



UNLOCKING MULTI-ATTRIBUTE ENGINEERING – FULL SPECTRUM SIMULATION

Experience Motion + Vibration + Sound of Virtual Prototypes

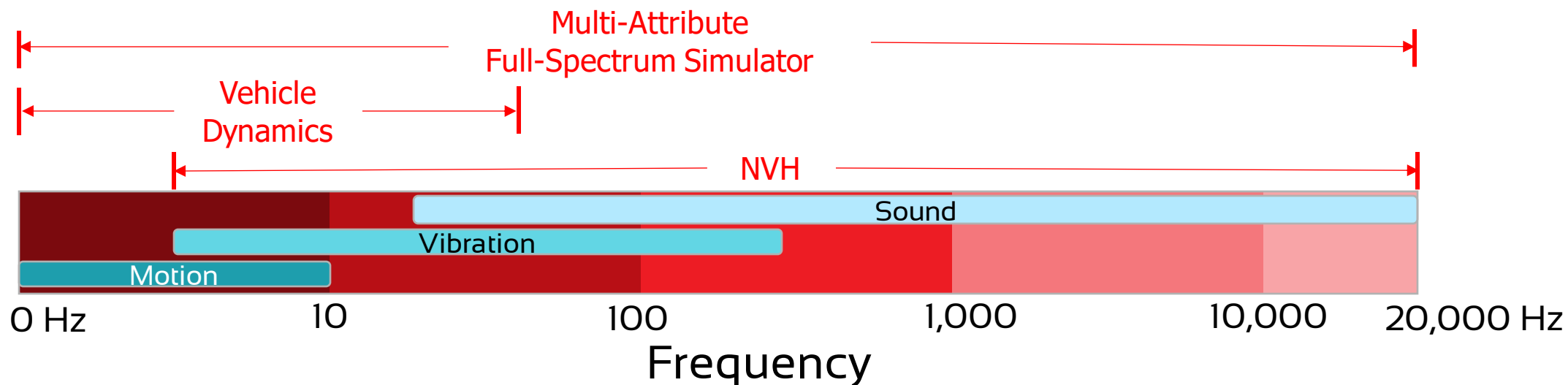
THE COMPLETE DRIVING EXPERIENCE

- Real driving conditions produce all vehicle phenomena together, at the same time
- Usually these characteristics are studied separately as sound, handling, vibration, etc.
- A complete multi-attribute virtual prototype driving experience enables better, faster decisions with high confidence

