Semi-Active Dampers [CVSAe]

For Mahindra's BEV Platform [INGLO]

Implementation of a driver-in-the-loop methodology for virtual development of semi-active dampers

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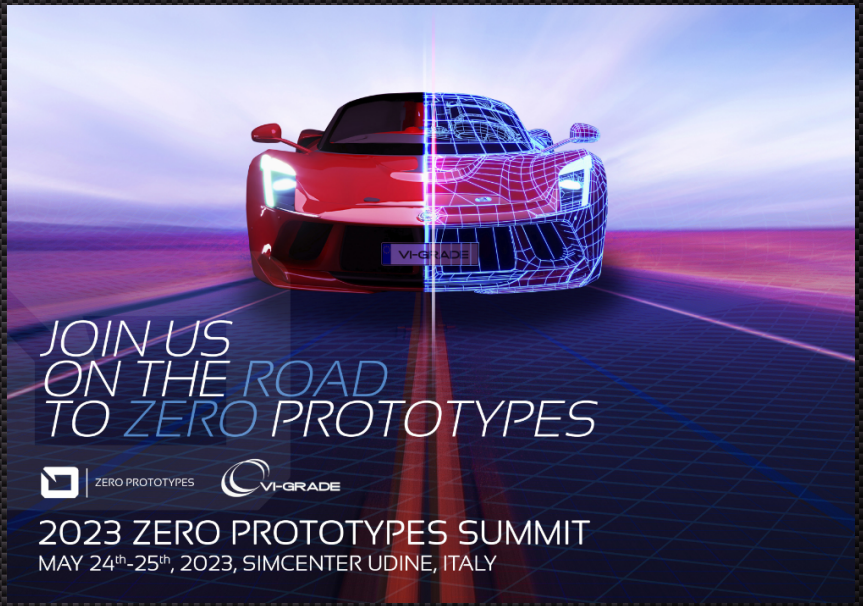
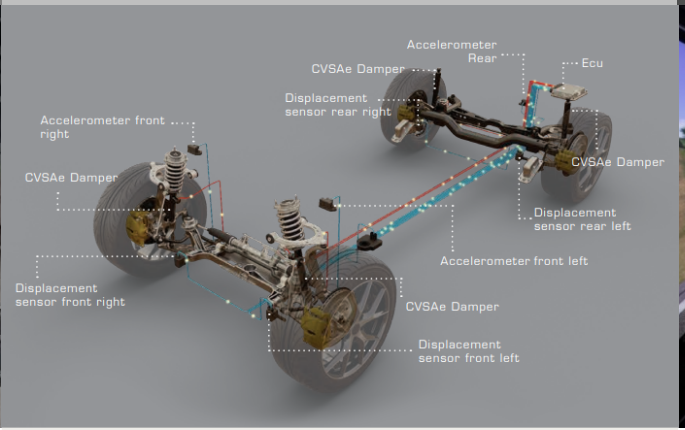


CONTENTS

1. MAHINDRA BEV

‘INGLO’
New BEV platform of Mahindra.

2. CVSAE VIRTUAL DEVELOPMENT



Advanced models to streamline the development process of semi-active dampers.

