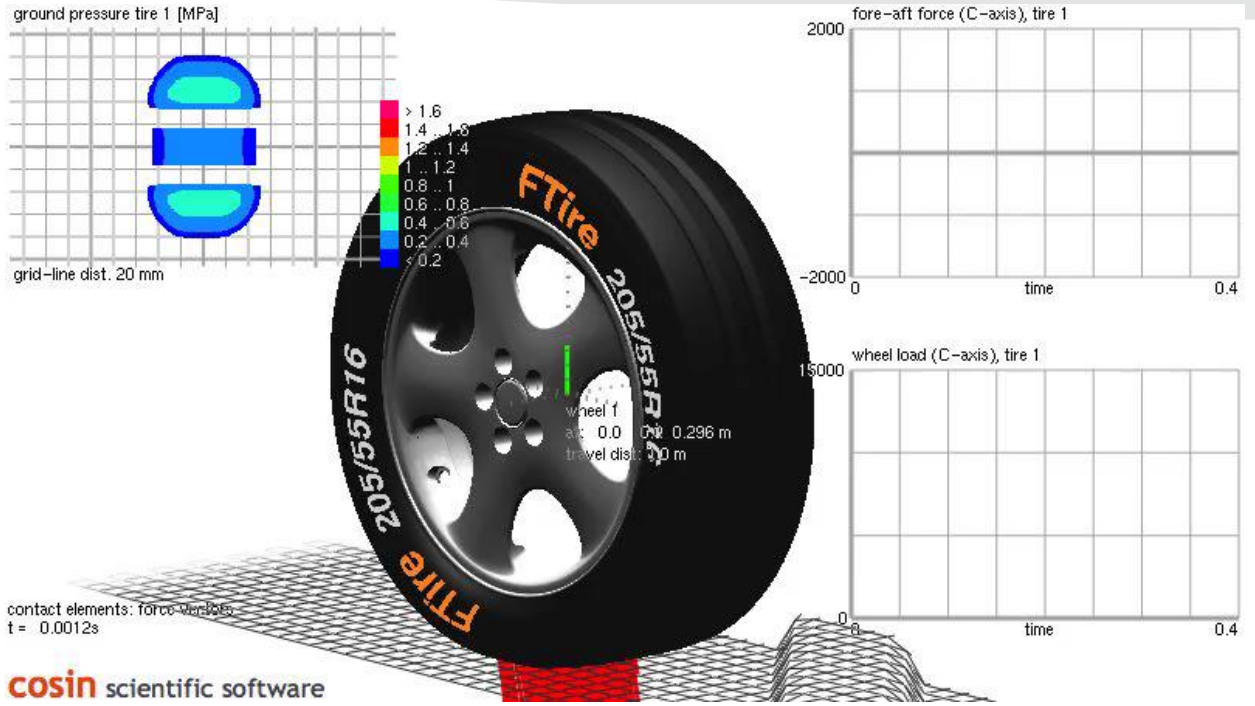
Approximation (MF) Models

one single contact point

Physical Model - FTire

many hundreds contact points,



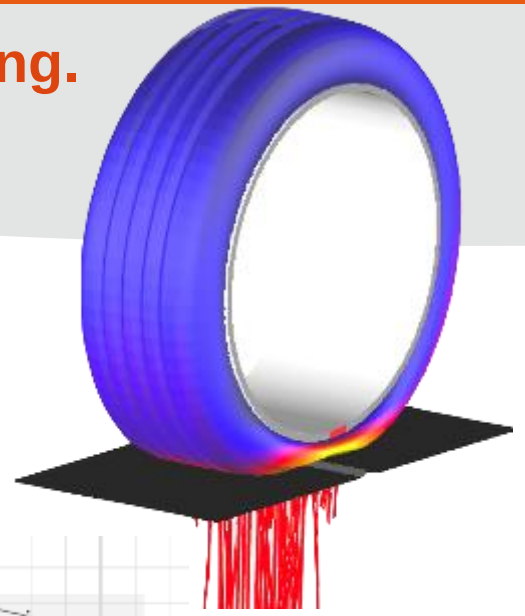


Slow rolling over curbstone

Simulating Real Tire Dynamics

Core mechanical model:

Structural Dynamics Modelling.

