



**THE COMPACT  
FULL SPECTRUM SIMULATOR:**

**A MULTI ATTRIBUTE, REAL-TIME,  
DRIVER-IN-THE-LOOP SIMULATOR**

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# INTRODUCTION

A REAL-TIME, DRIVER-IN-THE-LOOP SIMULATOR FOR ACCURATE  
AND COST-EFFECTIVE VIRTUAL PROTOTYPE EVALUATIONS

- Multi-attribute simulation introduction
- Why a multi-attribute simulator?
- The all-new Compact Full Spectrum Simulator
- Driver feedback
- Conclusions



# INTRODUCTION

## MULTI-ATTRIBUTE SIMULATION



- Engineers need hands-on experience to assess vehicle characteristics.
- They make million-dollar decisions without physical prototypes.
- Confidence in their choices is vital.
- Ride comfort combines vehicle dynamics and NVH.
- Accurate assessment of motion, vibration, and sound is key.



# VI-GRADE PURPOSE: OUR "QUEST"



**DREAM IT!**



**MAKE IT!**



**TRY IT!**

# VI-GRADE PURPOSE: OUR "QUEST"



**DREAM IT!**  
YOUR PROTOTYPE



**TRY IT!**



**BAITED!**  
YOUR VEHICLE

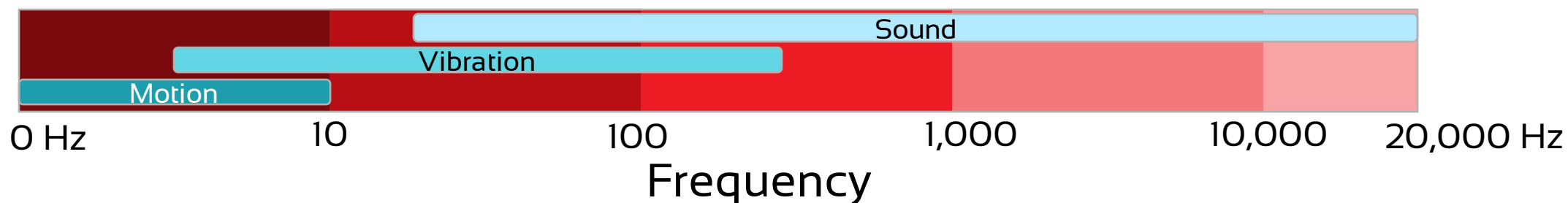
# THE COMPLETE DRIVING EXPERIENCE

- Real driving conditions produce all vehicle phenomena simultaneously
- Usually, these characteristics are studied separately as sound, handling, vibration, etc.



