Global NVH validation

Masking noise scaling across different regions

Alessio Figuretti
Staff NVH Engineer
Vehicle Attribute

Scan Here
Tesla.com

European Vehicle attribute team

The European Vehicle Attribute team operates between IDIADA Proving Ground and Gigafactory Berlin

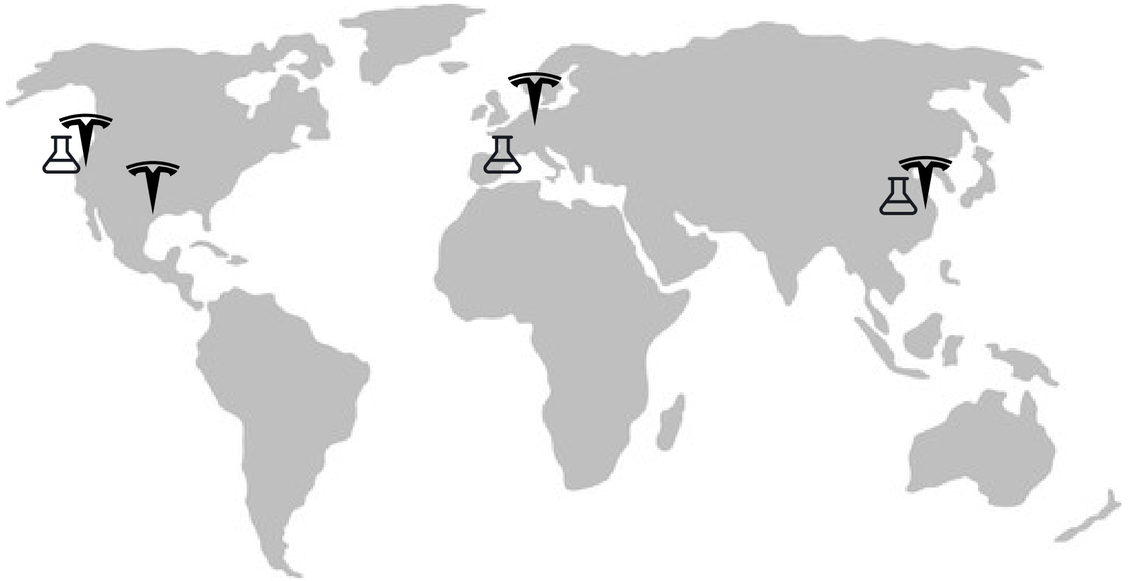
IDIADA Proving Ground

GigafactoryBerlin-Brandenburg

Tesla NVH teamglobal objective

Deliver optimal NVH performance across all vehicle models. Must achieve this despite global manufacturing and validation.

One global vehicle program, multiple regions, multiple test tracks



The Challenge – Road Surface Variation

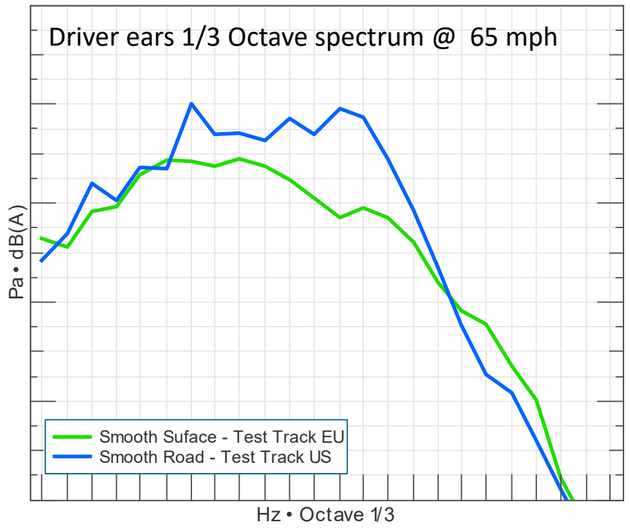
Same model is validated on test tracks with significantly different road surface characteristics

Road texture varies by region due to different construction standards

Region	Avg. IRI* (m/km)	Masking Increase (dB) in 50–2000 Hz	Key Source Papers
Europe	1.1	-	Sandberg & Ejsmont (2002), FEHRL (2006)
North America	1.8	+4 to +6	Wayson (1998), Rasmussen et al. (2007)
Asia	2.2	+6 to +9	Li et al. (2016), Fujikawa

**IRI (International Roughness Index)*

Comparisonbetween two smooth Surface intwo different regions



Why is important?

