

Analysis, 3D modeling and dynamic simulation of the vehicle steering system in the VIOS car.

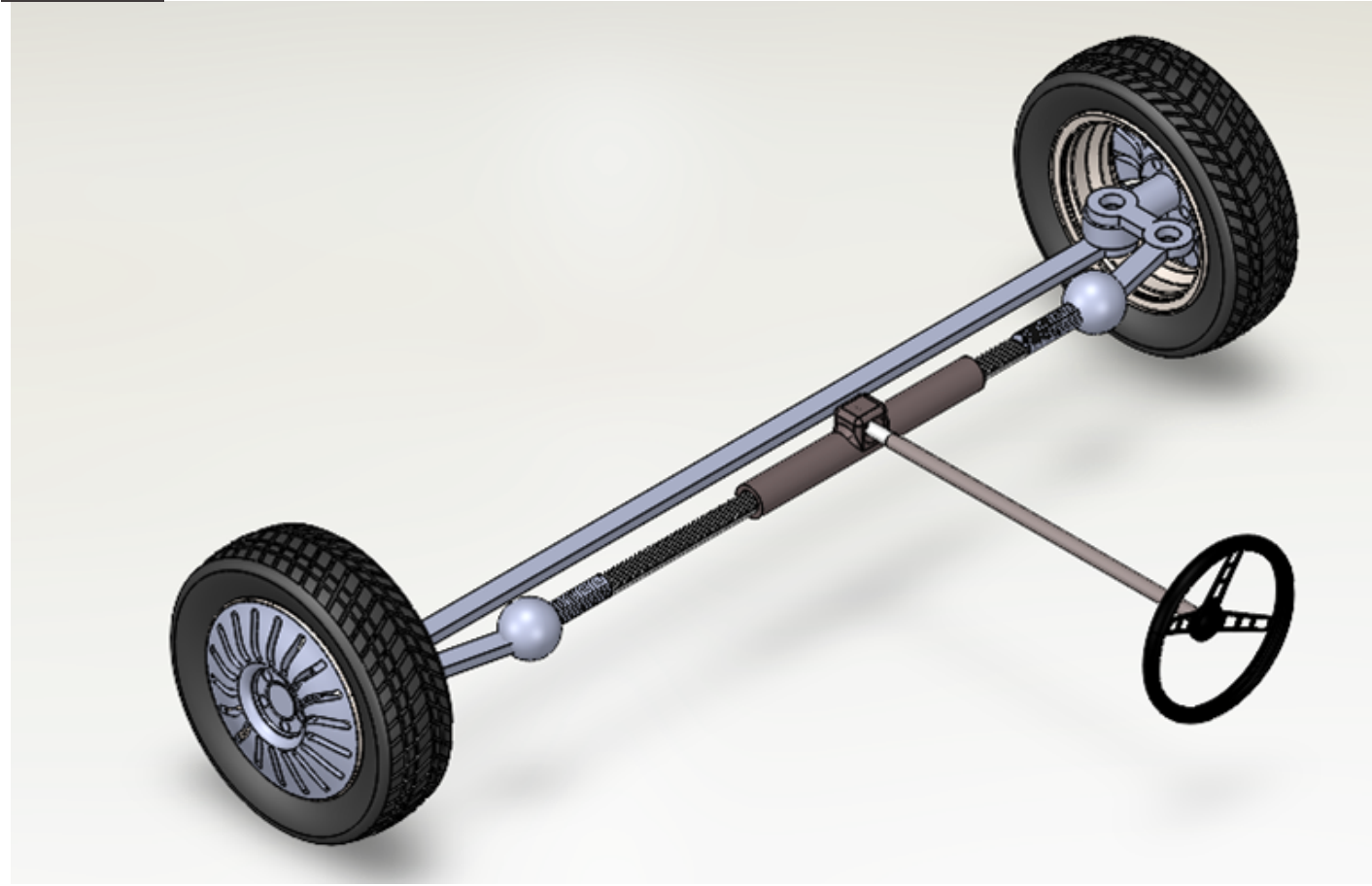
1 Abstract:

- This study presents a simulation of an Electric Power Steering (EPS) system for a Toyota VIOS car using MATLAB Simulink and Simscape.
- Simulation results demonstrate that the EPS system provides responsive and accurate steering control and maintains vehicle stability under various driving conditions.
- The study evaluates the EPS system's responsiveness and torque adjustments needed to maintain a predefined driving situation and also analyzes the impact of different parameters on the EPS system's performance.
- The study's findings provide insights into the design and evaluation of EPS systems for the Toyota VIOS car.