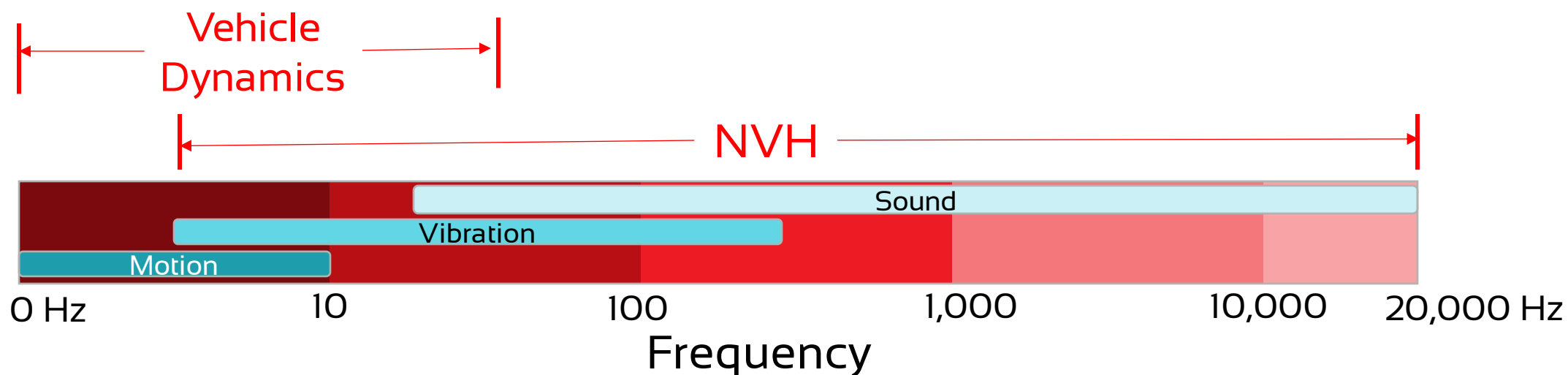
# MULTI-ATTRIBUTE SIMULATION

- Sound or the “Noise” part of NVH covers the range from 20 Hz to 20 kHz
- “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 to 8 Hz range
- Sound, Vibration and Motion all interact, especially in the “overlap” regions, but outside these as well



# MULTI-ATTRIBUTE SIMULATION

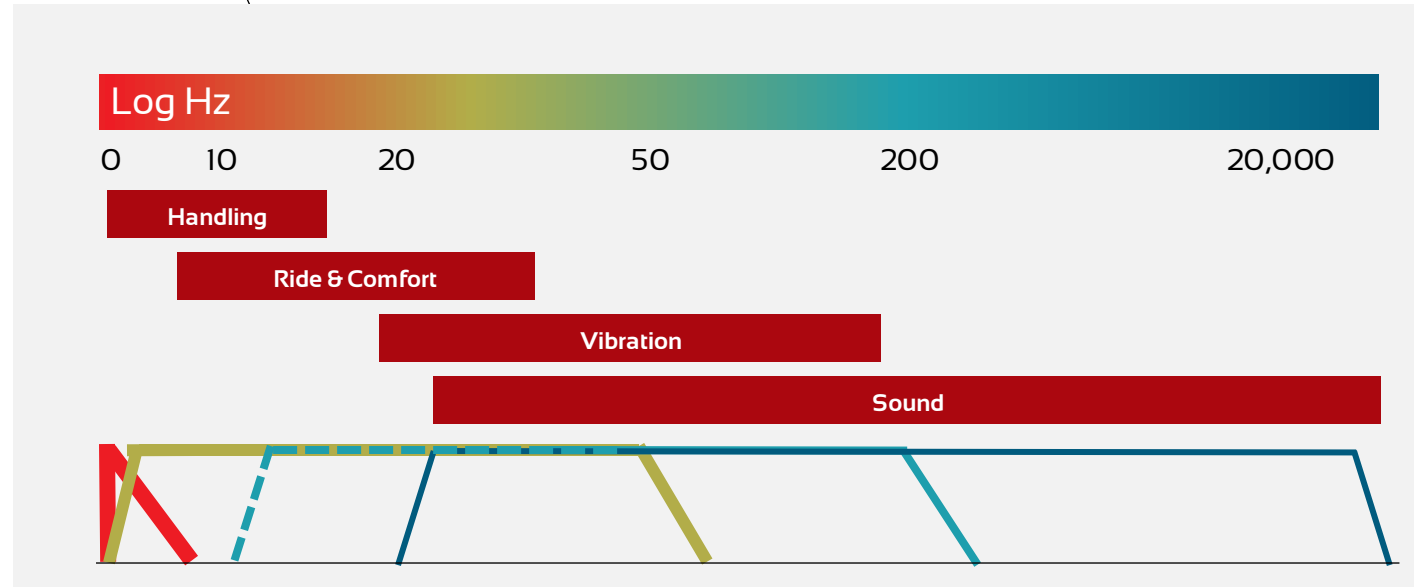
- The “Sound” or “noise” portion of NVH has traditionally been treated separate from the “Vibration” portion, with targets set independently
- Likewise, vehicle dynamics, ride and handling have typically been separated from Sound and Vibration
- Especially in the overlap region, but not limited to these, there is a high degree of interaction, especially between what is considered “ride quality” and what is considered “vibration”.