Road noise acts as masking noise between 50 and 2000 Hz

- High masking on one surface can hide issues that become obvious on another
- Leads to non-standardized, location-dependent subjective and objective data
- Creates risk of inconsistent NVH sign-off across global programs

The Challenge – Road Surface Variation

How we could take this into account?

Re-surface test tracks

- Impractical (test track usually are not owned)
- Cost and time

Chassis dyno

- Best control during test
- High cost and limited availability
- Does not fully replicate real driving conditions

NVH Simulator

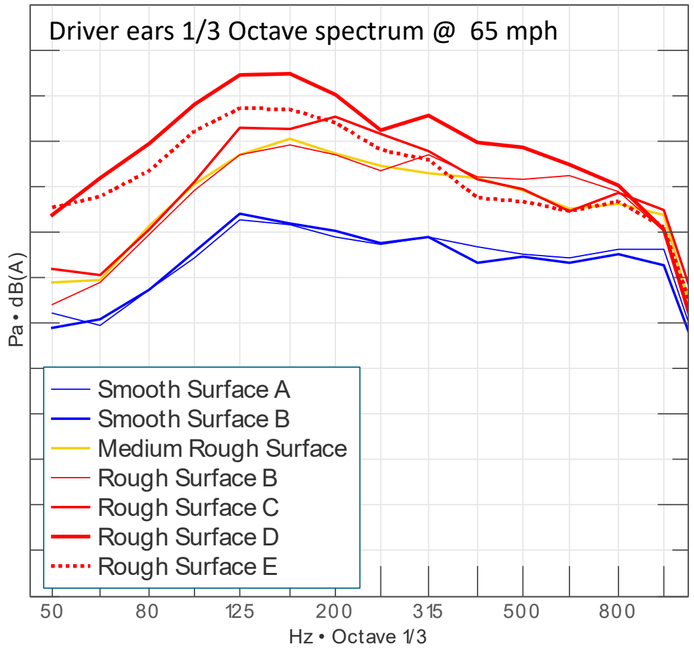
Could we use the NVH simulator to quickly and effectively evaluate models on different test tracks and consider the differences?

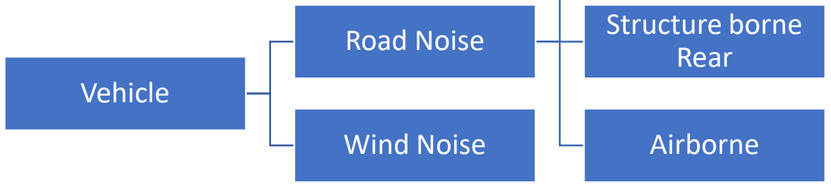
NVH Simulator approach
Step 1 – Data collection and Global Assessments