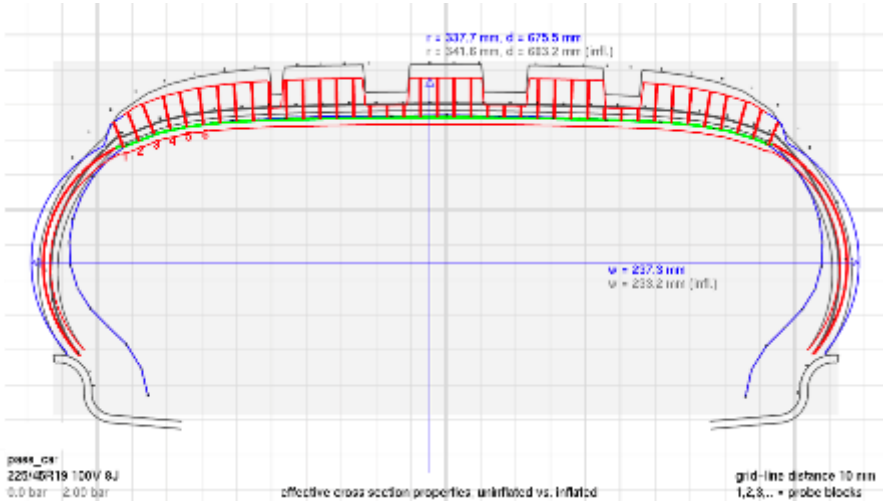


1.Tire structure consisting of bead, carcass, belt: sub-divided into 60 .. 360 (or more) belt segments connected to each other and to the rim by:

- non-linear stiffness and damping
- pressure-dependent distributed stiffness and damping elements

2.Tread consisting of 1000 .. 10000 (or more) contact elements connected to belt segments, sticking / sliding on road surface

- non-linear rubber stiffness and damping
- friction coefficient dependent on:
  - sliding velocity
  - ground pressure
  - temperature



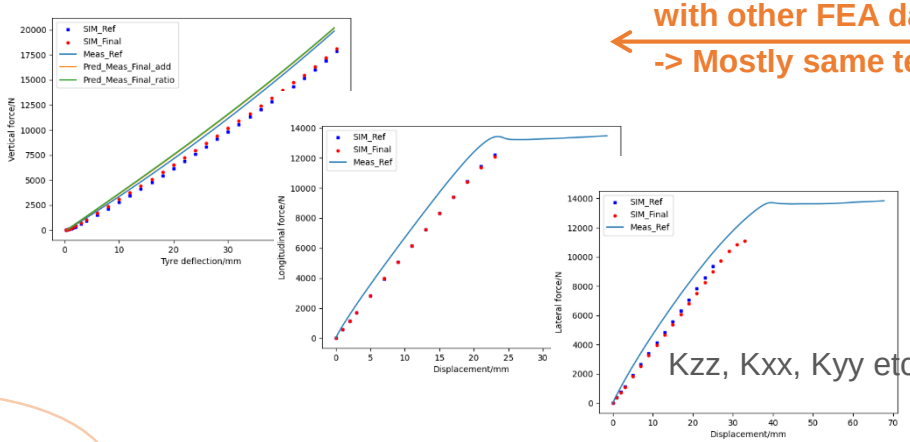
cosin
scientific software

Comfort-Oriented Relative FTire Fitting

Basic assumption: FEA simulation can correctly reflect the impact of design changes (ranking & amplitude) on these fitting conditions

*Rear tire as example

Fitting condition curves



Kzz, Kxx, Kyy etc.

4. Cross-check with other FEA data -> Mostly same tendency

FTire

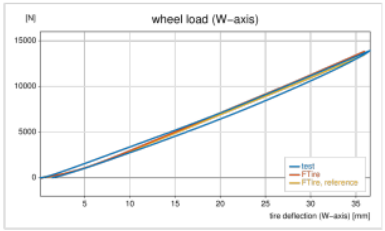


Fig. 12.2: vertical stiffness on flat surface, 2.31 bar, γ = -0.11 deg

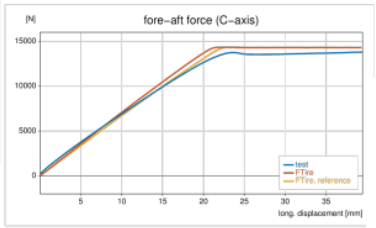


Fig. 12.11: longitudinal stiffness on flat surface, F_z = 11.19 kl 2.31 bar, γ = -0.1 deg