# HUMAN PERCEPTIBLE FREQUENCIES

## Perceived Frequencies

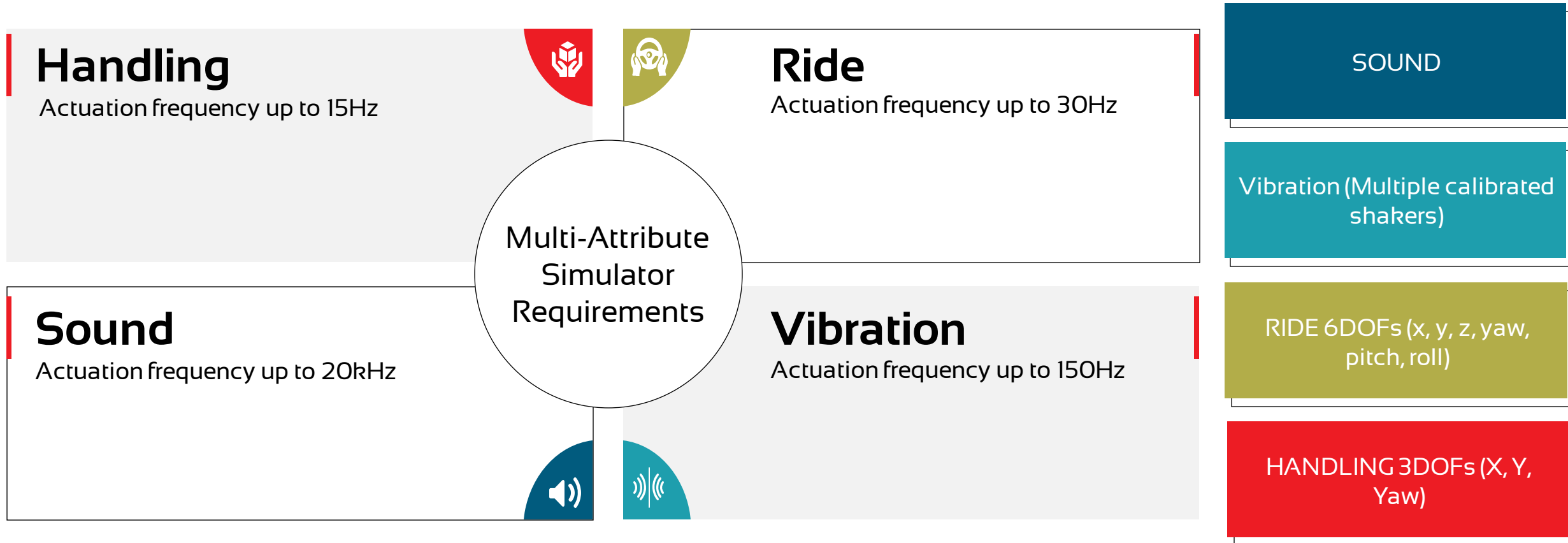
- 0 to 5Hz, **somato** - **vestibular**
- 5 to 30Hz, **vestibular** - **vibrational**
- 10 to 150Hz, **vibrational**
- 20 to 20000Hz, **acoustic**



## Driving Simulator Realism

Ideally, a professional Driving Simulator MUST provide a **FULL SPECTRUM** frequency immersion, no matter what its final application is meant to be (HANDLING, RIDE, Vibration, SOUND, ADAS/AD)

# MULTI ATTRIBUTE MULTI STAGE SIMULATOR



# SINGLE-ATTRIBUTE SIMULATION

## DESKTOP NVH SIMULATOR: SOUND

- Introduced by B&K in 2005
- Real-time driver-in-the-loop sound simulation
- Switch instantly between vehicle back-to-back
- Apply filters, modify the sound, understand the sound
- Modify component sounds in real-time
- Sound + visualization
- Experience virtual prototypes – CAE data, measured data or combination of both
- 20Hz-20kHz

