

Development of behavioral models of chassis control algorithms to enhance model- based development:

Rear Wheel Steering use case

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FUNCTIONALITIES



ENGINEERING,
TESTING &
HOMOLOGATION



CONTENTS

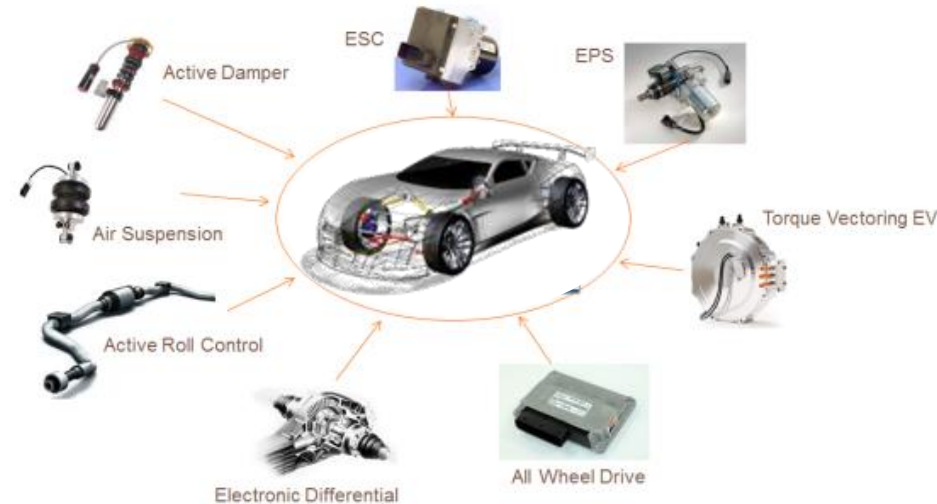
1. Introduction
2. Model generation & validation
3. Logic description
4. Results & Conclusion

THE "NEW" SCENARIO

THE CHALLENGES

Models for most the chassis control systems not available in the early development stages

1. Difficult to plan a comprehensive strategy for target cascading, with active & passive chassis
2. Limitation in the adoption of digital twins of benchmark vehicles.



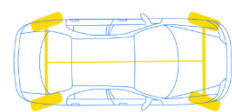
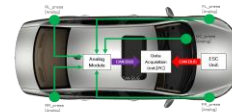
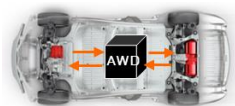
THE CHALLENGES

Models for most the chassis control systems not available in the early development stages

1. Difficult to plan a comprehensive strategy for target cascading, with active & passive chassis
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THE SOLUTION

Develop *behavioral* models of the most widely adopted chassis control systems



Purpose: adoption in the early stages of vehicle development and for digital twins

Joint R&D activity since 2017

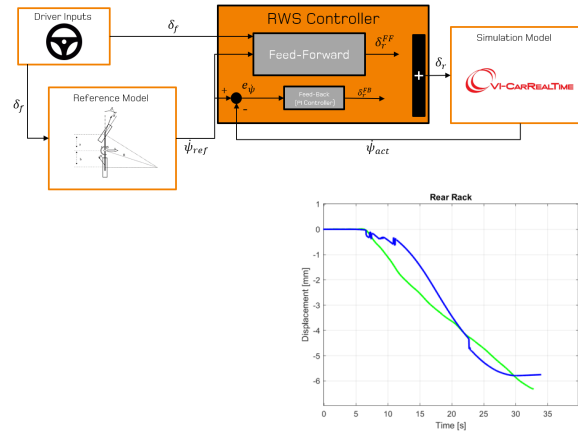


1



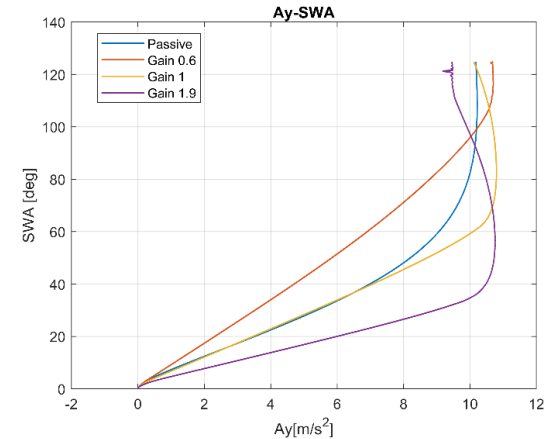
To develop a digital twin of one benchmark vehicle, that can be used as a digital reference in the Driving Simulator.