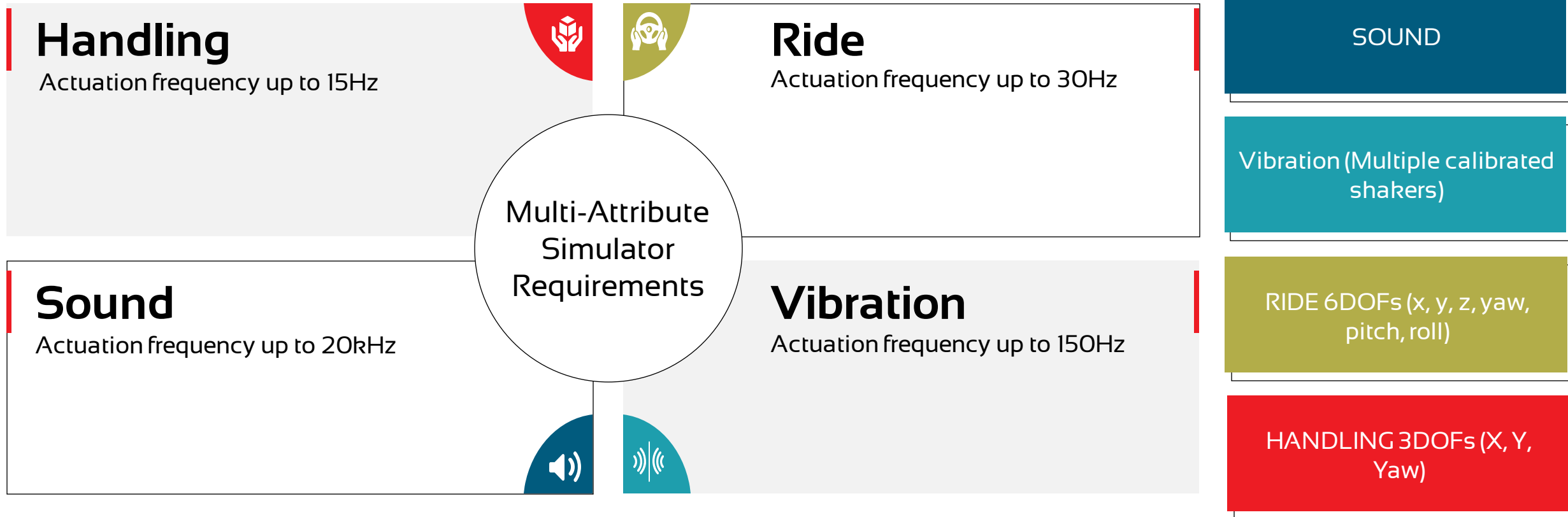


MULTI-ATTRIBUTE SIMULATION

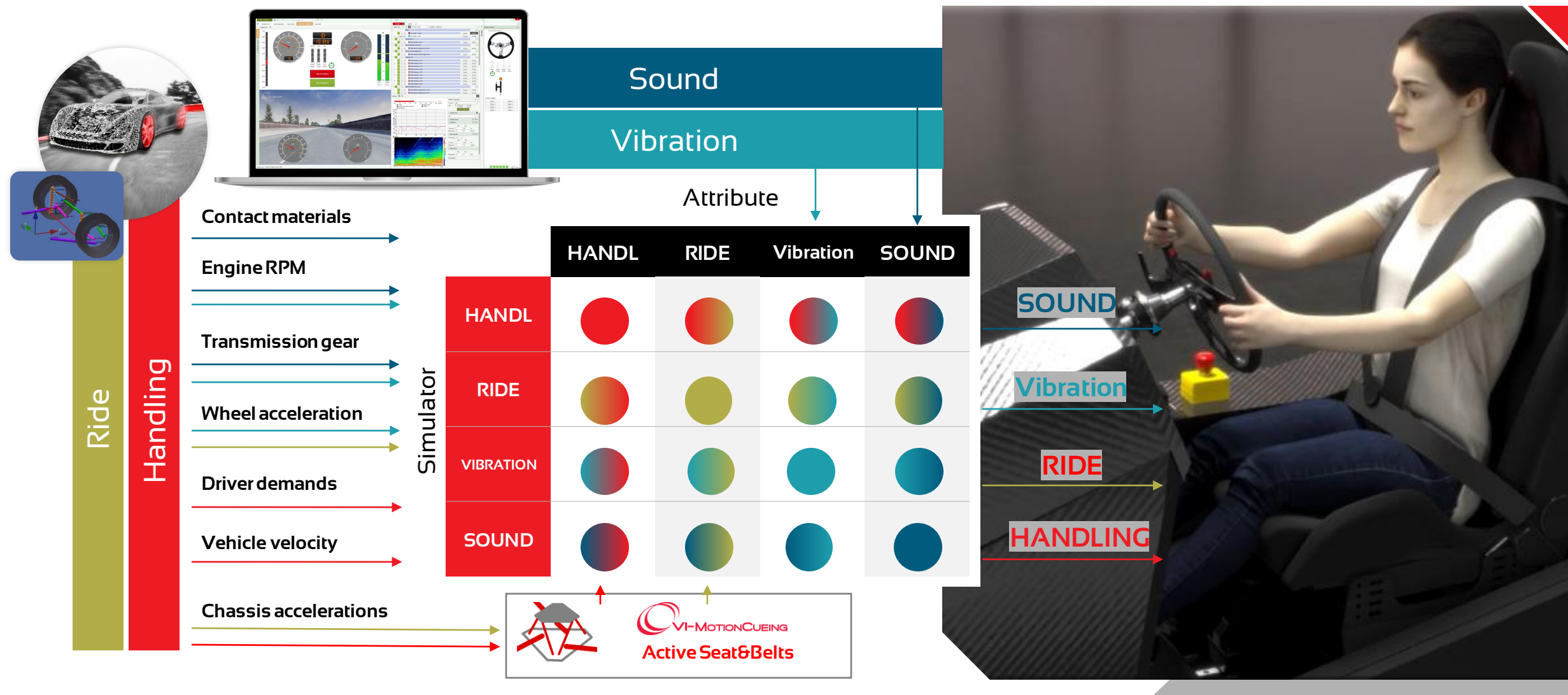
- Sound or the “Noise” part of NVH covers the range from 20-20k Hz
- “Vibration” typically is considered to cover the range from about 5 to 150 Hz
- “Motion” the overall movement of the vehicle, is generally in the 0-8Hz range
- Sound, Vibration and Motion all interact, especially in the “overlap” regions, but outside these as well