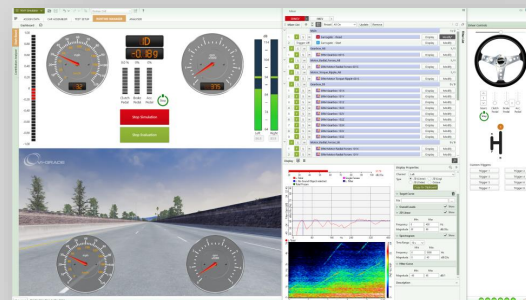
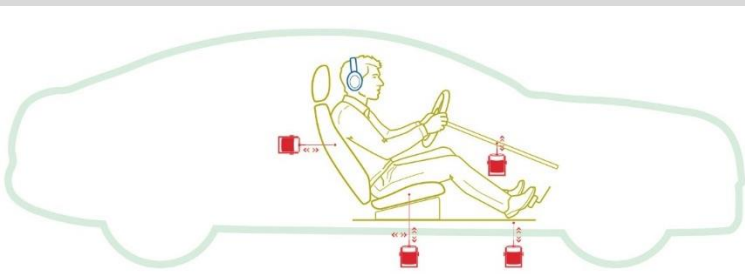


# MULTI-ATTRIBUTE SIMULATION

## SOUND + VIBRATION: STATIC NVH SIMULATOR

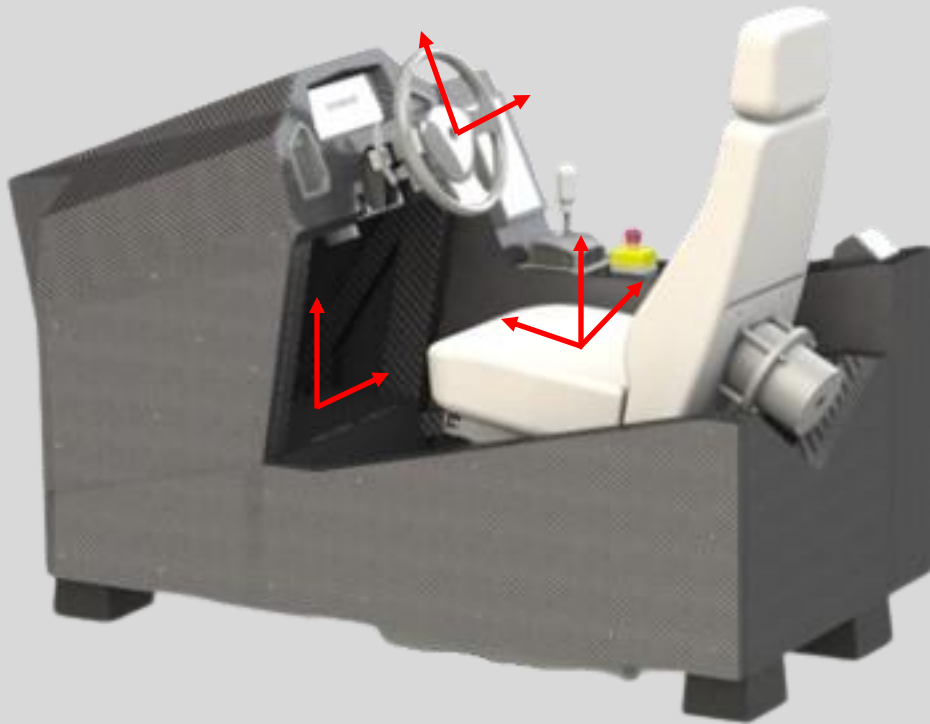


- Multi-axial, calibrated vibration at all primary driver touch points
- 7 independent degrees-of-freedom of vibration
- Calibrated Full-spectrum Sound
- Immersive Sound + vibration experience
- ~8Hz – 20kHz



