



# VEHICLE DYNAMICS PERFORMANCE ENHANCEMENT ON DRIVING SIMULATOR THROUGH SHOCK ABSORBER HIL BENCH



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SMART PROTOTYPES  
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- Stellantis and driving simulators: where, what, how
- Damper HiL bench: characteristics and integration
- Objective validation
- Subjective validation
- Tuning session
- Conclusions



A woman is shown from the chest up, driving a car. She is wearing a dark top and has her hair pulled back. The car's interior, including the steering wheel and dashboard, is visible. The entire image is overlaid with a semi-transparent blue filter. The text 'STELLANTIS AND DRIVING SIMULATORS: WHERE, WHAT, HOW' is written in white, bold, sans-serif capital letters across the center of the image.

STELLANTIS AND DRIVING  
SIMULATORS:  
WHERE, WHAT, HOW



-  Balocco PG
-  Poissy GC
-  Rüsselsheim TC
-  ARDC
-  PUCMinas University in Betim

+ 6 between static and compact simulators equipped with HiL systems



Same SW s in all the regions



Global standardized methods

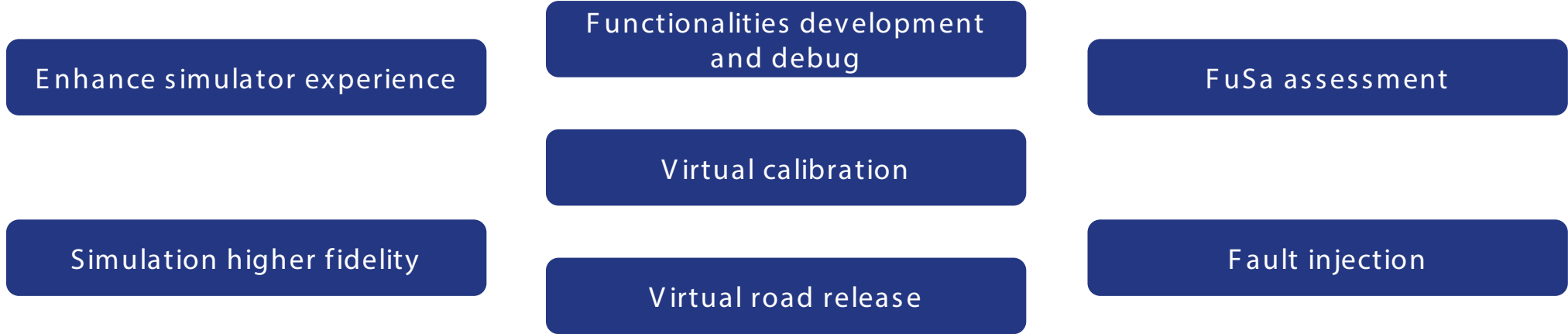


Sharable models, scenarios, tracks



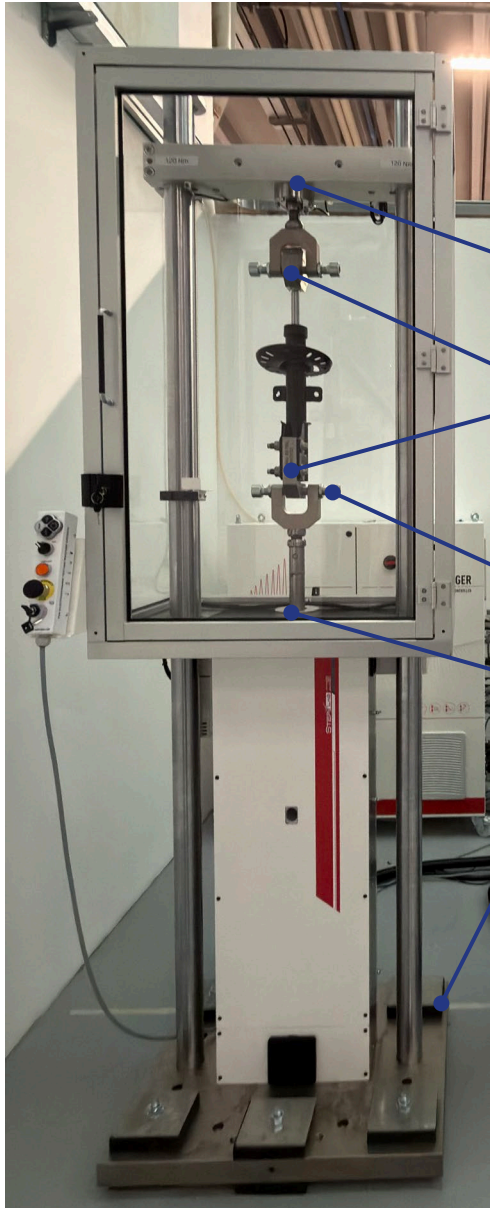
Unique vision for a global team







# DAMPER HIL BENCH: CHARACTERISTICS AND INTEGRATION



Load cell

Custom adapters

Custom gripper

Actuator

Seismic isolators

- 4 individual electro dynamic test benches
- Up to 22kN peak dynamic load
- 260mm actuator stroke
- Custom interfaces to fit physical component

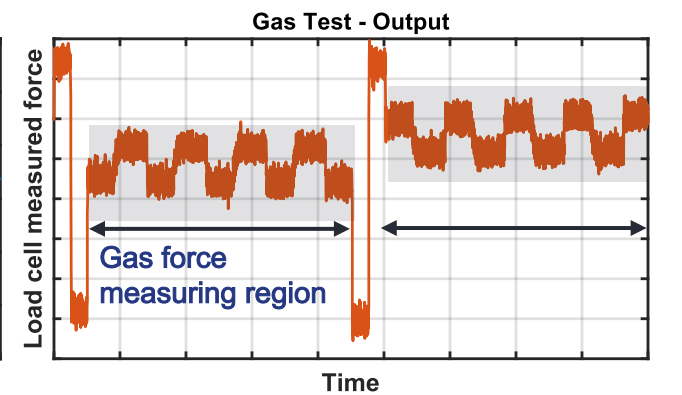
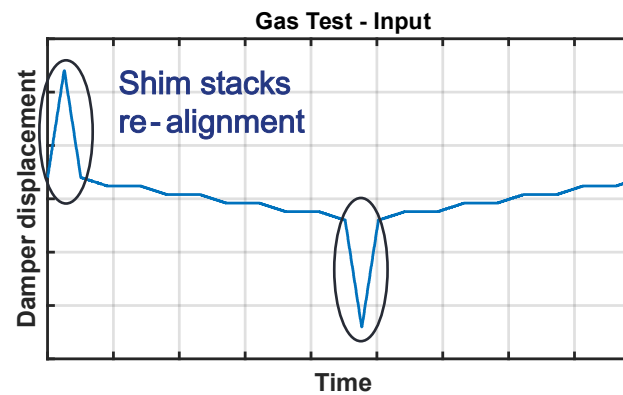
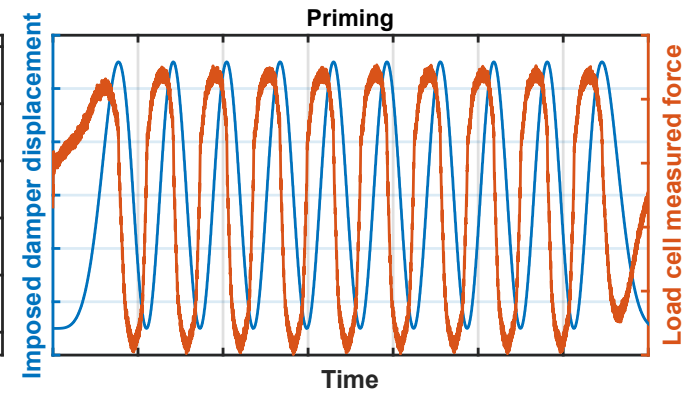
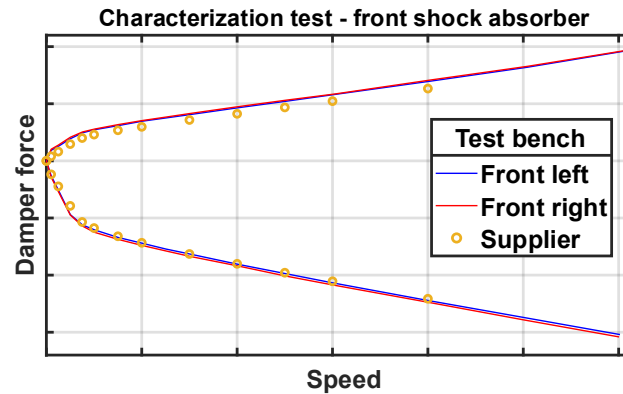
Standalone usage