3. RESULTS & CONCLUSION

How the simulator made it possible to reduce the development time and cost

CONTENTS

MAHINDRA INGLO PLATFORM

ELECTRIC SUVS

PLATFORM HIGHLIGHTS

- COMMON & MODULAR
- 5 DIFFERENT TOP HATS
- 250+ KW DUAL MOTORS
- 10.2 M TCD
- UPTO 78 KWH BATTERY
- 5 / 7-SEATER

XUV.E8

HIGH R.A.W & C.G

BE 05

HIGHEST IN CLASS GROUND CLEARANCE

XUV. E9

SPORTY HANDLING

CVSAE DAMPER TECHNOLOGY

ENSURE BEST IN CLASS RIDE-HANDLING PERFORMANCE

INDIAN ROAD PROFILE

BROKEN SURFACES

PLUSH RIDE-COMFORT

MARKET EXPECTATION

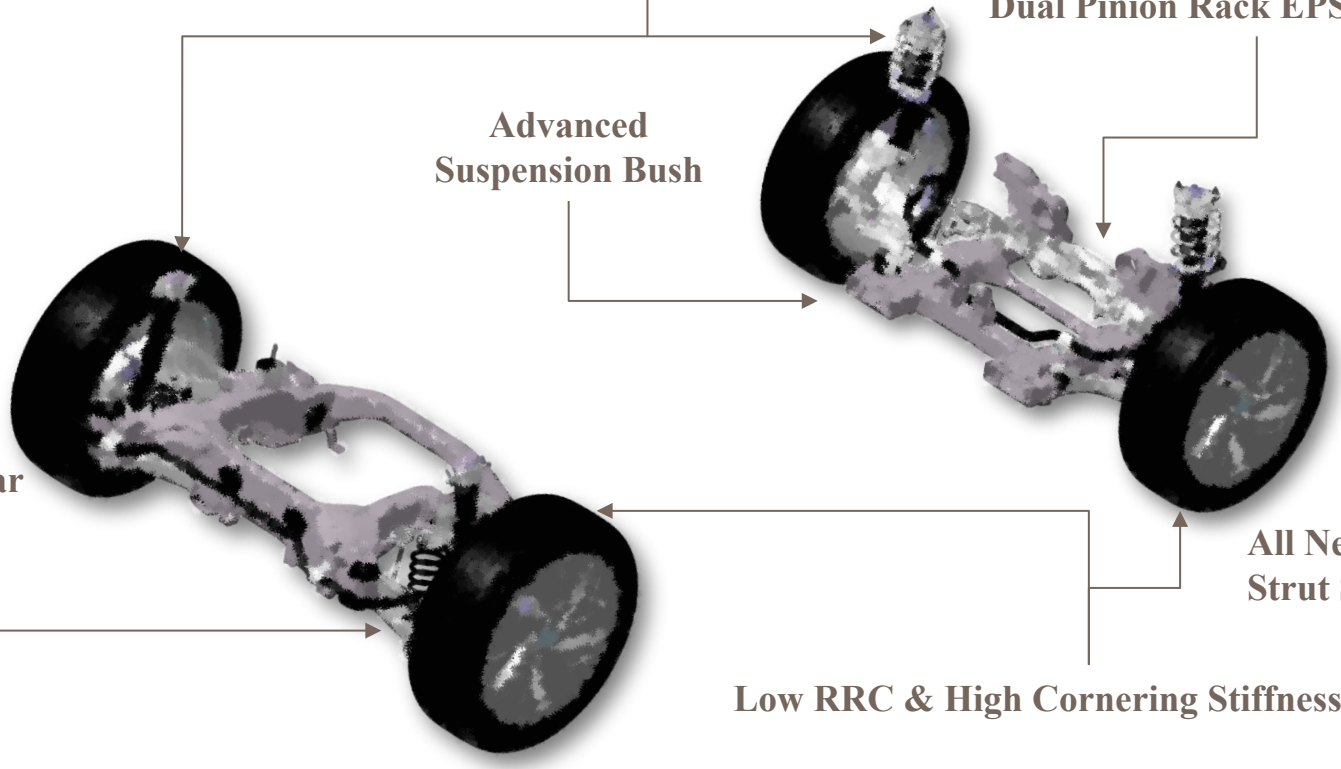
MAHINDRA INGLO PLATFORM

VEHICLE ARCHITECTURE

Semi-Active Damping Control

Dual Pinion Rack EPS with VGR

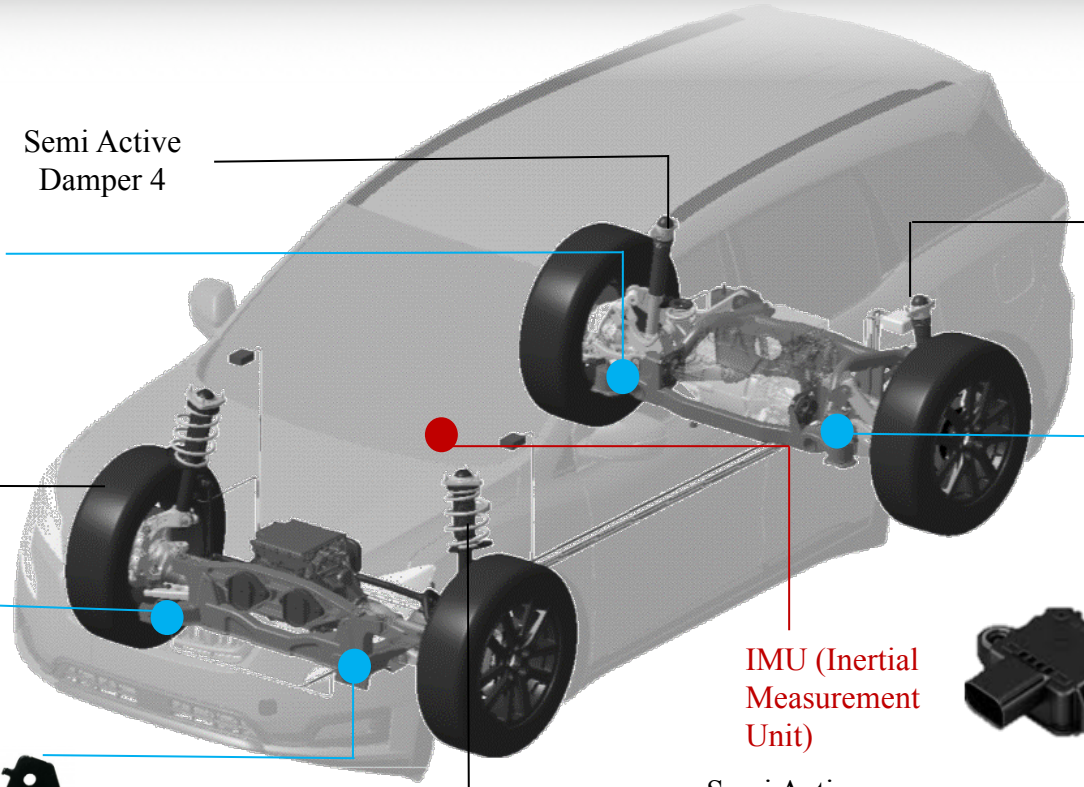
Advanced Suspension Bush



All New 5-Link Independent Rear Suspension

All New MacPherson Strut Suspension

Low RRC & High Cornering Stiffness Tyres


Semi Active Damper 4
Displacement Sensor 4
Semi Active Damper 3
Semi Active Damper 1
Displacement Sensor 1
Displacement Sensor 3
IMU (Inertial Measurement Unit)
Displacement Sensor 2
Semi Active Damper 2

Mahindra's 1st BEV Platform Concept

All New Steering & Suspension Development

All New Brakes System Development

All New E-Powertrain Integration

Validation & Durability on Indian RWUP

START OF PRODUCTION

CONCEPT TO START OF PRODUCTION: 30 MONTHS

JUNE 2022

APRIL 2023

Chassis System Developments with DiM 250

- Suspension Concept & Hardpoint
- Steering Response & Assist Tuning
- Tyre Development through Virtual Models
- Semi-Active Damper Valve & Controller Tuning

CONTENTS

Comfort and control

Independant controlled dampers

More dynamic damping

Ride comfort & Handling in any condition.