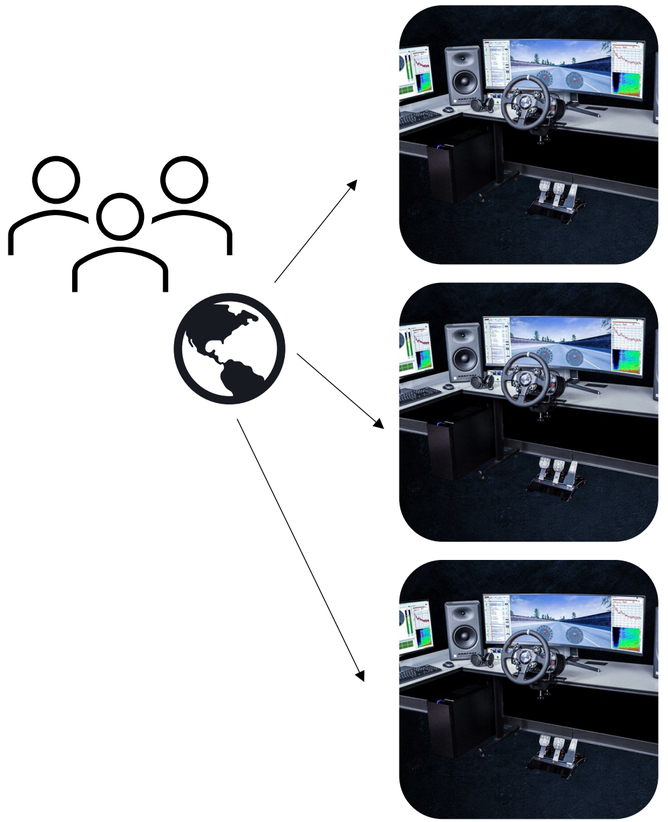
Data acquisition on wide range of test track surfaces

NVH Simulator models creation

Global subjective driving assessments across different locations







NVH Simulator approach Step 2 –Masking noise scaling

measured road noise from a reference surface

frequency-dependent scaling factors to predict masking on target surfaces

scaled noise directly into the NVH simulator

Binaural head microphones

Wheel Reference microphones

Wheel Reference Accelerometers

Frequency-dependent transfer function

$$TF = \frac{ROAD\ B\ (\omega)}{ROAD\ A\ (\omega)}$$

$$SCALED\ MASKING = TF * ROAD\ A(\omega)$$

NVH Simulator approach
Step 3 – Prediction validation

To validate the methodology multiple correlation checks were performed using different vehicles data and track surfaces

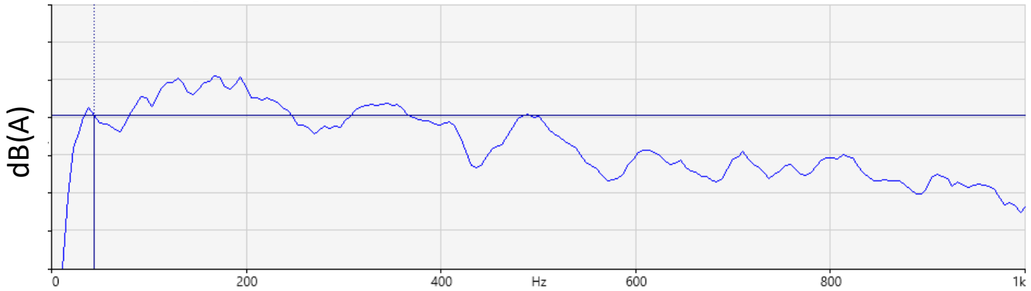
Masking noise Prediction

- Prediction among different surfaces on the same test track
- Prediction on recently re-surfaced track
- Prediction of cross-regional comparison