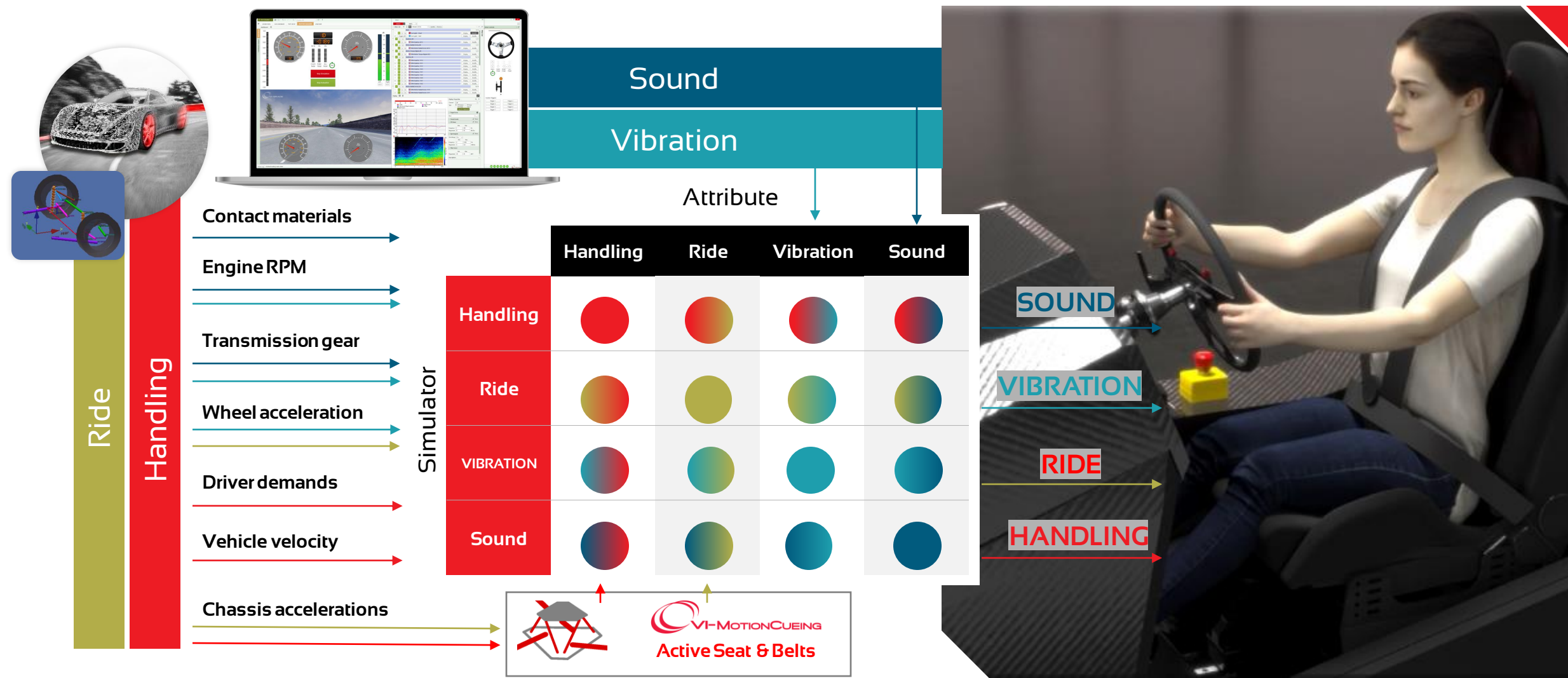
# MULTI-ATTRIBUTE SIMULATION

## SOUND + VIBRATION: COMPACT NVH SIMULATOR



- Multi-axial, calibrated vibration at all primary driver touch points
- 7 independent degrees-of-freedom of vibration
- Calibrated Full-spectrum Sound
- Full Carbon fiber Cockpit and steering wheel
- Small footprint for engineering office
- ~8Hz – 20kHz