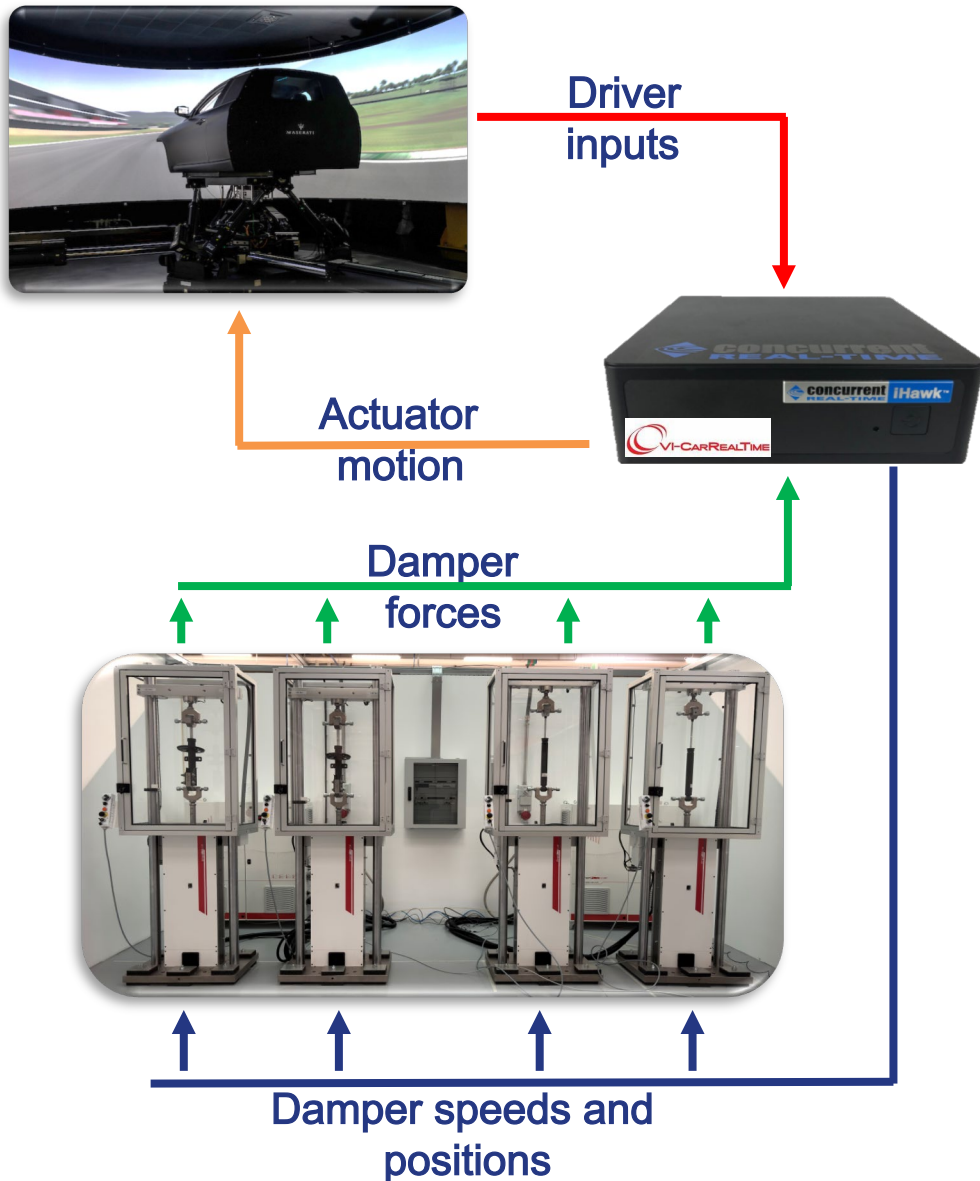
Full characterization

Priming procedure

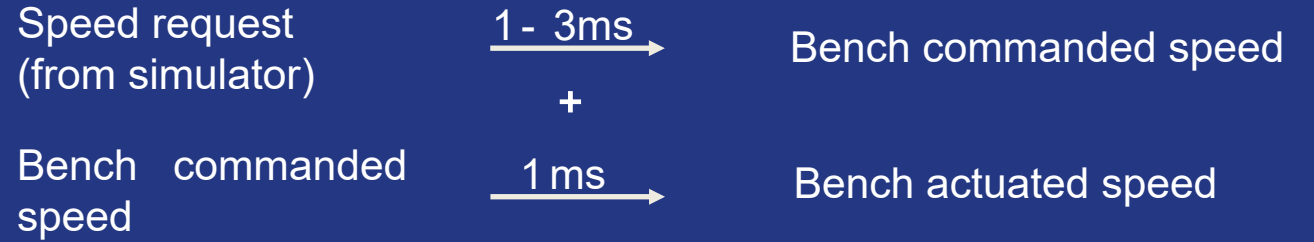
Gas force measurement

Real-time integrated with simulator

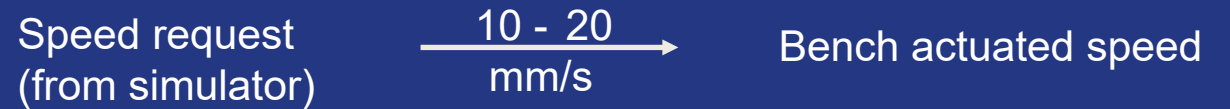




### DELAY



### AMPLITUDE ERROR



### Validation

- ✓ Delay and error depending on the request
- ✓ 4ms total input/output delay in **worst case scenario**
- ✓ 20mm/s maximum amplitude error in **worst case scenario**
- ✓ Delay not perceived by drivers

A woman is shown from the chest up, driving a car. The image is heavily tinted with a blue color. The text 'DAMPER HIL BENCH: OBJECTIVE VALIDATION' is overlaid in white, bold, sans-serif font across the center of the image. The woman's hair is blonde and tied back. The car's interior, including the steering wheel and dashboard, is visible in the lower half of the frame.