2



To generate a rear wheel steering logic representative of the application in the benchmark vehicle.

3



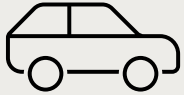
To make the RWS logic highly tunable for application in target cascading.

INTRODUCTION

PROJECT CASE ACTIVITIES

ACTIVITIES

OUTCOME



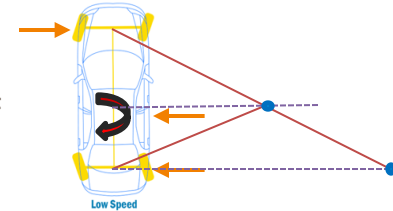
BENCHMARK VEHICLE TESTING

DATA FOR MODEL BUILDING
AND VALIDATION



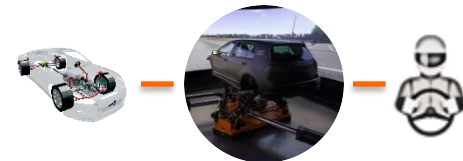
PASSIVE MODEL GENERATION & CONCEPT LOGIC DEVELOPMENT

RWS LOGIC INTEGRATED IN
THE DIGITAL TWIN MODEL OF
THE COMPETITOR



INTEGRATION TO DS

VALIDATED MODEL OF
THE BENCHMARK
VEHICLE

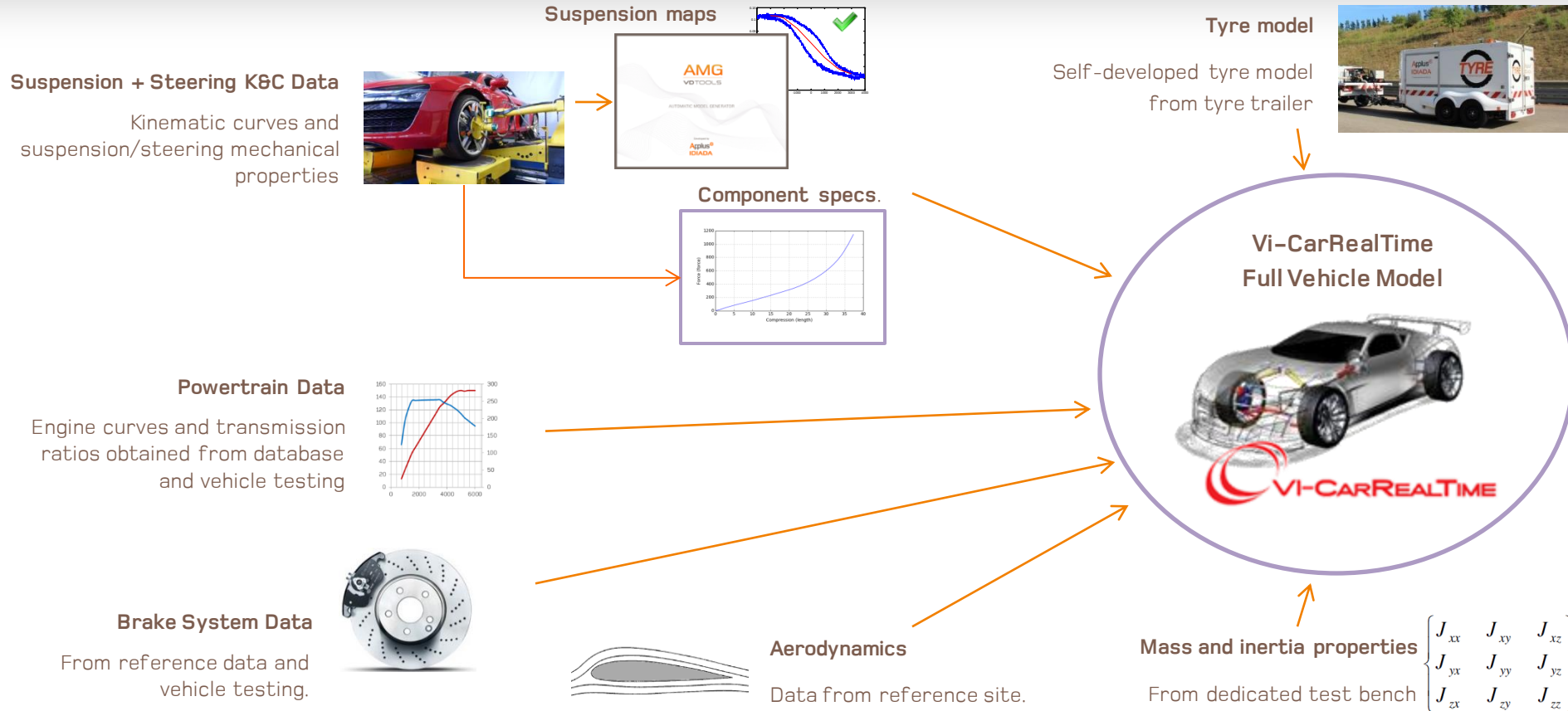


1. Introduction

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Manoeuvres

1. ISO manoeuvres (wide range of speeds).
2. Close-loop driving (e.g. Dry Handling sub-limit and at the limit)

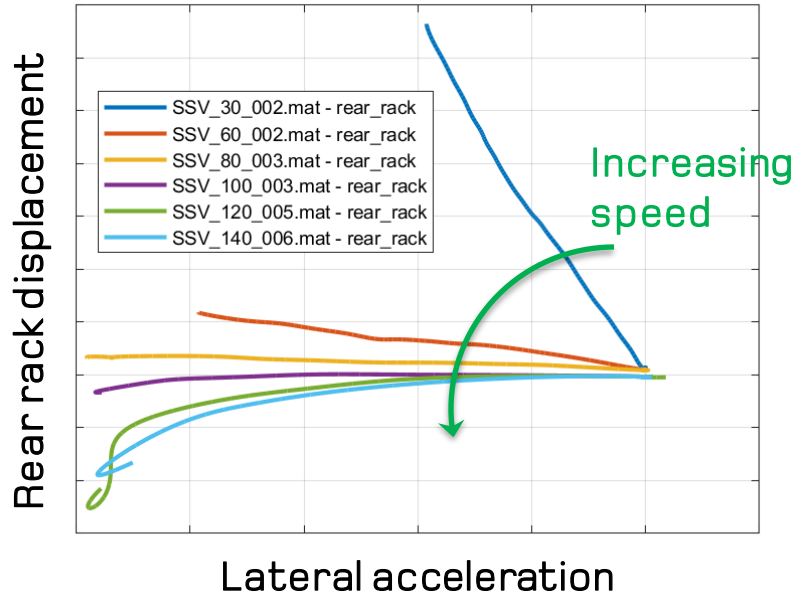


Instrumentation

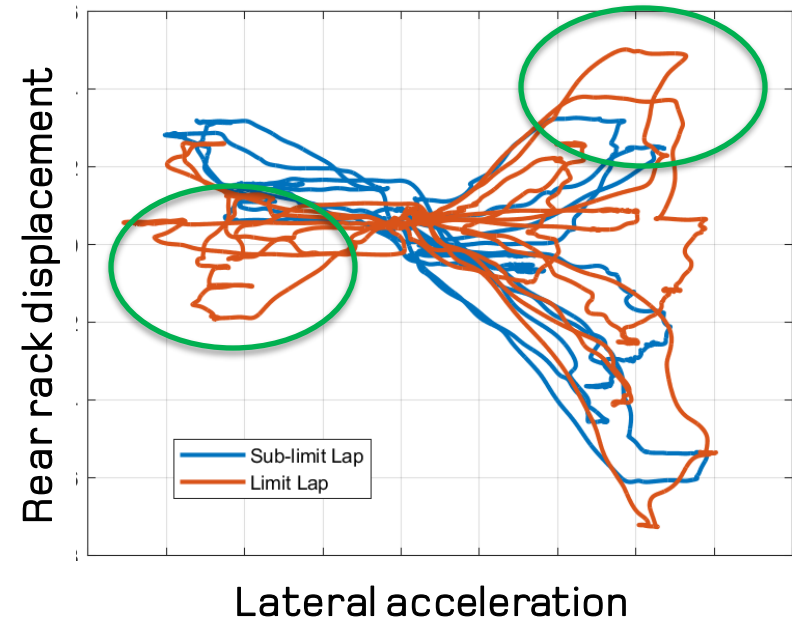
1. Measure complete vehicle behaviour.
2. Apply additional sensors to the specific actuator under investigation (rear rack displacement)