# 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



# THE COMPACT FSS – FEATURES



## Standard

- Motion with legs – Roll, Pitch, Heave
- Vibration with shakers
  - Seat X, Y, Z; Steering Y, Z
- Sound via SimsoundX
  - High-frequency vibration from SimsoundX
- Standard VI-grade steering wheel, steering motor



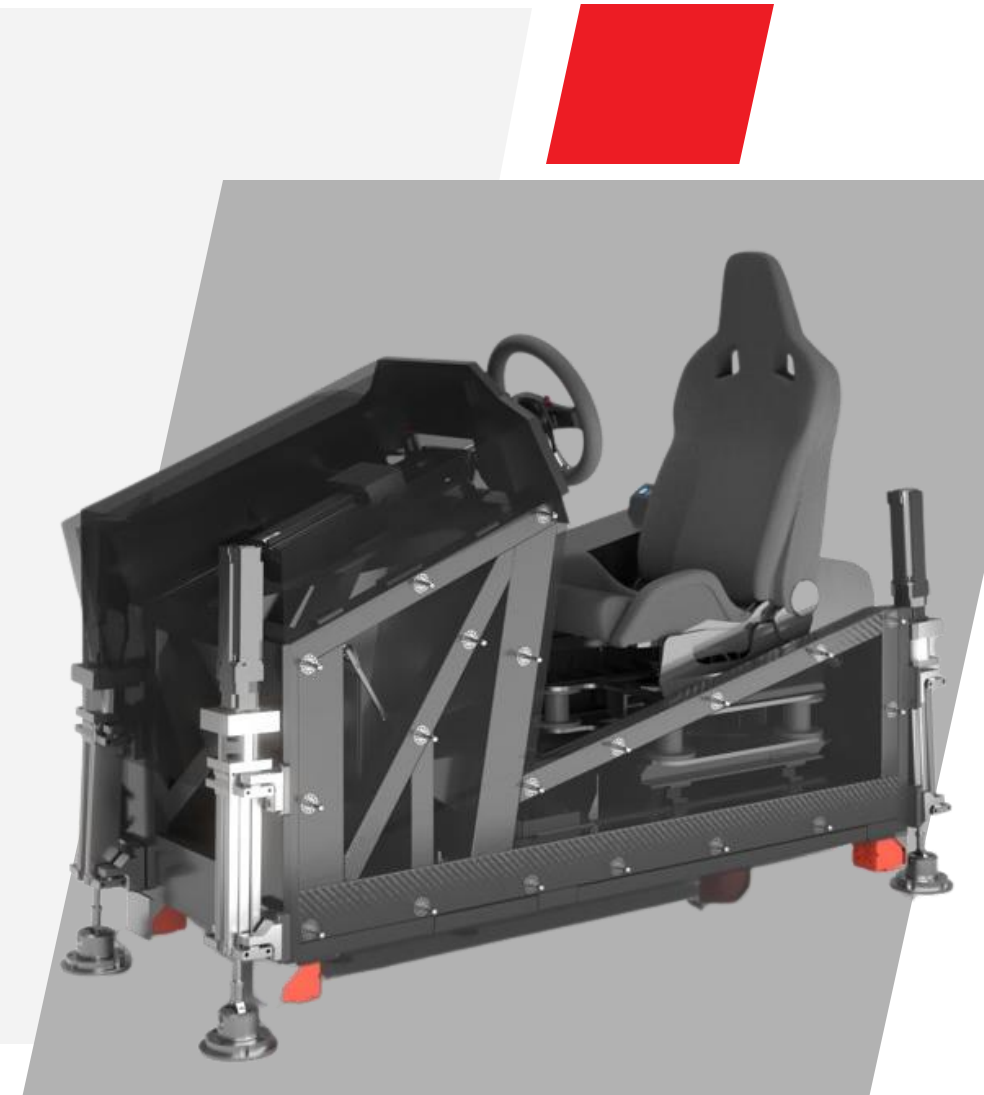
## Optional

- NVH Simulator Software
- Active Brake
- Ability to mount any seat
- Active seat
- Active belt