MULTI ATTRIBUTE MULTI STAGE SIMULATOR



FULL SPECTRUM ACROSS SIMULATORS



COMPACT FULL SPECTRUM SIMULATOR



VEHICLE DYNAMICS + NVH: MOTION + VIBRATION + SOUND



THE COMPACT FULL SPECTRUM DYNAMIC SIMULATOR



COMPACT FSS: VEHICLE DYNAMICS + NVH



Key Benefits

- Experience Motion + Vibration + Sound
- Multi-attribute experiential simulation: Vehicle dynamics + NVH
- Real-time, Driver-in-the-loop
- Minimal space requirements



Applications

- Ride comfort and overall vehicle refinement
- Experiencing virtual prototypes with multiple attributes (NVH + Vehicle Dynamics)
- Seat comfort
- Tire evaluations and comparisons

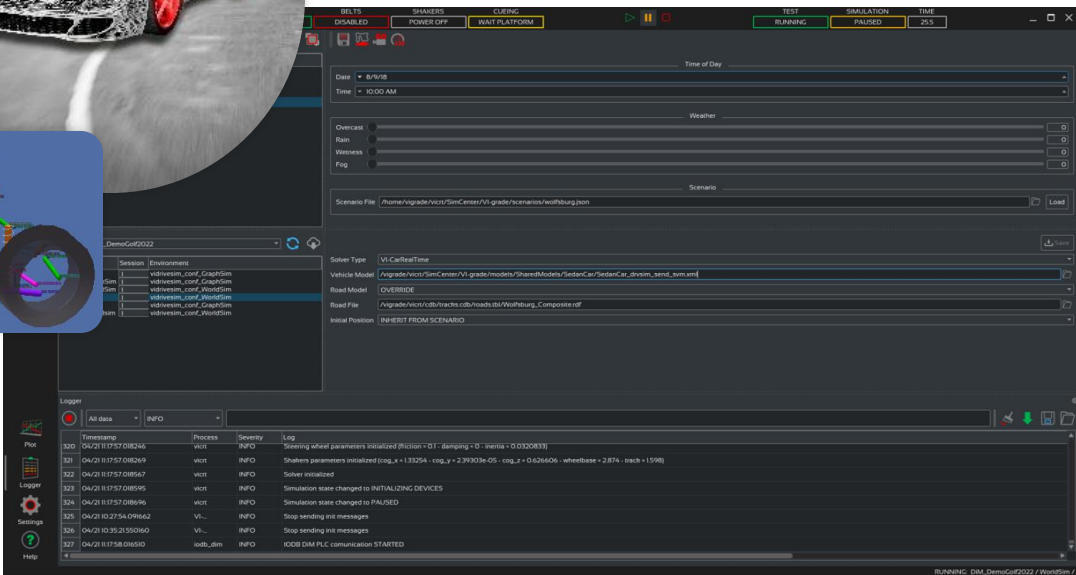
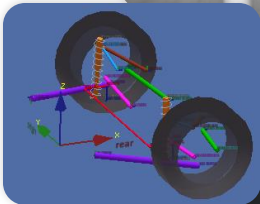
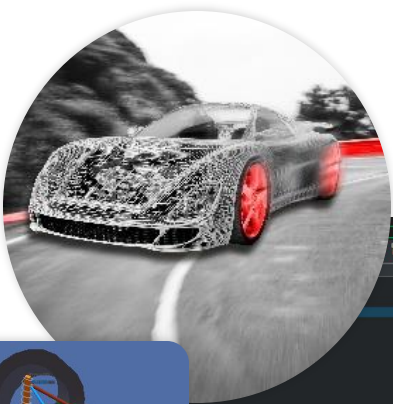