Analysis of Steady-state cornering

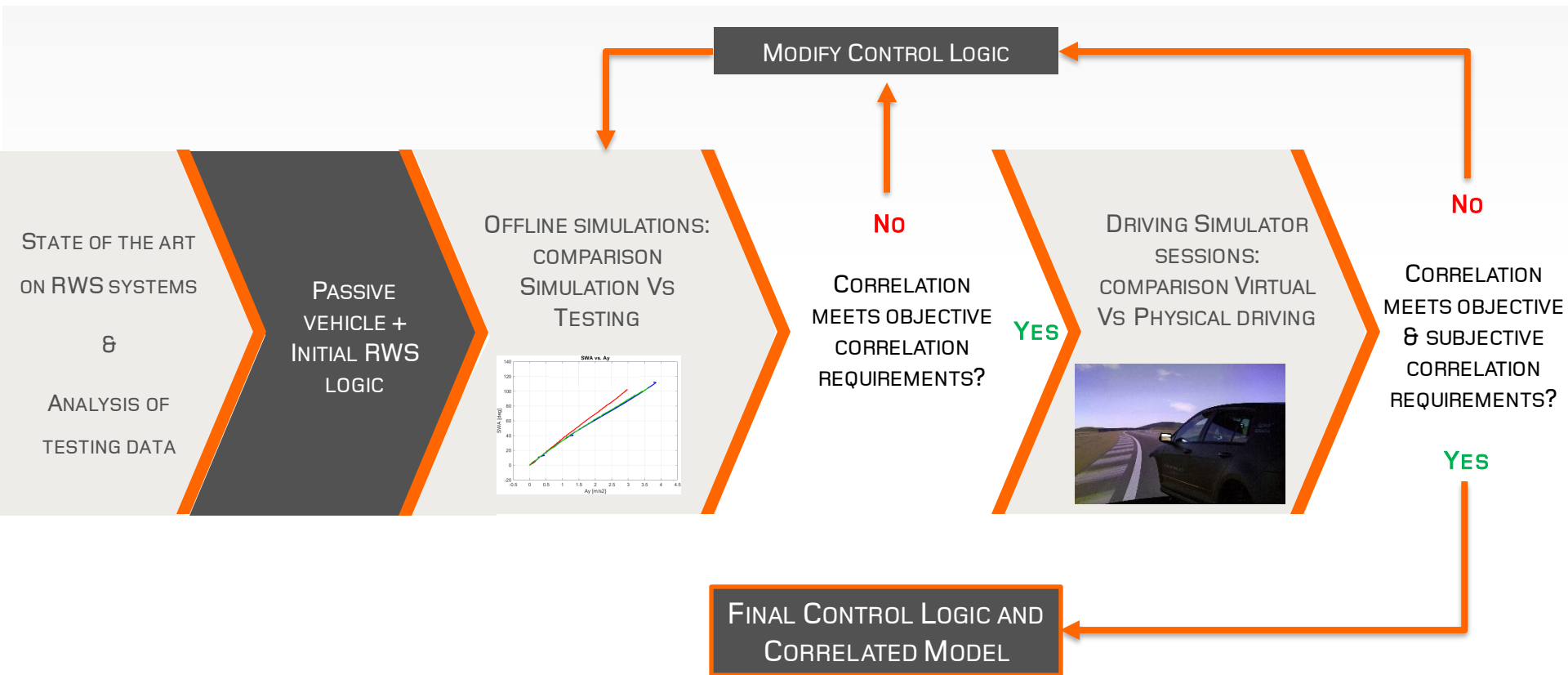


Analysis of Dry Handling laps



MODEL GENERATION & VALIDATION

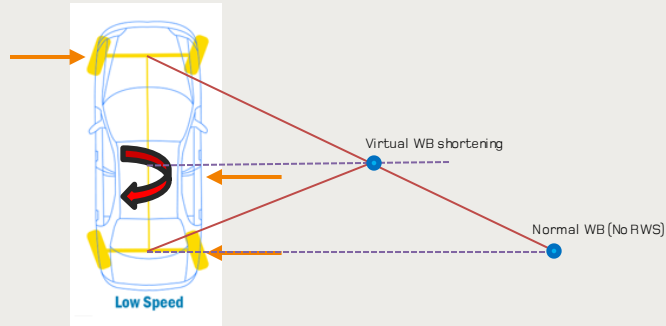
ACTIVE MODEL GENERATION & VALIDATION



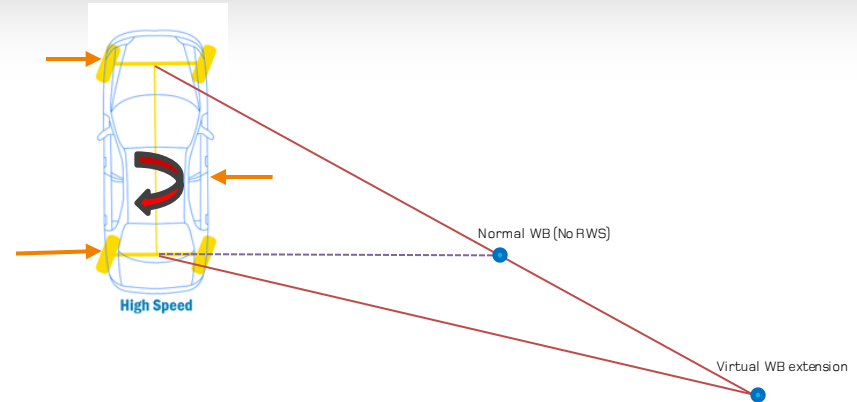
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Basic objectives of Rear Wheel Steering