## Operating modes

- Realtime driver-in-the-loop
- Offline / Fixed-driving playback



# FULL-SPECTRUM SIMULATION

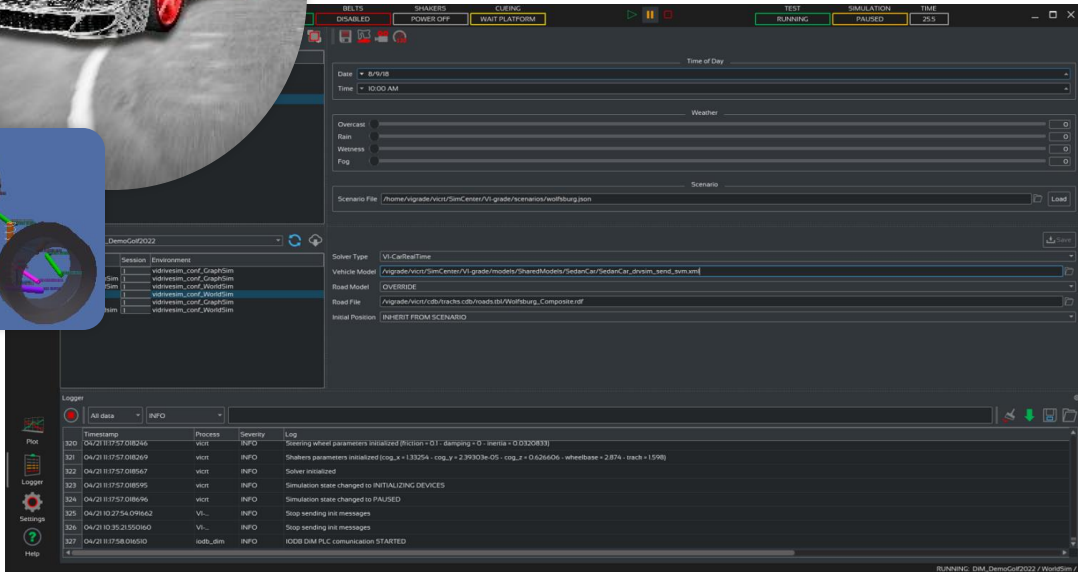
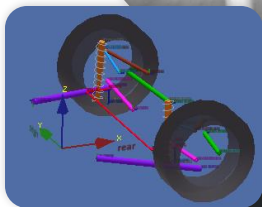
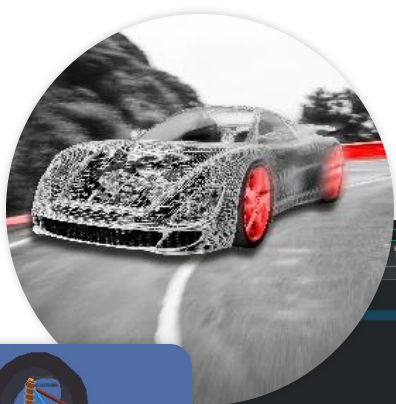
BEYOND THE PHYSICAL SIMULATOR



VI-Drivesim + VI-CarRealTime +  
Autohawk



Powered by



NVH Simulator Software





# CONCLUSIONS

DRIVE – EXPERIENCE – UNDERSTAND - DECIDE

- 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





# THANK YOU FOR YOUR ATTENTION

Visit [www.vi-grade.com](http://www.vi-grade.com) for more information on the COMPACT FSS simulator and our other simulator and simulation solutions