FULL-SPECTRUM SIMULATION

BEYOND THE PHYSICAL SIMULATOR

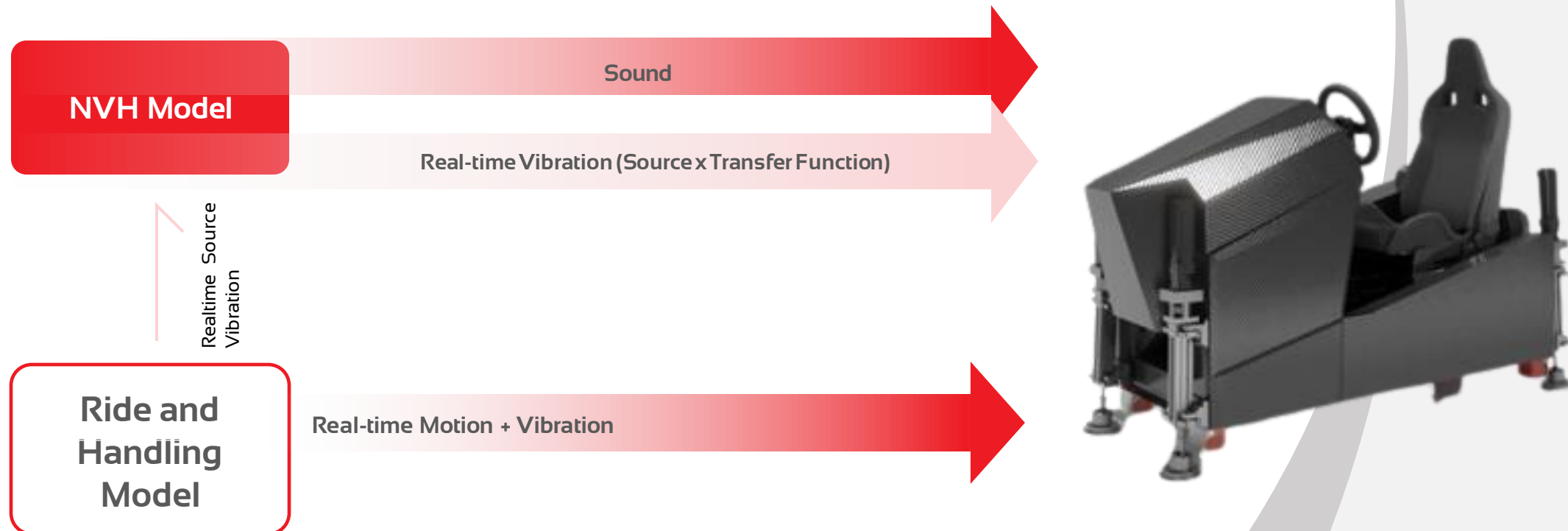


Powered by concurrent REAL-TIME



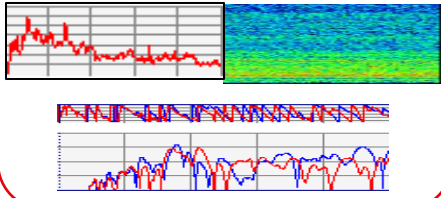
FULL-SPECTRUM REAL-TIME SIMULATION

- Two simultaneous real-time models running in parallel
 - R&H model
 - providing motion and lower frequency vibration
 - and as a source to the NVH model
 - NVH model
 - providing higher frequency vibration and sound