- Improve vehicle performance in terms of steering maneuverability and handling/stability.
- Higher agility at low speeds and stability at higher speeds.



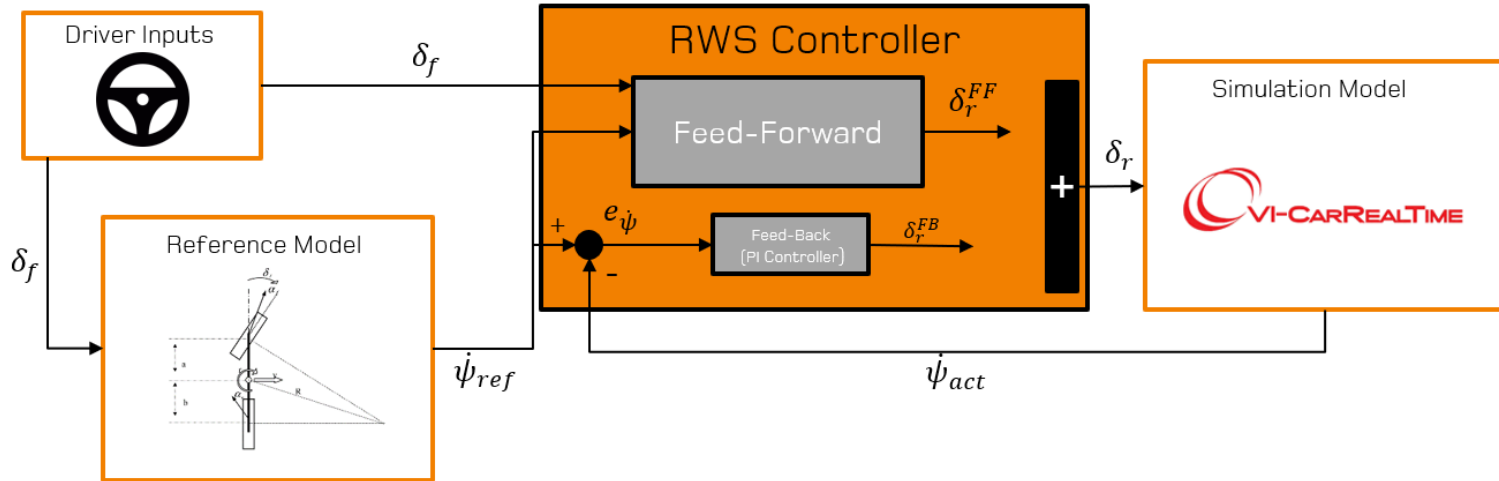
Steering in the opposite direction $\delta > 0; \delta_r < 0$ increases yaw and inhibits lateral acceleration, which is desirable at lower speeds. It also helps to reduce turning radius.