Electronic valve

Active **electrohydraulic valve**

IMPROVED COMFORT

DRIVING AGILITY

SECURE FEELING

SUITABLE FOR SPORTS CARS, SUV, BEV AND LUXURY SEDANS

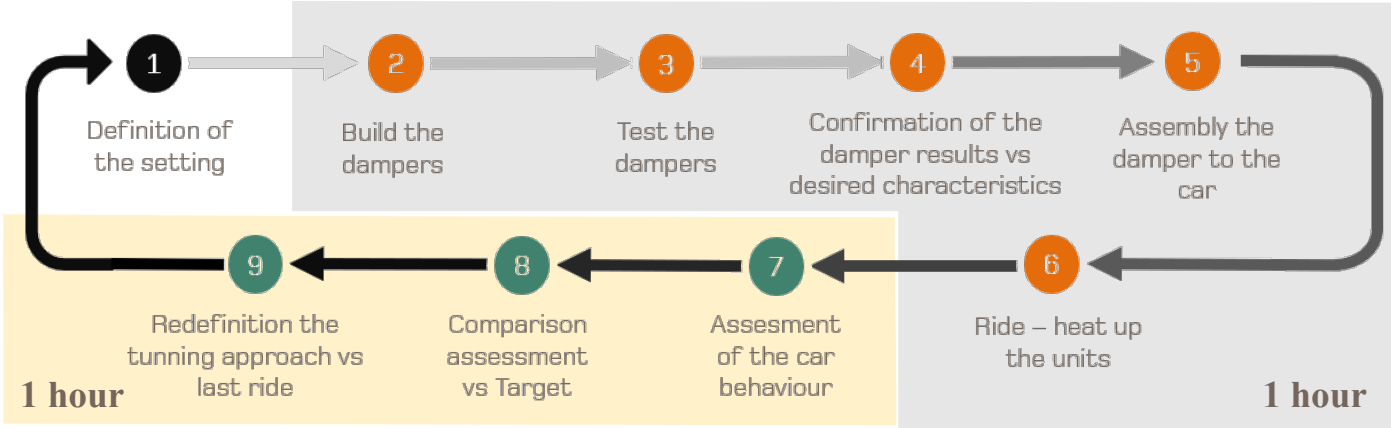
OVER 16
Million units sold

75
Different models in the global market

12 OE BRANDS

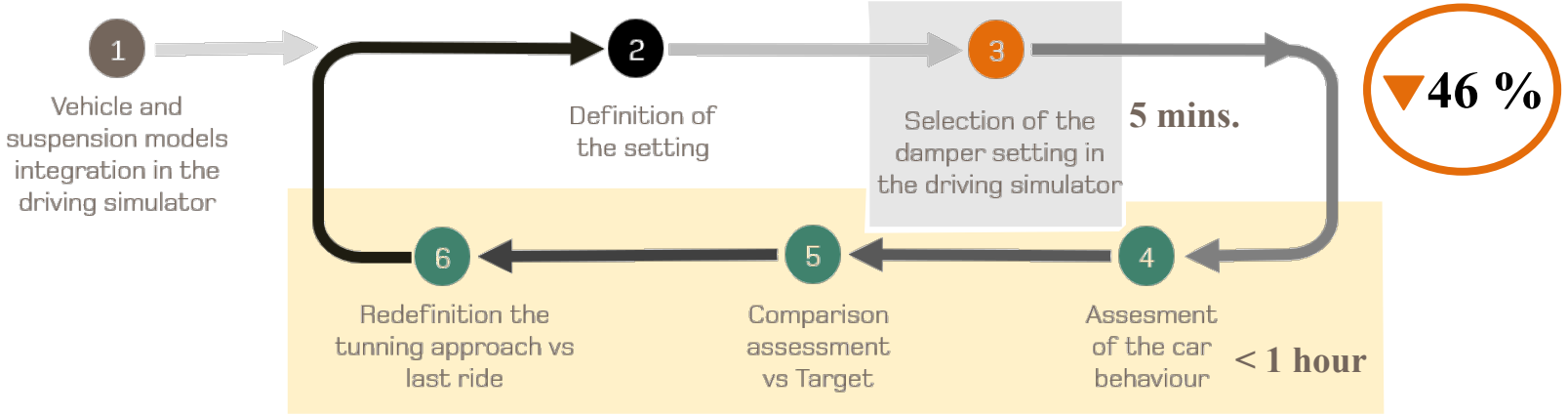
Definition: session where the parameters of the suspension are defined in order to meet the ride quality and vehicle handling requirements.

Traditional approach – Define the setting + Assembly the dampers + Assesment

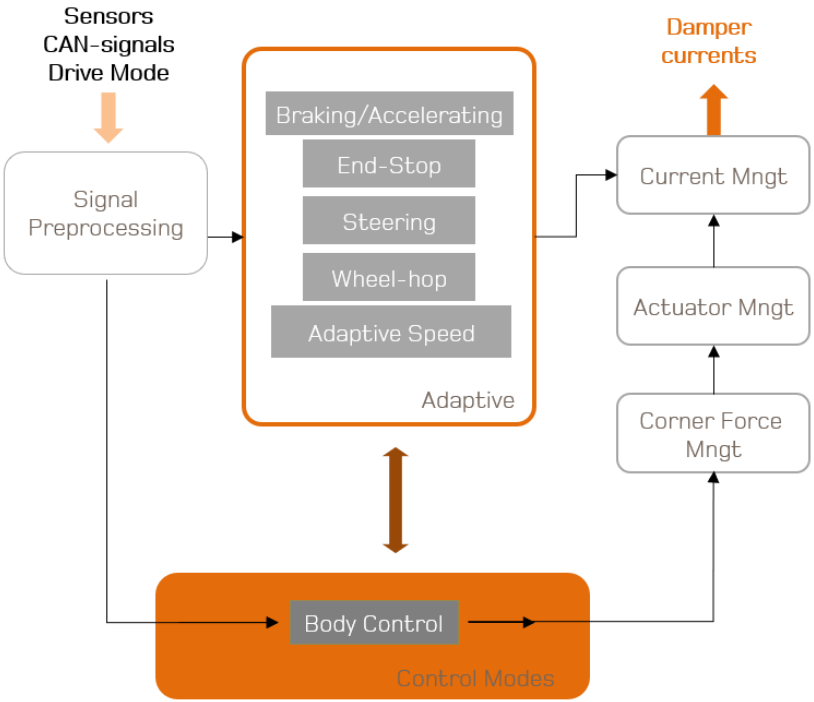


Definition: session where the parameters of the suspension are defined in order to meet the ride quality and vehicle handling requirements.