# DAMPER HIL BENCH: OBJECTIVE VALIDATION

## Validation and performance assessment of Damper HiL bench across handling and ride comfort maneuvers

 Comparison between MiL results and HiL results

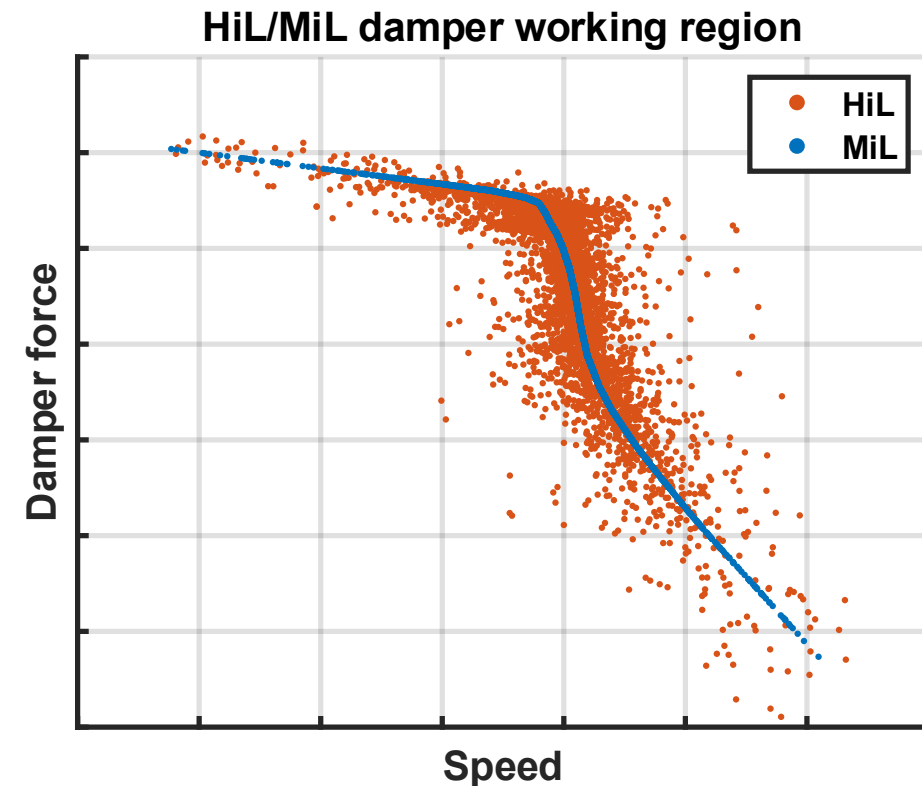
Open loop maneuvers using VI - driver on Simulator: more than 20 test cases

## Ride Comfort maneuvers:

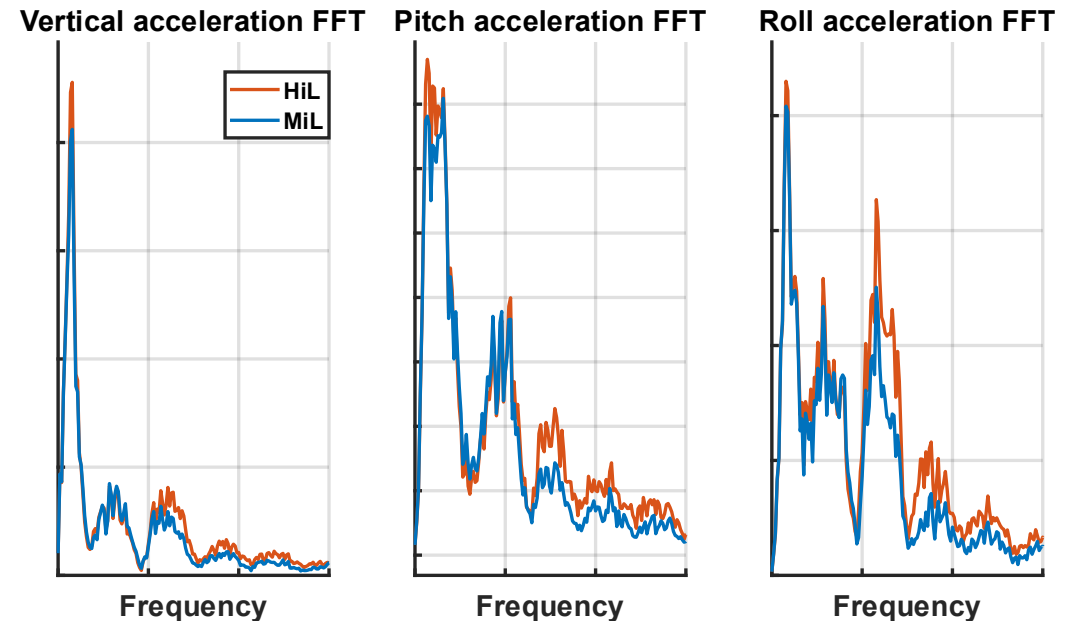
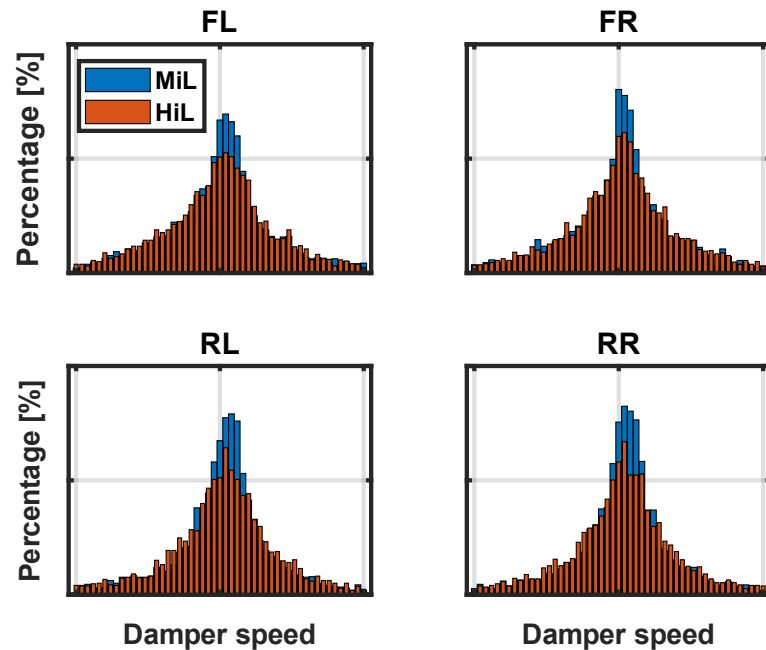
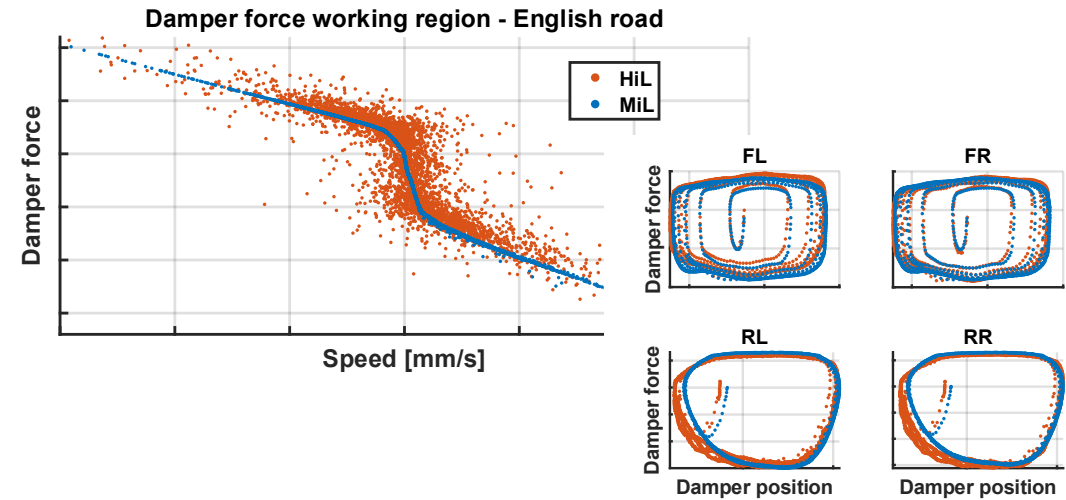
- Long Waves
- Positive and negative Steps
- Uneven Road
- High Speed Track