Steering in the same direction $\delta > 0; \delta_r > 0$ allows lateral acceleration to build up more quickly, since the lateral forces on the rear axle are built up faster. This reduces necessary slip angle of the rear axle, reflected in a lower $\dot{\phi}$

Logic Development

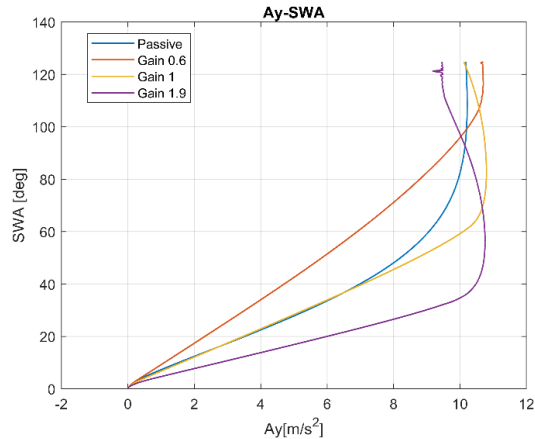
- **Feed-Forward:** applies control actions in advance, according to a yaw rate reference
- **Feed-Back:** compensates for model variations provides error correction, robustness and adaptability.



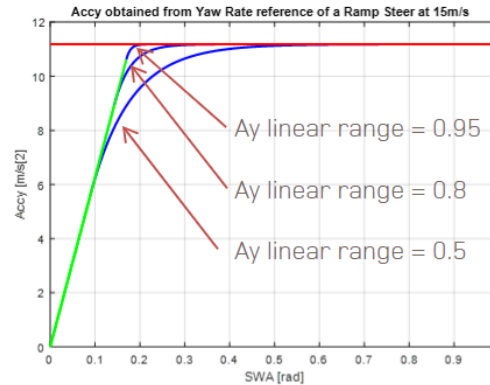
Main Parameters for logic tuning

The reference generator provide adaptability to a very wide range of vehicles through its parameters.