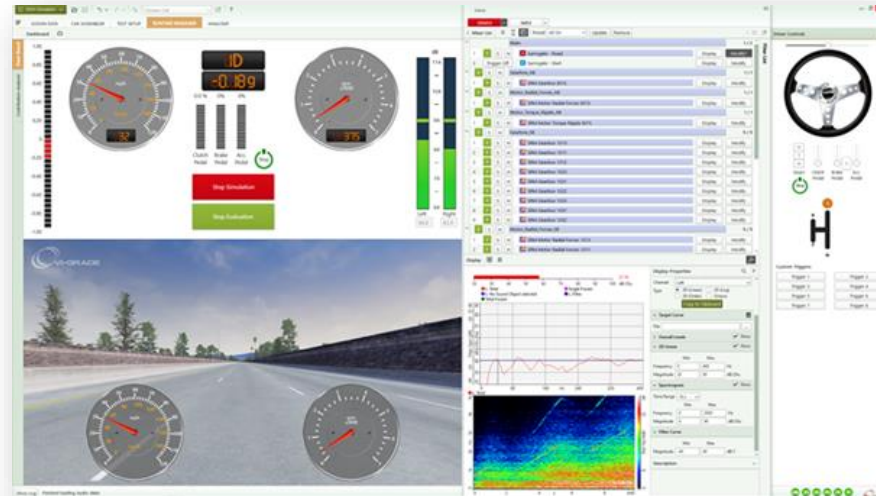
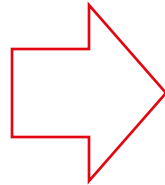
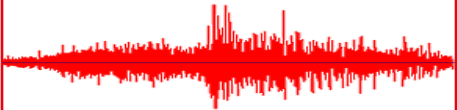