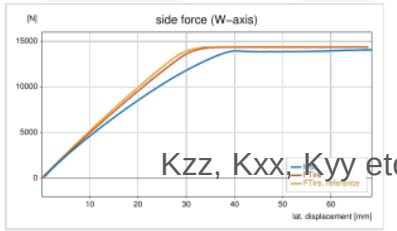
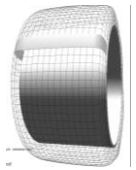


Fig. 12.14: lateral stiffness on flat surface, F_z = 11.19 kN, 2.31 bar, γ = -0.12 deg

Kzz, Kxx, Kyy etc.

3. Get fitting report for curve changes

1. Predicted change in modal properties



Modal properties

Boundary condition: Loaded, rolling

Frequency			
Tire mode	Ref	Final	Variation
X mode	33.31	34.26	2.9%
Z mode	73.31	75.35	2.8%
Y mode	55.67	55.51	-0.3%
Damping			
Tire mode	Ref	Final	Variation
X mode	7.93	7.61	-4.0%
Z mode	5.22	4.64	-11.1%
Y mode	5.28	5.24	-0.8%

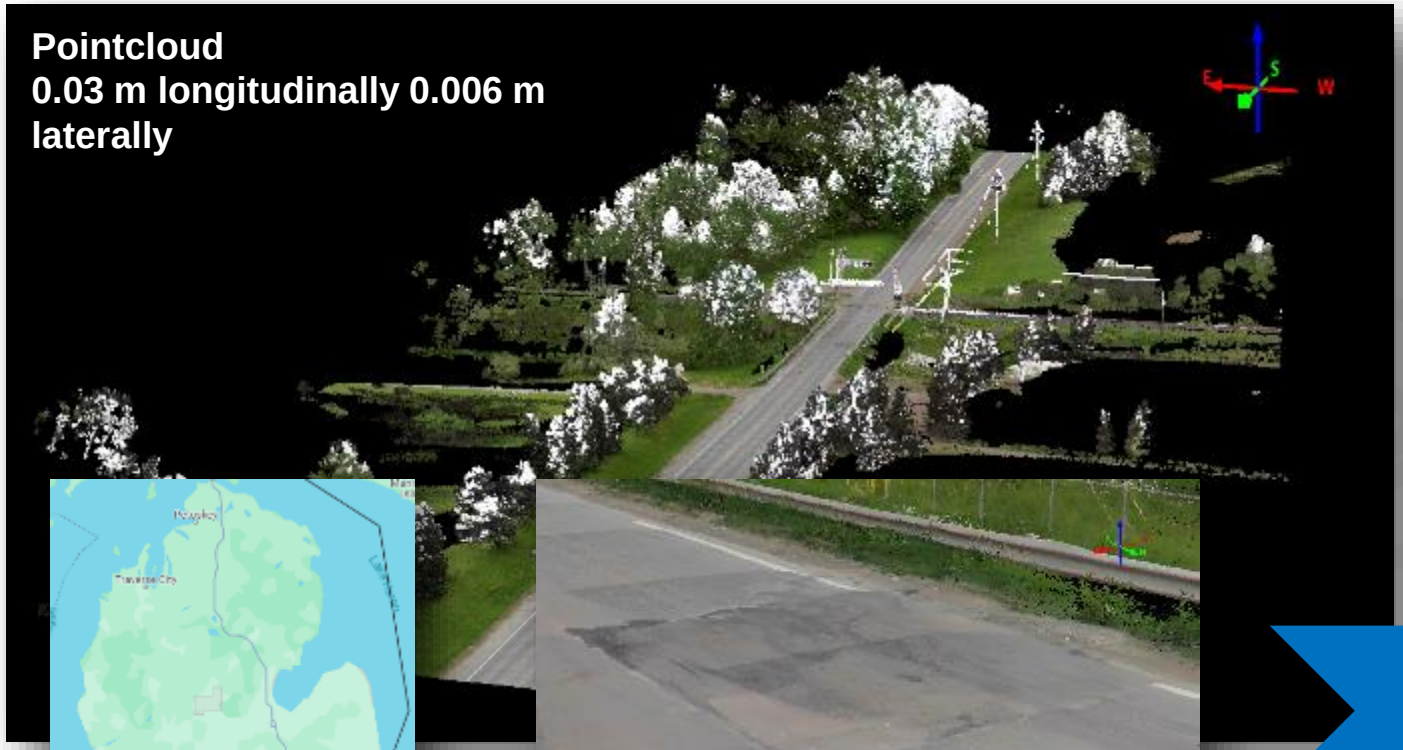
2. Relative fitting to reflect change

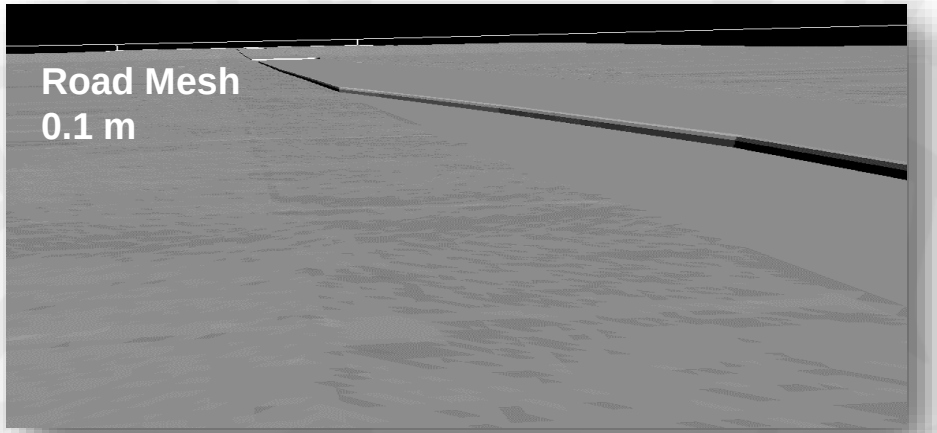
Boundary condition: Free-free

Frequency			
Variation	Ref	Final	Tire mode
2.9%	63.8	65.67	R0/F1
2.8%	76.03	78.19	R1/F2
-0.3%	90.71	90.44	T1/F4
Damping			
Variation	Ref	Final	Tire mode
-4.0%	5.5	5.28	R0/F1
-11.2%	4.2	3.73	R1/F2
-0.8%	5.2	5.16	T1/F4