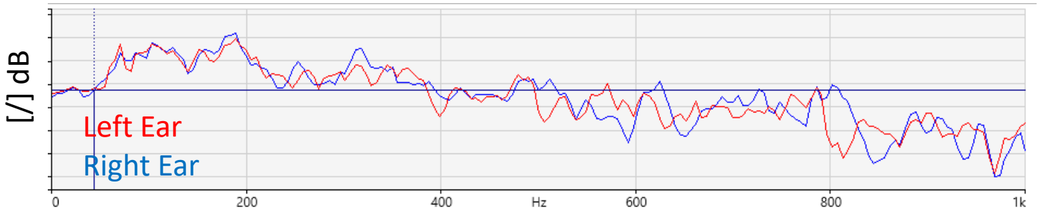
Methodology Validation

Prediction from Smooth Surface to Rough Surface on the same proving ground

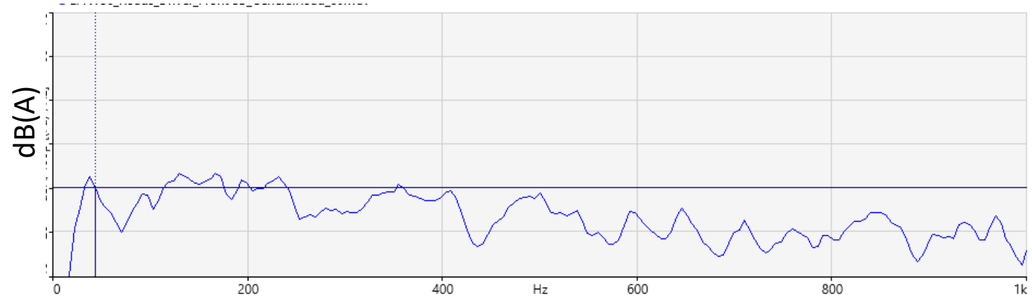
Predicted Rough Surface spectrum @65 mph