Virtual approach – Integrate the models + **Define the setting** + Select the damper setting + Assesment



CONTROLLER


Sensors
CAN-signals
Drive Mode
Signal Preprocessing
Braking/Accelerating
End-Stop
Steering
Wheel-hop
Adaptive Speed
Adaptive
Damper currents
Current Mngt
Actuator Mngt
Corner Force Mngt
Body Control
Control Modes

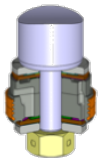
DAMPER MODEL

F-V Curves Model

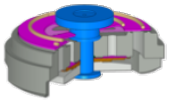
Model definition

Passive valves

Piston valve



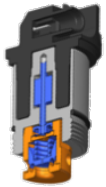
Base valve



Discs configuration (disc arrangement, dimensions, thickness…)

Active valve

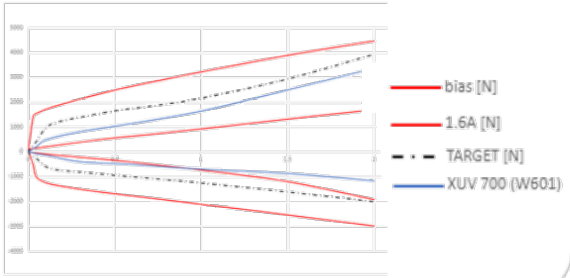
CES valve



- Main spring stiffness
- Pilon shim stiffness
- Pilot diameter
- Main stage type

Outputs

Damping forces in rebound, compression and failsafe



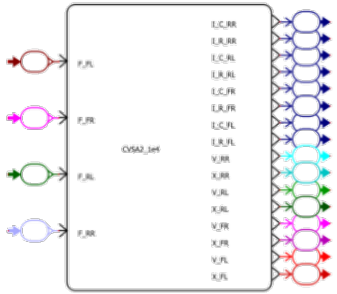
Hydraulic AMESIM Model

Model definition

- Co-simulated model AMESIM-Simulink.
- Direct motion on the piston.
- **Bidirectional CES valve**
- **Bidirectional passive valves**
- **No compliant volumes** for piston or third tube.
- Fixed gas pressure.
- Oil **bulk modulus** set at **10 kBar**.