MODELLING USING MIXED CAE AND TEST DATA

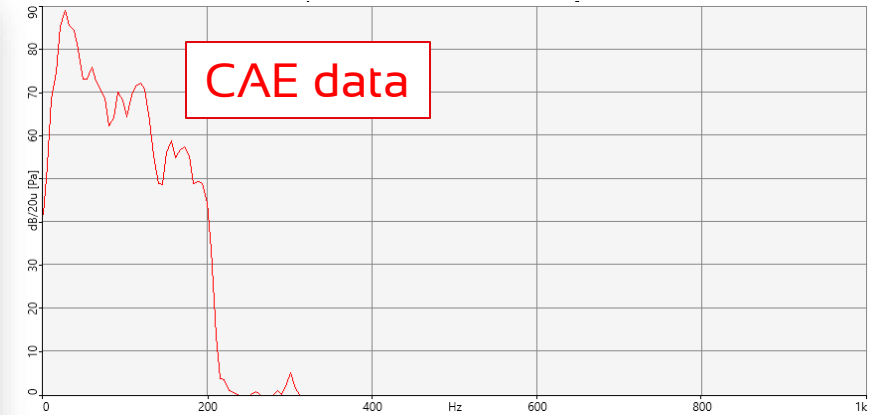
CAE Data



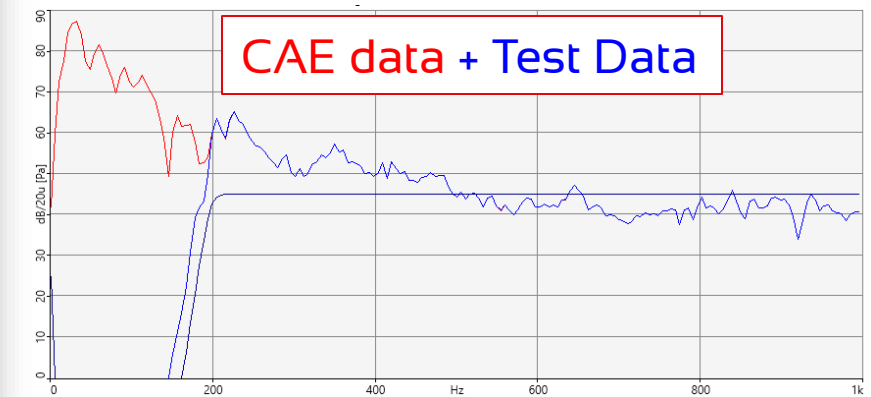
Test Data

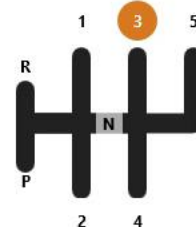
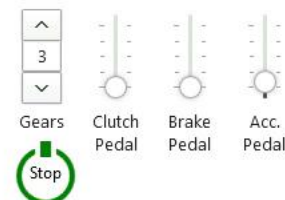
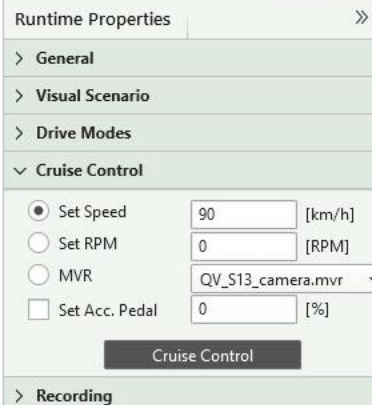


CAE data



CAE data + Test Data





Custom Triggers:

Trigger 1

Trigger 2

Trigger 3

Trigger 4

Trigger 5

Trigger 6

Trigger 7

Trigger 8



Mixer

<	Lux3 wCAE	+	SRMEV	+	IMEV	+	CAE	+	Quiet	>
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≡ Mixer List

SRMEV

IMEV

Quiet >

≡ Mixer List

 Pre

✓

▼

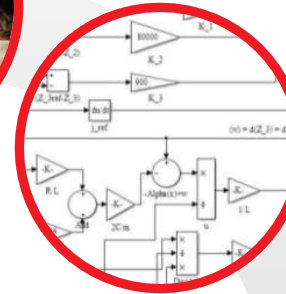
12	7
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1	P	S	H	A CAEgenerated - Front Road Rough	Display	Modify	Other List
2	P	S	H	A CAEgenerated - Rear Road - Roug	Display	Modify	
3	P	S	H	A Golf - Multi-Road (from Coastdown	Display	Modify*	
4	P	S	H	A Golf - Multi-Road (from steady-sta	Display	Modify*	
5	P	S	H	A Sports - Total Masking	Display	Modify*	
6	P	S	H	O Small I4 - Engine	Display	Modify*	
7	P	S	H	A Small I4 - Engine Masking	Display	Modify	
8	P	S	H	O CAEgenerated - Base Engine	Display	Modify	
9	P	S	H	O CAEgenerated - Exhaust	Display	Modify	
10	P	S	H	O CAEgenerated - Front Susp	Display	Modify*	
11	P	S	H	O CAEgenerated - Rear Susp	Display	Modify	
12	P	S	H	O Context Ords	Display	Modify	

XiL: DiL, MiL, SiL, HiL



Driver-in-the-loop



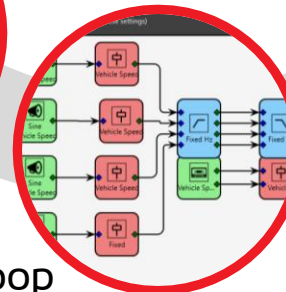
Model-in-the-loop



Hardware-in-the-loop



Controllers-in-the-loop



Software-In-the-loop

Other applications
In-the-loop



CONCLUSIONS

- Vehicle attributes like ride, handling, sound and vibration cannot be fully understood from plots, graphs and numbers, they need to be experienced
- In the past, vehicle dynamics and NVH have been developed and simulated independently
- Today, multi-attribute simulation is now possible, combining vehicle dynamics and NVH in a single simulator
- Combining multiple attributes creates a deeply immersive experience and enables decisions to be made quickly and with confidence



DRIVE – EXPERIENCE – UNDERSTAND - DECIDE



THANK YOU FOR YOUR ATTENTION

Experience the Full-Spectrum Simulator for yourself here at
the North American ZERO PROTOTYPES SUMMIT