## Handling maneuvers:

- Slow ramp steer
- Frequency sweep steer
- Straight acceleration
- Straight braking
- Brake - in - turn
- Tip - in - turn

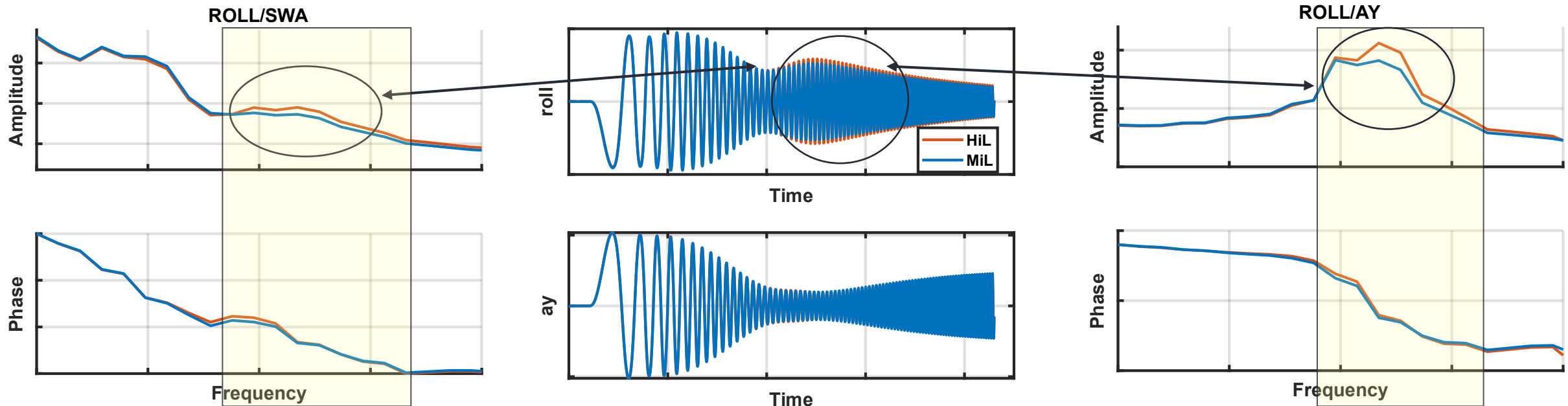


- Damper speed distributions differences due to real damper behavior in HiL testing
- Damper force differences and small delay due to damper hysteresis
- Perceivable variations in pitch, roll and chassis vertical accelerations



- Noticeable difference in roll angle amplitude within 2 - 3Hz frequency range
- Corresponding lateral acceleration profile

	Roll angle / Ay			
	Peak value / static value	Peak frequency	Peak value	Delay
	-	[Hz]	[deg/g]	[s]
MiL	Ref	Ref	Ref	Ref
HiL	+17.5 %	+20.0 %	+16.1 %	-4.7 %