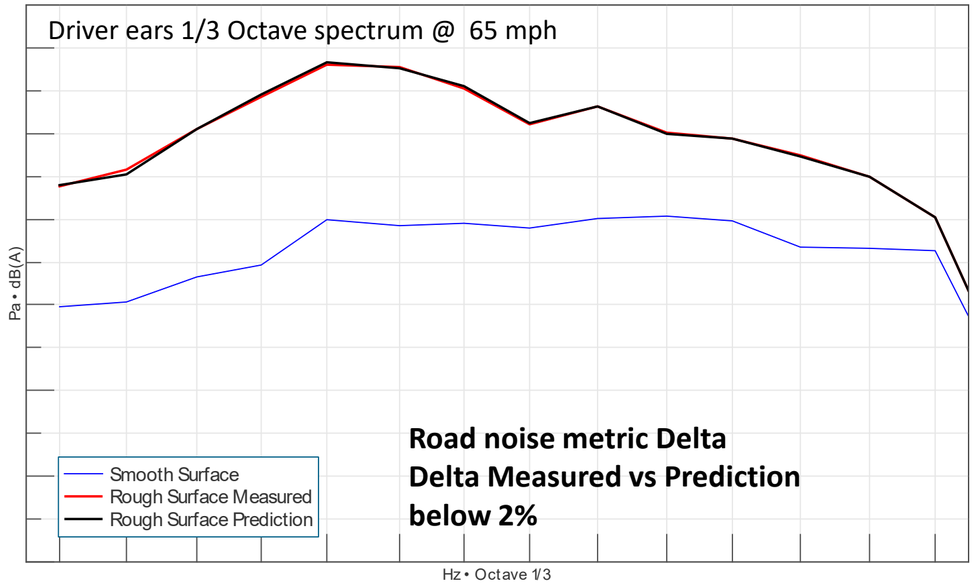


TF @65 Smooth Surface to Rough Surface



Reference Smooth Surface spectrum @65 mph

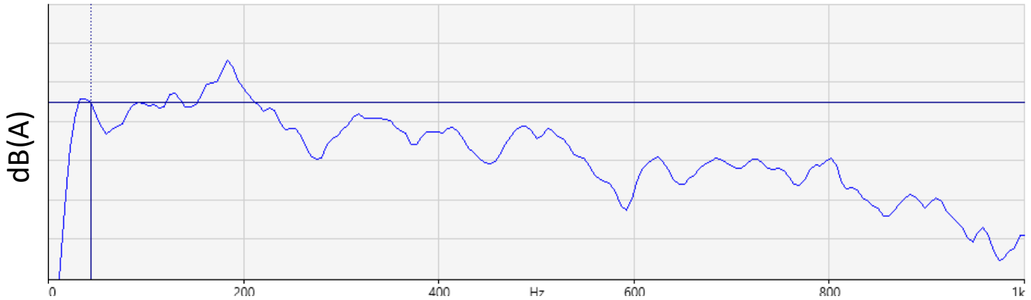




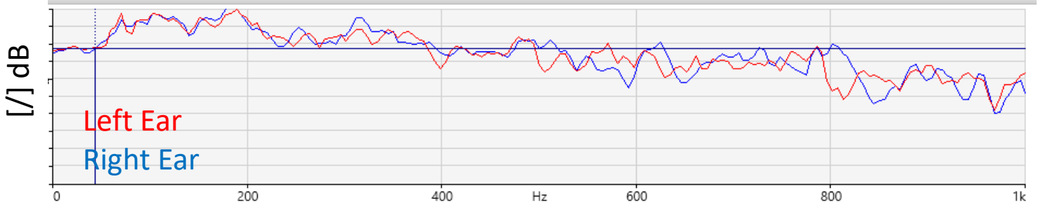
Methodology Validation

Prediction of a re-surface track

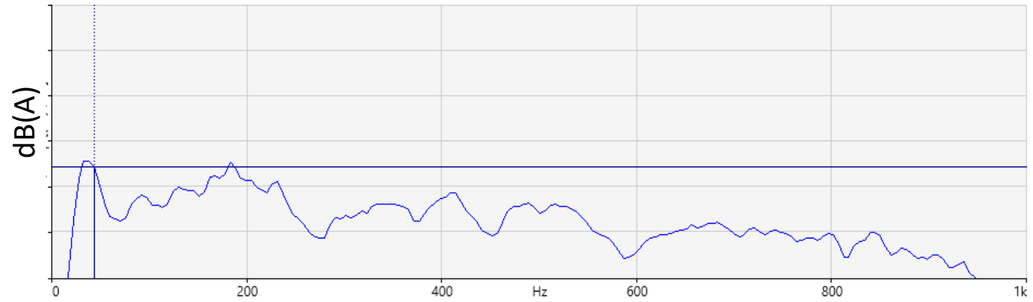
Predicted Rough Surface spectrum @65 mph