Outputs

Damping forces in rebound, compression and failsafe



DAMPER & CONTROLLER

CAR

Damping Control Output

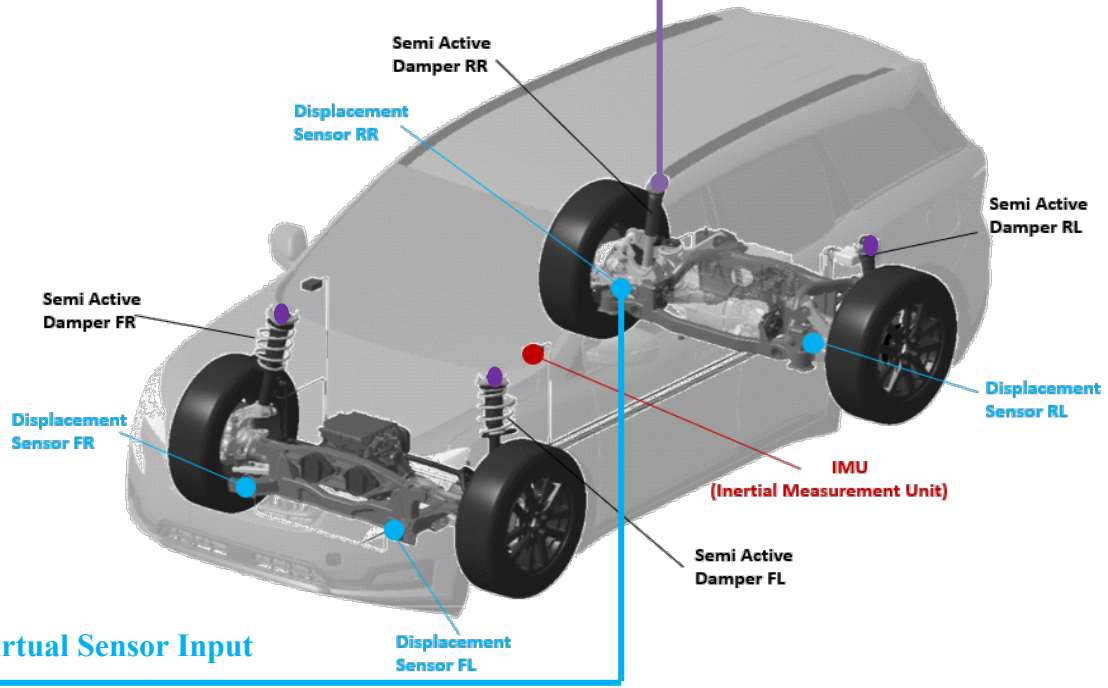
CVSAe Damper Model

- Simulink
- Force Velocity
- 9 x 144 Valve setting

Current Signal

Controller Model

- Amesim
- Vehicle State Estimation
- Chassis Control Strategy:
  - Adaptive Control
  - Predictive Control



Virtual Sensor Input

CONTENTS

Loop 1

- Definition of “elastic” components
- Integration of HW models (no control logic)
- Evaluation with fixed current levels on specific roads (IDIADA ride and General Road)
- Select HW for max. - min. damping curves

Loop 2

- Integration of controller model
- Validation of HW selection from Loop 1
- Pre-tuning of control modules to define initial parameters to speed up the physical tuning
- Overall performance targets status

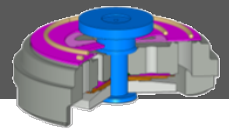
ARBs and springs freeze

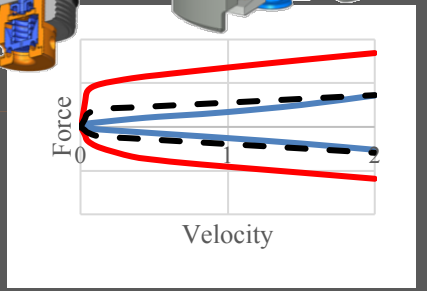
Valve selection: min. damping

Valve selection: max. damping

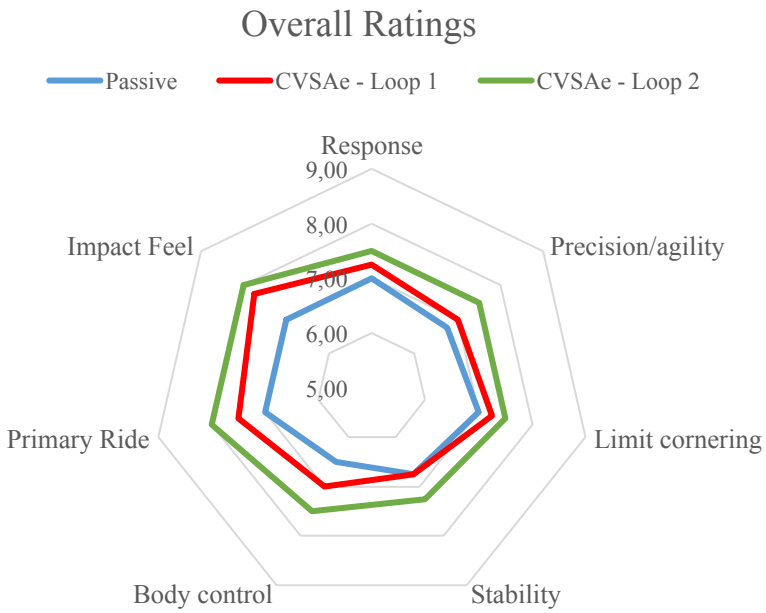
HW verification with controller

Logic tuning





EVALUATION RESULTS



SUMMARY

(physical) *vs.* simulator

(15+) **6**
Days of evaluation

(~30) **~35**
Set-ups evaluated

(40+) **0**
Physical dampers components

(1) **0**
Mule vehicles

CONCLUSIONS

Key decisions for CVSAe dampers have been taken based on driving simulator evaluation.

Substantial reduction of the cost and time in comparison with the “traditional” process.

NEXT STEPS

Samples are being prepared for prototype tuning.

Verify HW selection and initial parameters tuning on physical vehicle.

Models validation and preparation for next virtual loops


DRIVING SIMULATOR
LABORATORY
Applus
IDIADA