Generating a Virtual Road for Simulation

VI-Grade's GridMesh road surface generation process with a resolution of 0.01m

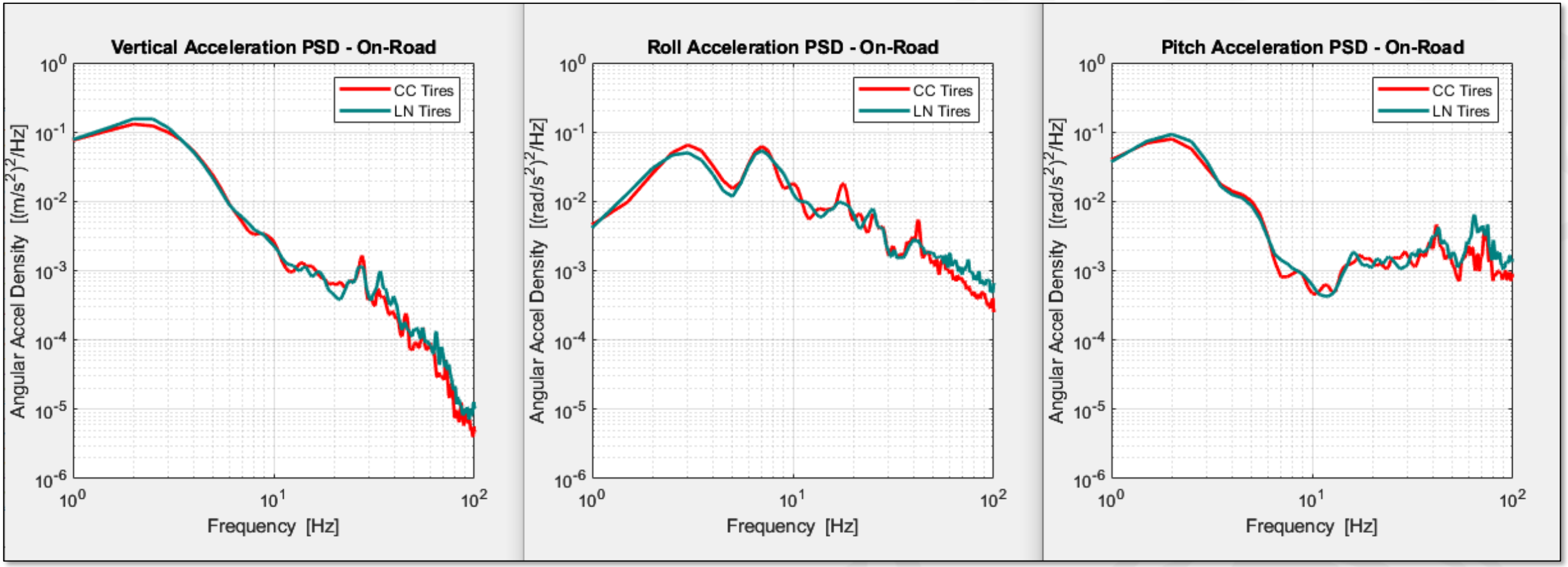




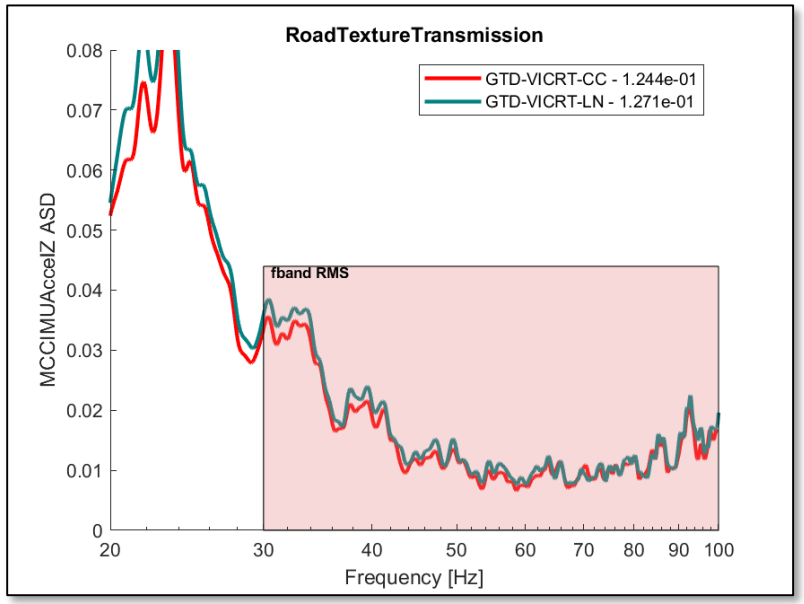
Ride Comfort View

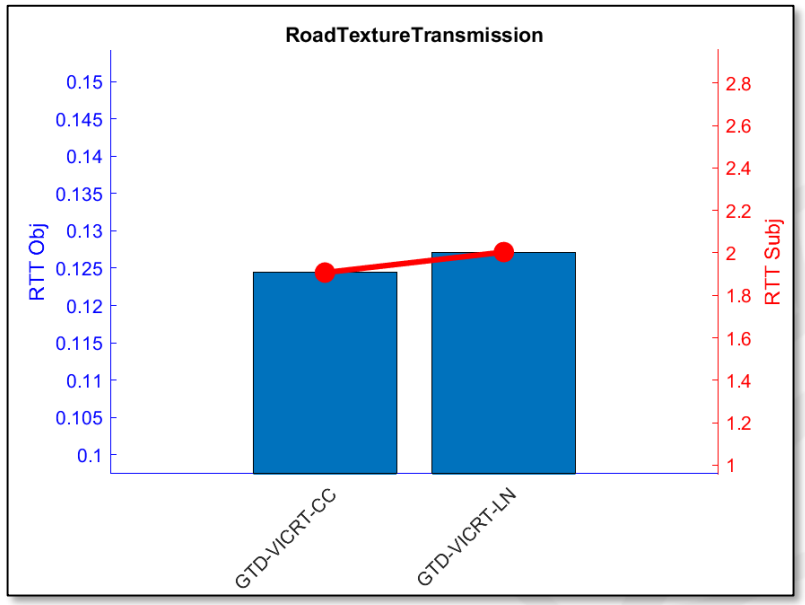
On-Road Vehicle Data

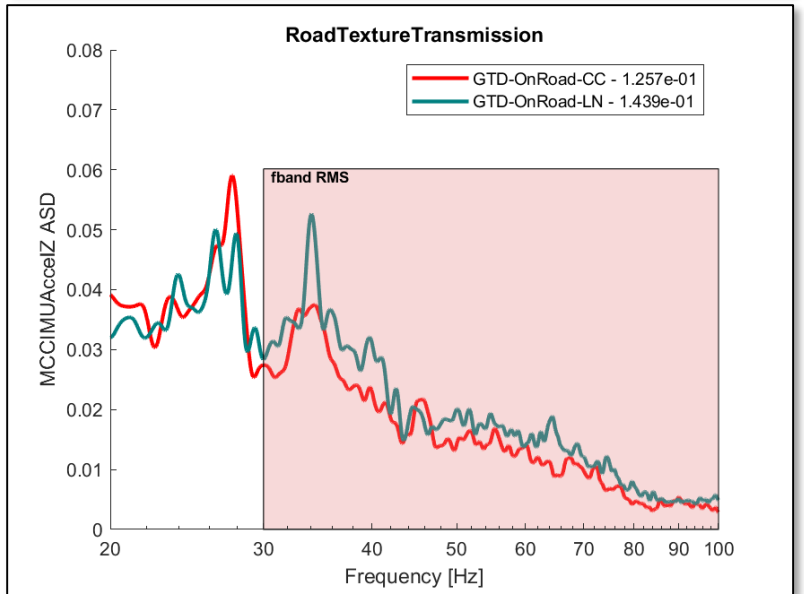
- Difference in ride comfort performance, between tires, is predominantly above 30 Hz
- Despite being several orders of magnitude lower amplitude, the difference are still noted by our evaluators

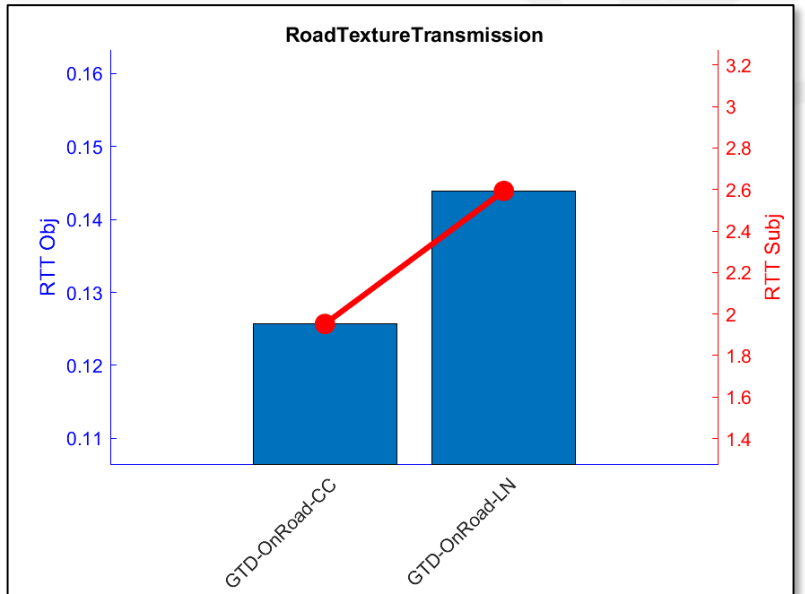


Road Texture Transmission









VI-CRT Simulation

- Rigid body
- No transfer function between suspension and body

On-Road Vehicle Data

- Real vehicle
- Complex transfer function from suspension to body

CC vs. LN: Full-Spectrum Simulator (FSS) Subjective Evaluation

The VI-Grade FSS is a ride dynamics simulator capable of reproducing the full frequency bandwidth of vehicle response (0 – 20 kHz).

A back-to-back comparison of FTire models representing CC and LN tire constructions was performed in realtime on virtual Coolidge Highway.

Development driver feedback:

- *LN feels more aggressive vertically, definitely more vertical activity. More choppiness, more midfrequency.*
- *Definitely can perceive a difference between them and the difference is directionally correct.*
- *This confirms the on-vehicle observation that LN tires are vertically stiffer than CC tires.*

Next Steps and Future Developments

Develop faithful transfer function representation for Mustang GTD vehicle

Prove-out on the soon-to-be-delivered Hyperdock FSS-DiM250 in Novi

Additional computational power from Auto-Hawk delivery will allow assessment of higher fidelity FTire implementation

Thank You