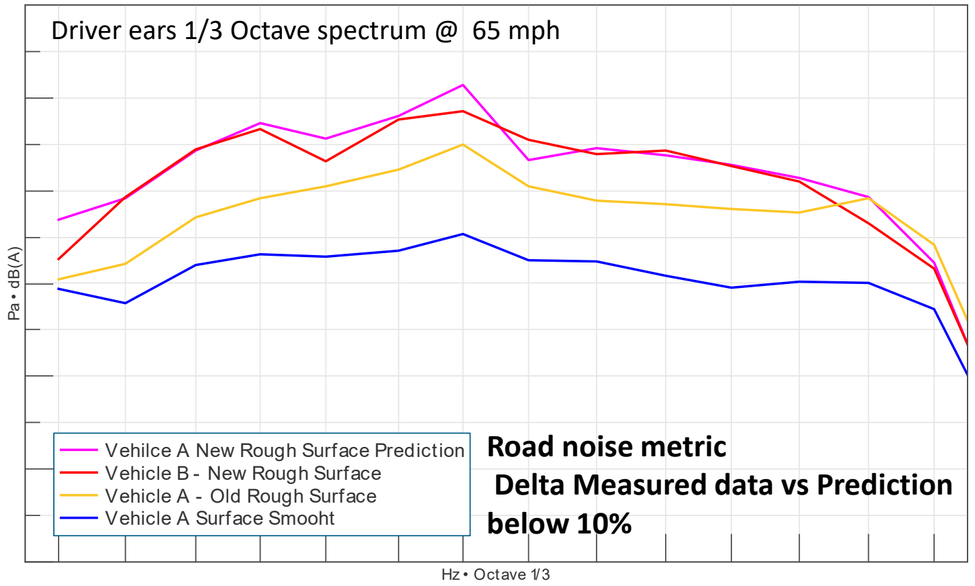


TF @65 Smooth Surface to Rough Surface



Reference Smooth Surface spectrum @65 mph





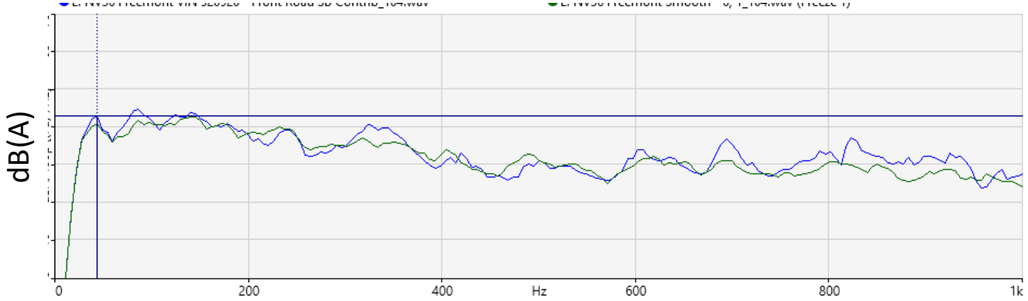
Road noise metric

Delta Measured data vs Prediction below 10%

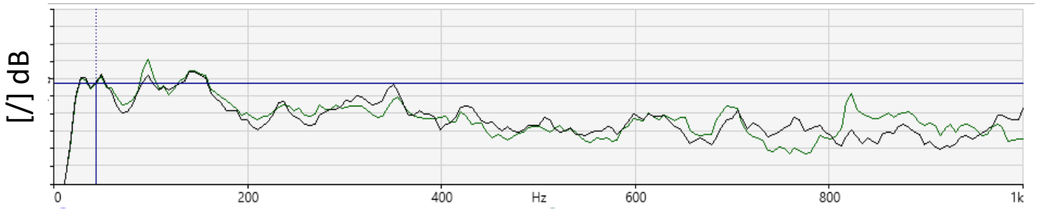
Methodology Validation

Prediction cross-regional

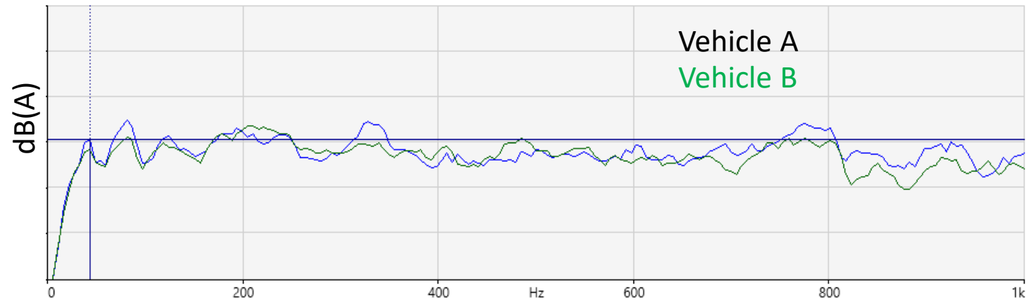
Predicted EU Smooth Surface spectrum @65 mph