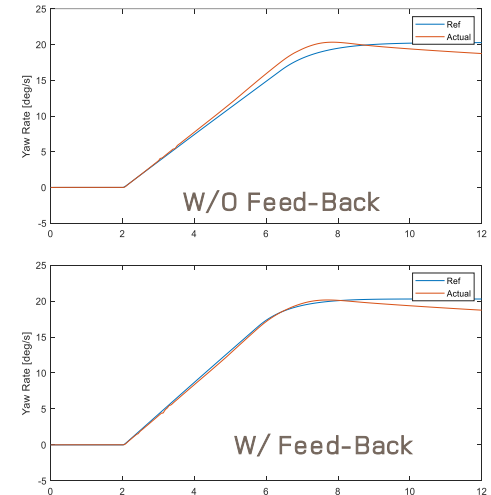
Feed-forward Reference Yaw Rate Gain



Feed-forward Ay Linear Range



Feed-back PI parameters

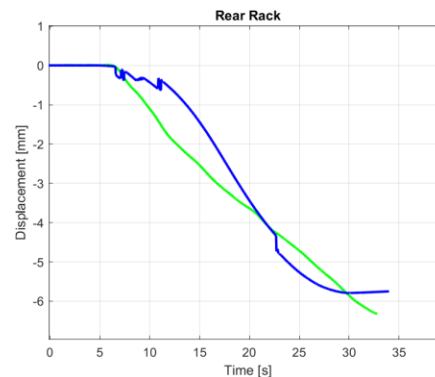
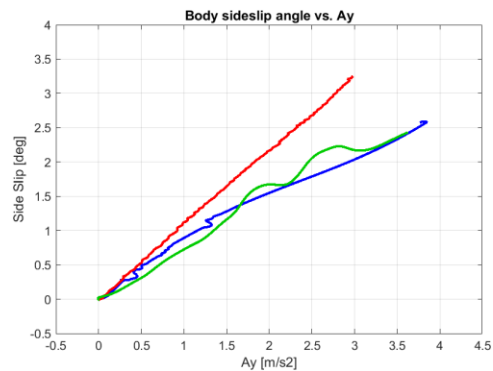
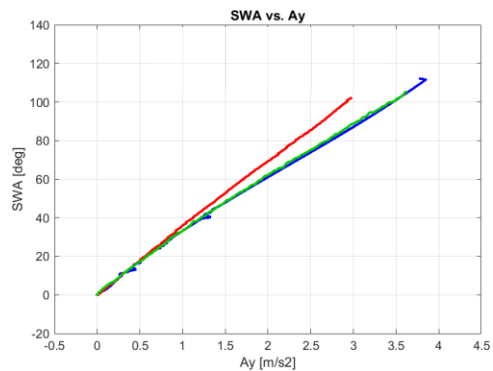


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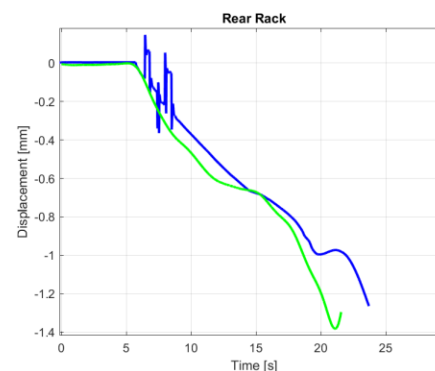
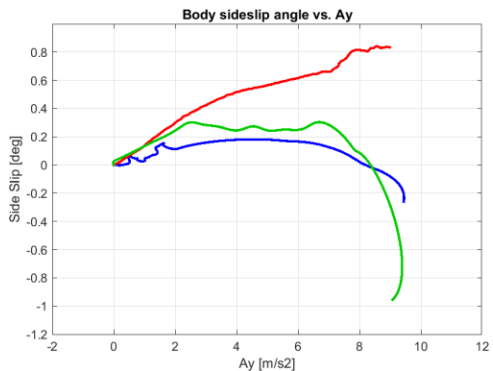
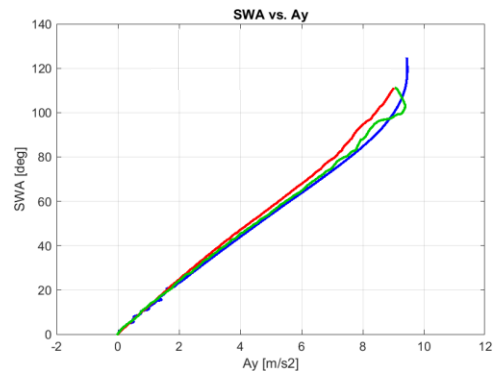
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MEASUREMENT - SIMULATION PASSIVE - SIMULATION ACTIVE