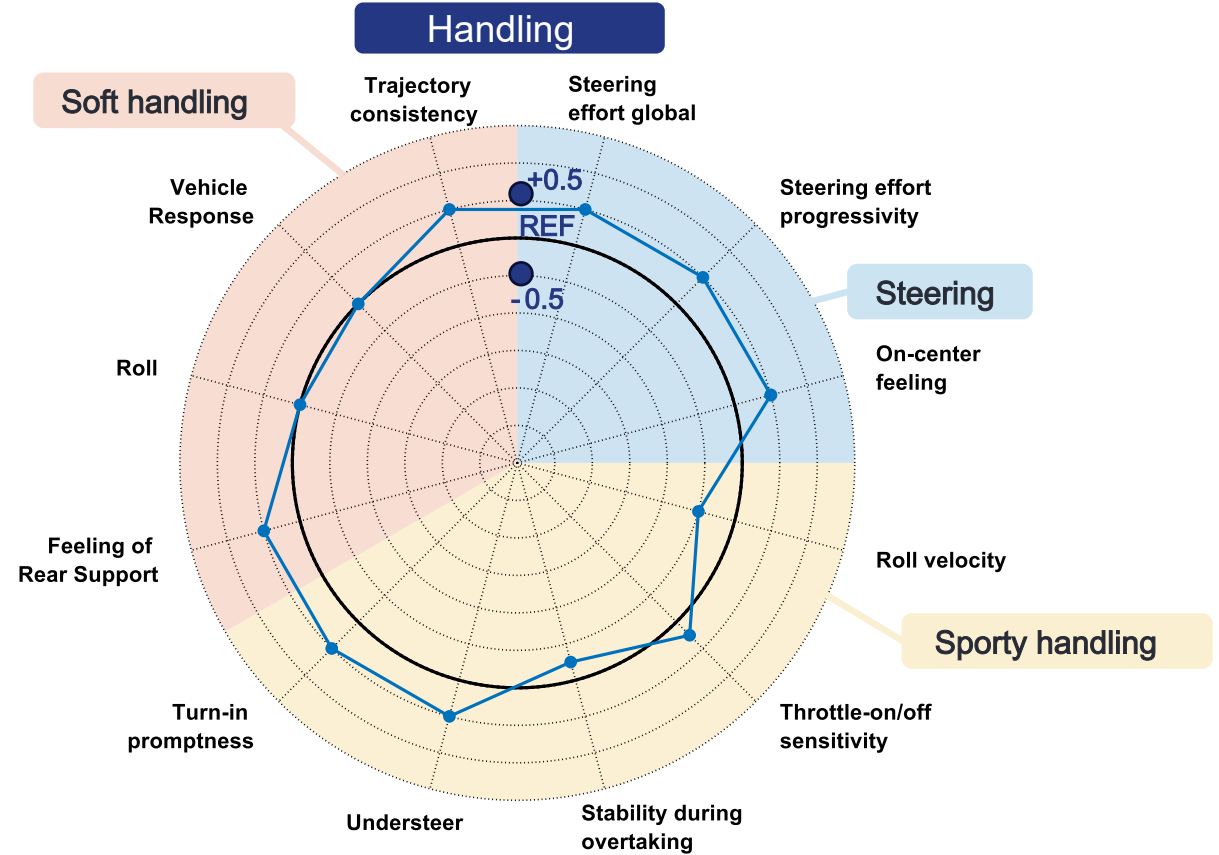
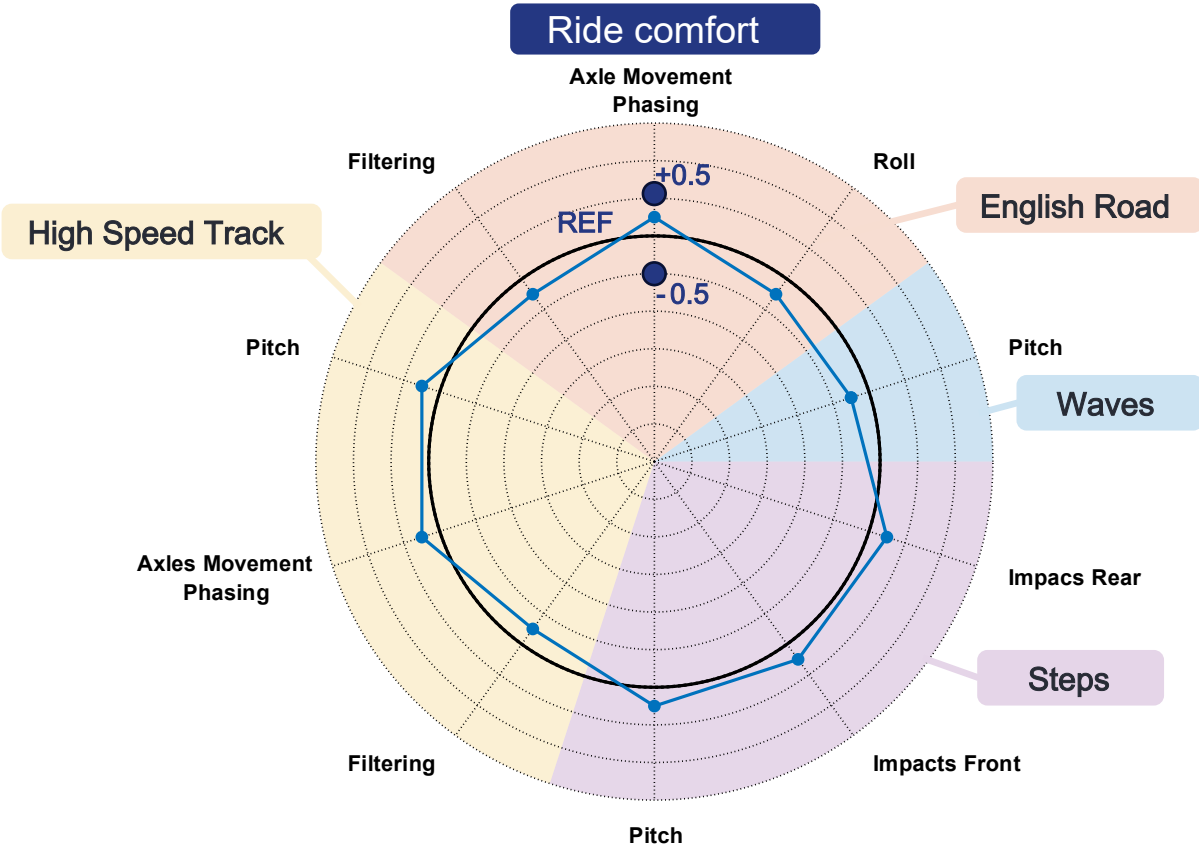


A woman is shown from the chest up, driving a car. She is wearing sunglasses and has her hair tied back. The image is heavily tinted with a blue color. Overlaid on the image is the text "DAMPER HIL BENCH: SUBJECTIVE VALIDATION" in a white, bold, sans-serif font. The text is centered horizontally and spans across the middle of the image.

# DAMPER HIL BENCH: SUBJECTIVE VALIDATION

Understand driver subjective evaluation when switching from HiL to

MiL configuration using same dampers



Drivers can recognize and distinguish MiL from HiL configurations

Driver comments - MiL (with respect to reference HiL)

- Increased perception of rear axle movement
- Worse filtering
- Faster response and reduced delays
- Higher perceived chassis roll rate

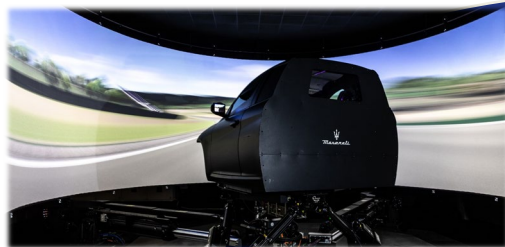
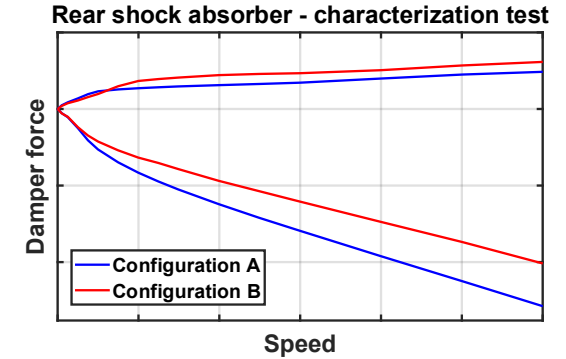
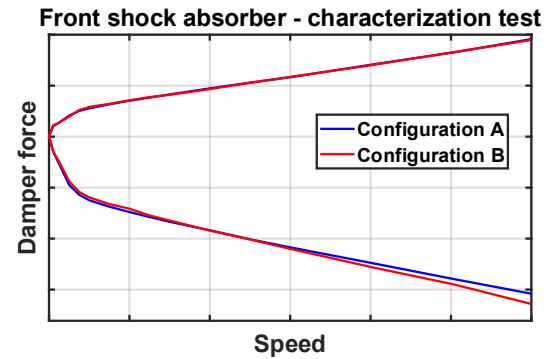
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# DAMPER HIL BENCH: TUNING SESSION