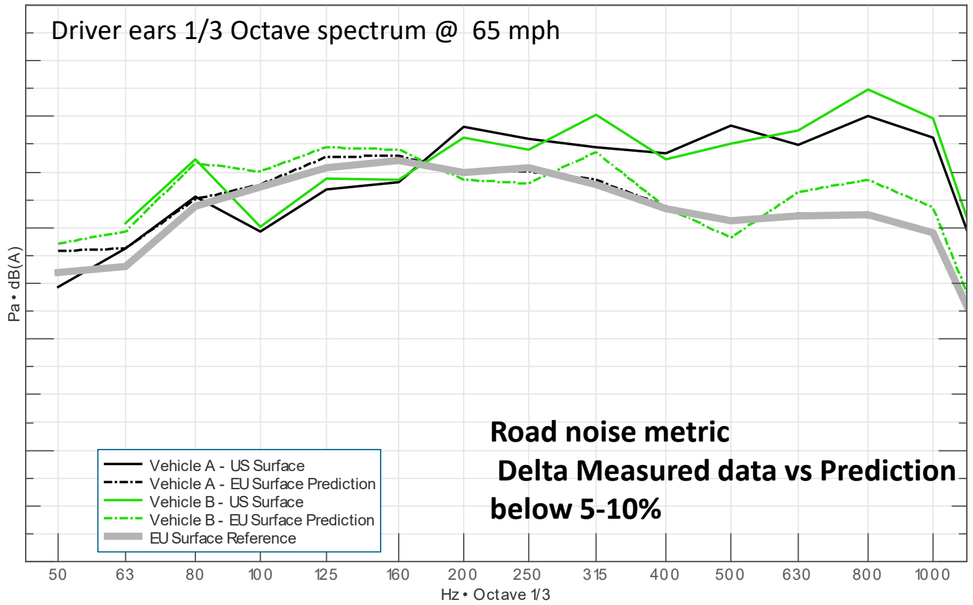


TF @65 Smooth Surface US to Smooth Surface EU



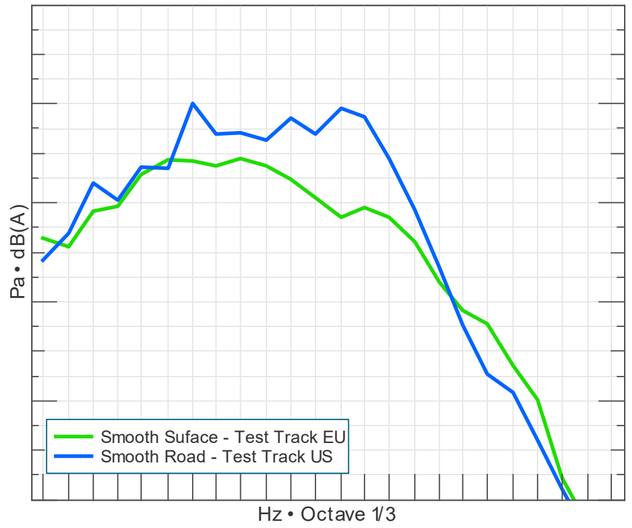
Reference US Smooth Surface spectrum @65 mph



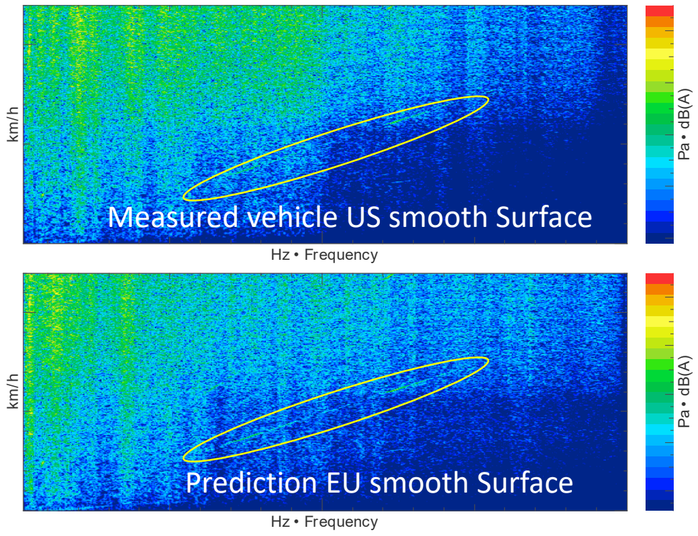


ApplicationExample: PWT noiseevaluation

A vehicle was assessed on North America Smooth Surface. How the PWT will be perceived on a smoother surface?



Acceleration at fixed pedal – Driver´s ear colormap



Order-related content is predicted to be ~20% more prominent on EU smooth surfaces.

Conclusions & Takeaways

The methodology presented, together with an extensively usage of the NVH Simulator allow us to:

- Reduces need for physical testing on every regional surface
- Enables standardized subjective evaluations across locations
- Improves development efficiency and consistency
- Supports Tesla’s goal of optimal NVH performance on all vehicle models worldwide