STEADY-STATE CORNERING CONST. SPEED



30 km/h

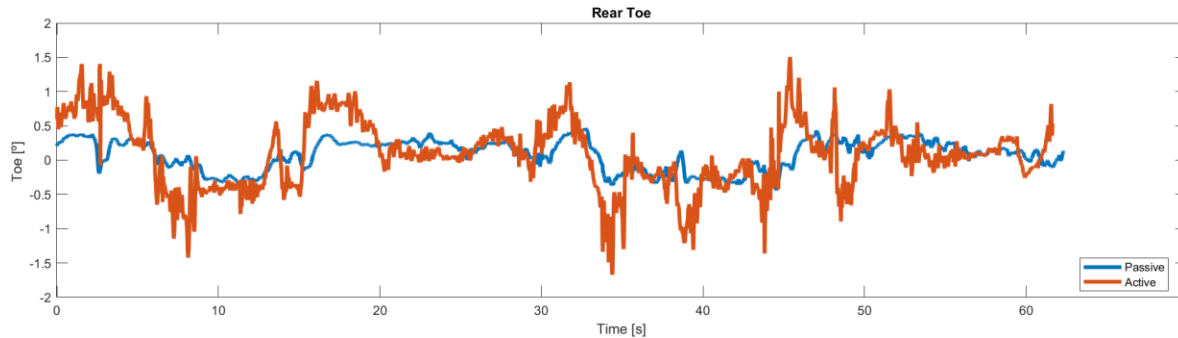
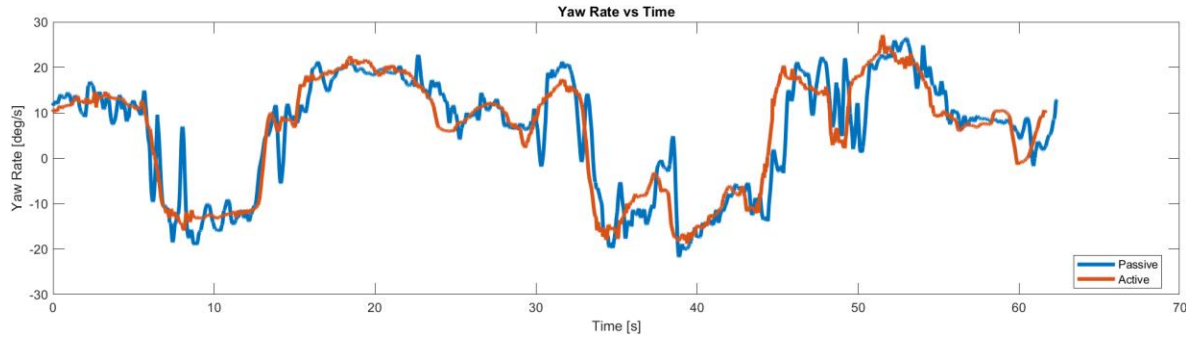


60 km/h

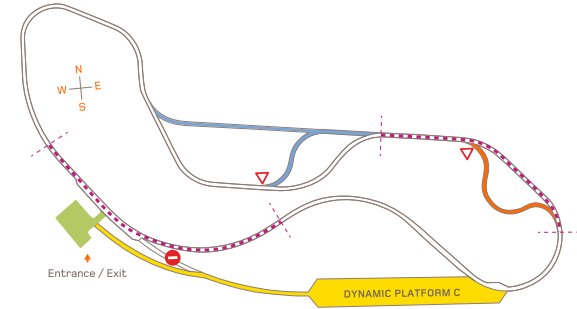
RESULTS

RWS EFFECTIVENESS

SIMULATION ACTIVE - SIMULATION PASSIVE



DRY HANDLING LAP ON DIM250



CONCLUSIONS & NEXT STEPS

CONCLUSIONS

The digital twin of the competitor has been generated and correlated.

This model includes the complete RWS logic.

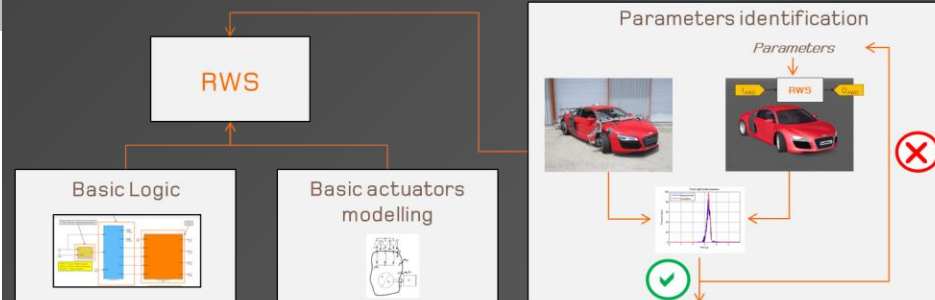
Such logic has been used for both benchmarking and early-stages development of new Nissan products.



NEXT STEPS

To expand further the library of chassis control systems

To develop a more systematic and automated parameter tuning is being developed to adapt more rapidly the existing logics to new vehicle models.





T H A N K Y O U F O R Y O U R K I N D A T T E N T I O N



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