Perform damper tuning session on the Simulator with HiL bench and on track with real vehicle (2 configuration sets)

Test sequence (Simulator & Track)

- DiL with configuration A → driver comments
- Dampers change on HiL benches/Vehicle in workshop
- DiL with configuration B → driver comments
- Final driver report evaluation on relative differences between Configuration A & B



**SIM +HiL / Track**

Driver marks of configuration B relative to configuration A (reference) on both environments

**Driver comments  
RIDE COMFORT**

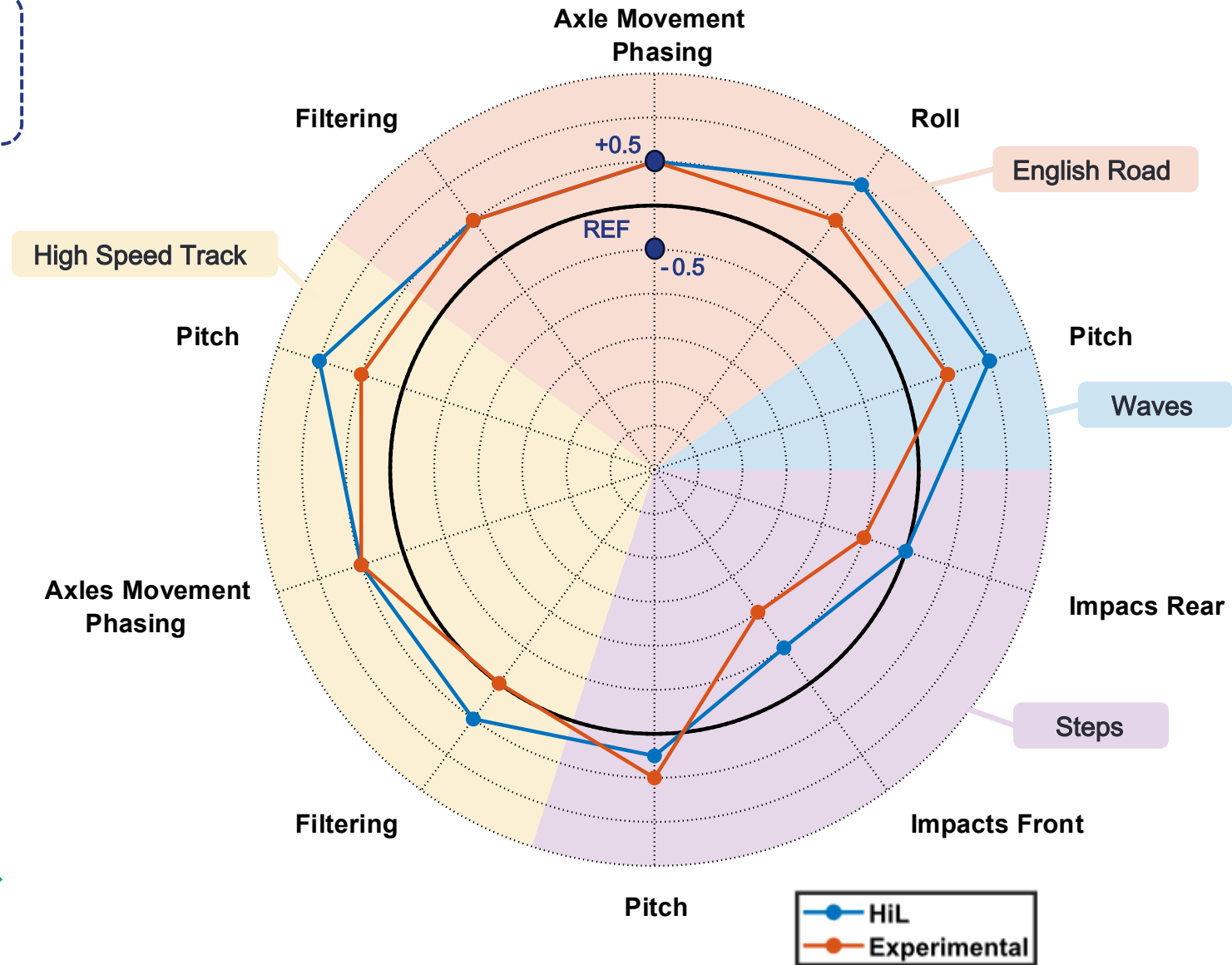
**Configuration A (Reference)**

- Significant front motion and limited rear involvement
- Substantial pitch perception

**Configuration B**

- Improved front to rear phasing leading to better balance
- Subjectively pleasant response
- Slightly worse filtering on steps

- Driver confirms same perception on simulator and on track
- Different amplitude → SIM+HiL emphasize dampers contribution, with much more clear understanding



### SIM +HiL / Track

Driver marks of configuration B relative to configuration A (reference) on both environments

### Driver comments HANDLING

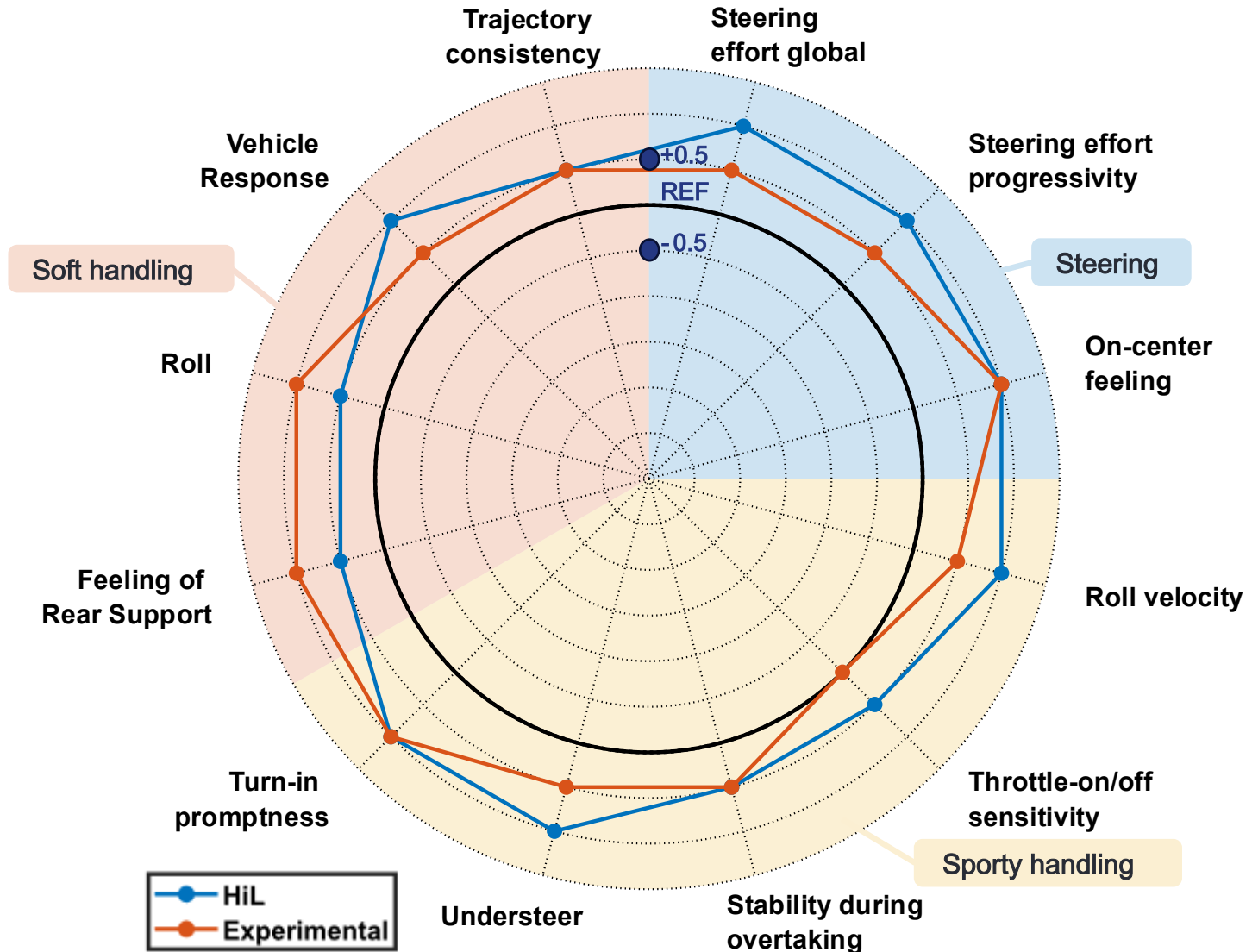
#### Configuration A (Reference)

- High steering angle demand
- Excessive understeer perception
- Poor turn -in response

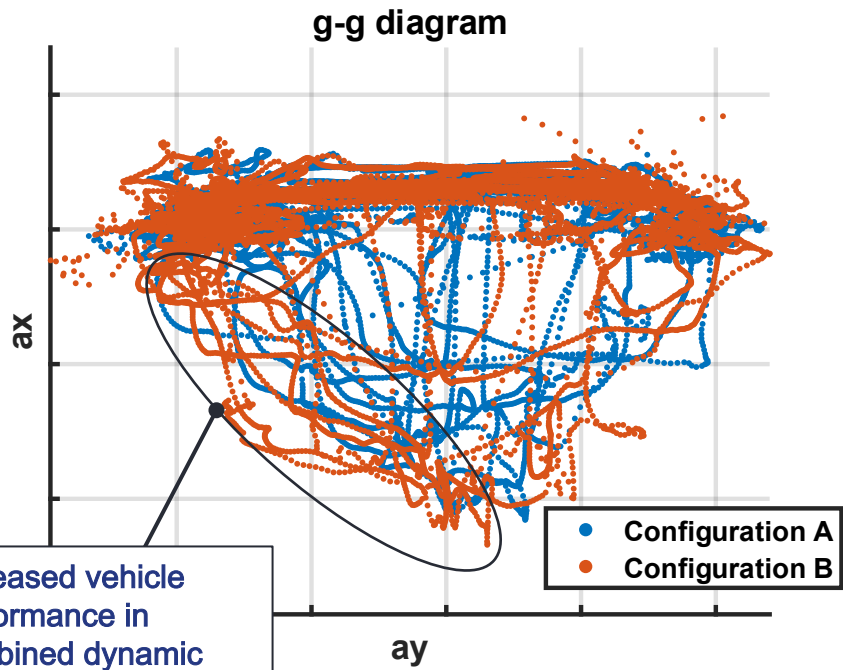
#### Configuration B

- Improved feeling on the rear axle
- Improved turn -in response
- Improved front/rear phasing

- Driver confirms same perception on simulator and on track
- Different amplitude → SIM+HiL emphasize dampers contribution, with much more clear understanding

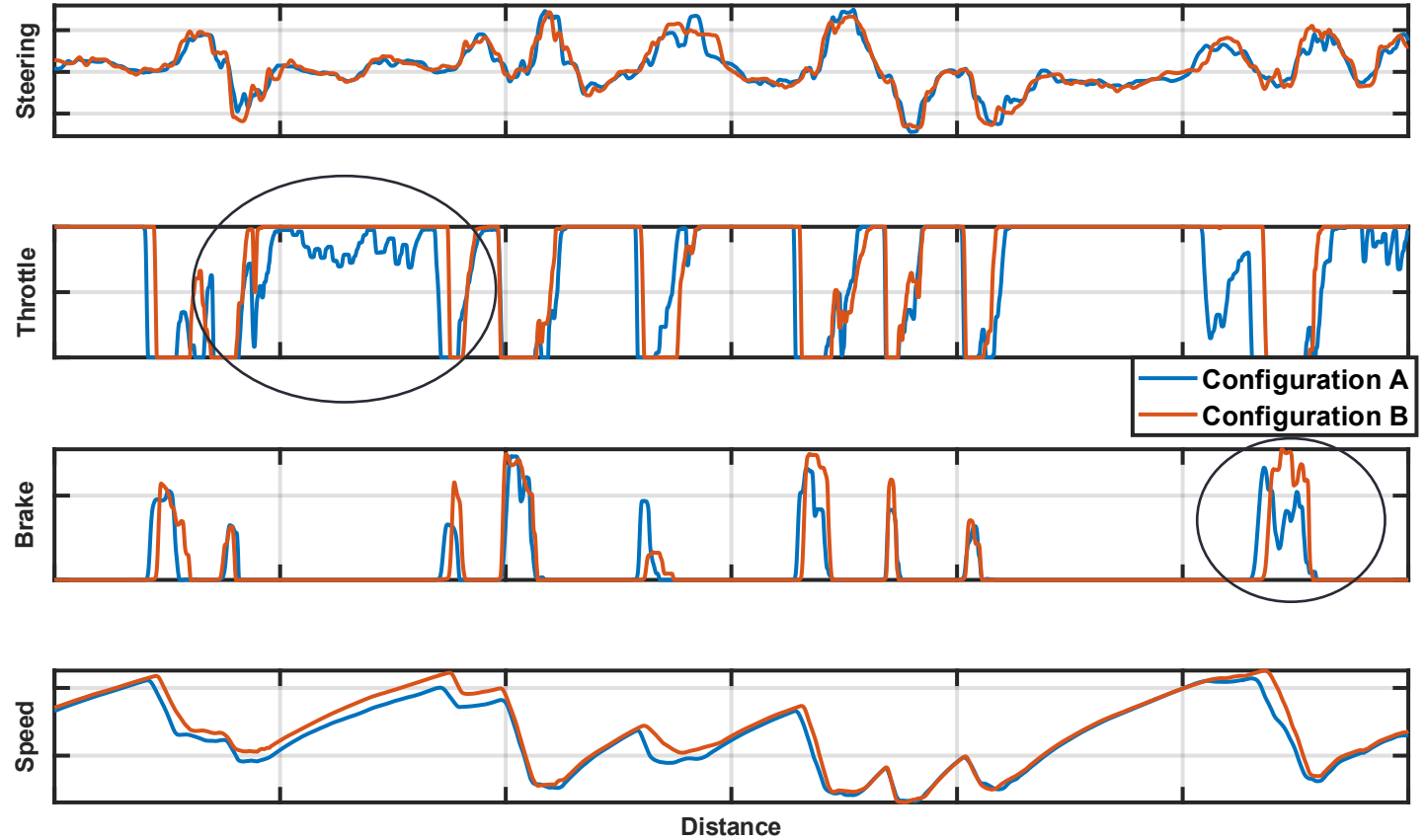
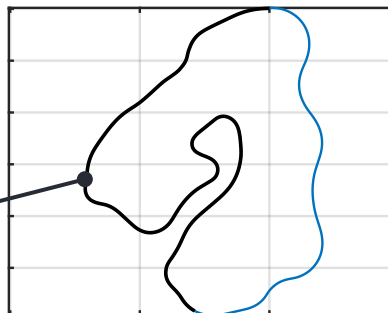


Configuration B improves handling while combining pleasant comfort response



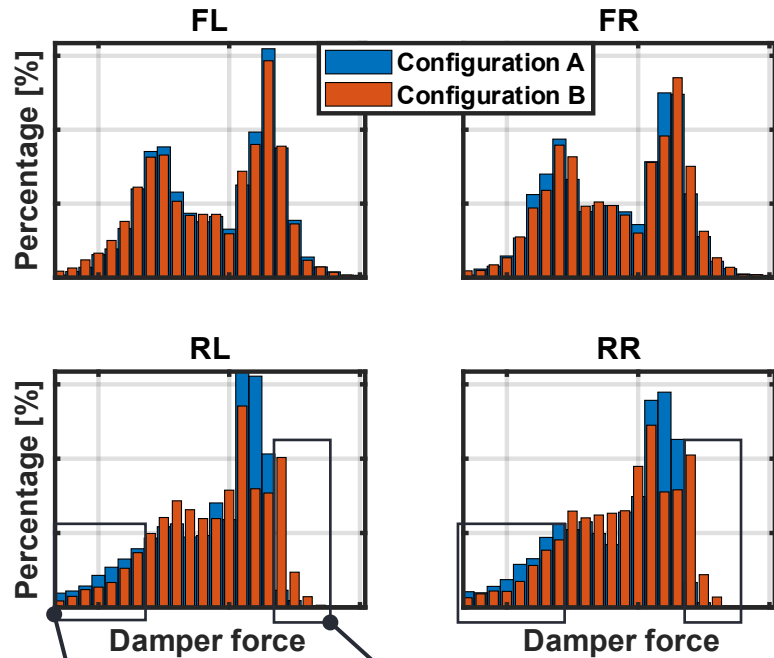
Increased vehicle performance in combined dynamic

Track section under analysis



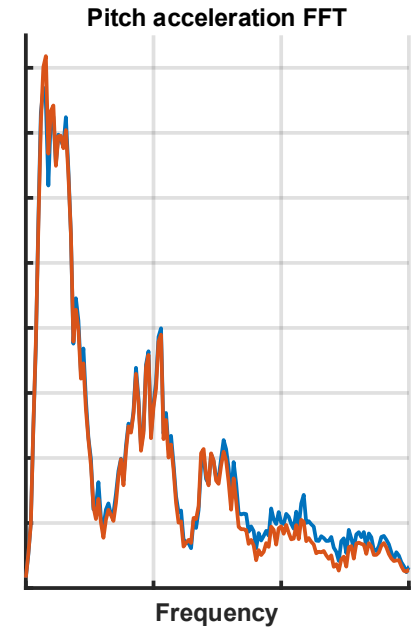
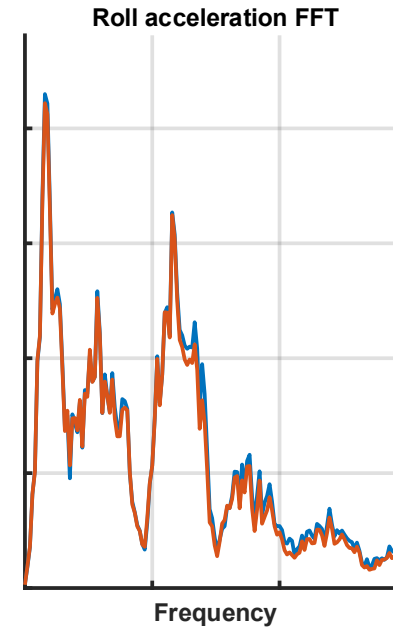
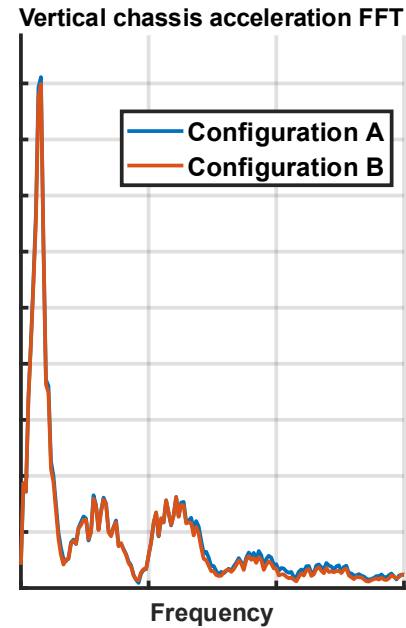
	Configuration A	Configuration B
RMS of throttle [%] channel	REF	+ 9%
RMS of active brake [%] channel	REF	+ 18%

Configuration B improves perceived ride comfort through better front to rear phase alignment



Reduced damper force in rebound

Increased damper compression force



	RMS chassis vertical acceleration	RMS roll acceleration	RMS pitch acceleration
Configuration A	REF	REF	REF
Configuration B	- 2.5 %	- 3.2 %	- 1.2%

## Objective validation

- ✓ Completed full damper characterization test
- ✓ Checked bench-simulator layout integration and existing closed loop delay
- ✓ Completed objective validation in standard comfort and handling driving scenario

## Subjective driver evaluation

- ✓ Drivers can clearly identify differences between MiL and HiL in terms of delay due to damper hysteresis and vehicle response
- ✓ Drivers can successfully identify differences between HiL configurations
- ✓ Driver comments points in the same direction of experimental test
- ✓ HiL testing allows to reduce waiting time between consecutive damper test session with respect to experimental testing
- ✓ HiL testing allows to effectively isolate damper tuning from the rest of vehicle setup

## Next steps

- ❖ Install top-mount to enhance consistency
- ❖ Introduce active valves electric drives
- ❖ Introduce thermal monitoring



# CONTACT

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