2 Objectives:

To demonstrate the process of building an EPS model using Solidworks and Simscape, simulating its dynamic behavior in Matlab/Simulink with Simscape, and validating the model for the control of an equivalent electric-powered steering system.

3 Theoretical basicc and parameters



Rack	Pinion: Rack ratio	Track Width
0.37m	1:3	1.4m
Tie Rod	Steering Linkage	Radius of steering wheel
0.265m	0.1m	180mm
Steering gear ratio	Number of teeth on the pinion	Number of teeth on the rack
19.5	9	27

Table : Parameter of components

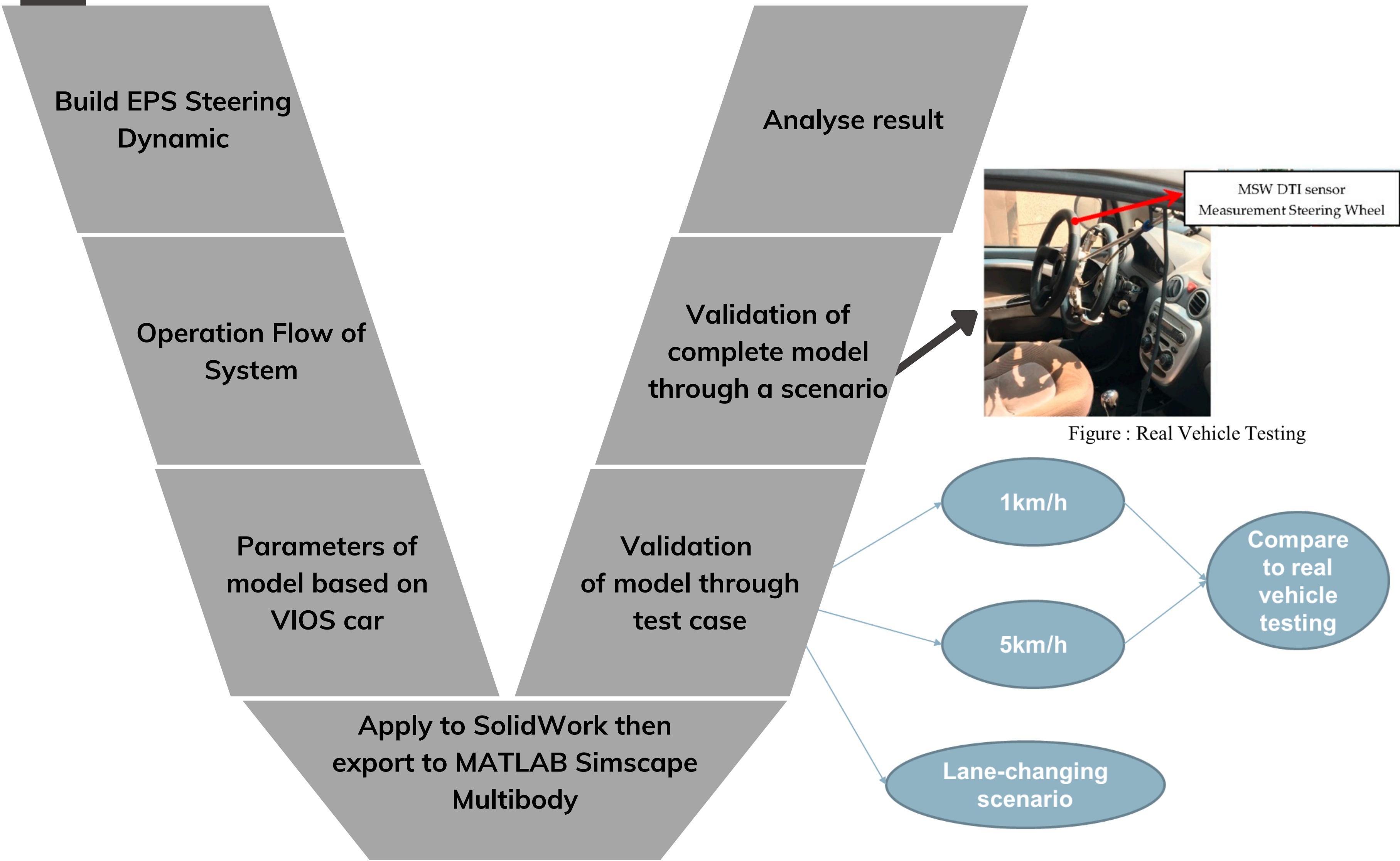
❖ Kinematics of the steering trapezium

$$\cot\beta_i - \cot\alpha_i = \frac{B_0}{L}$$

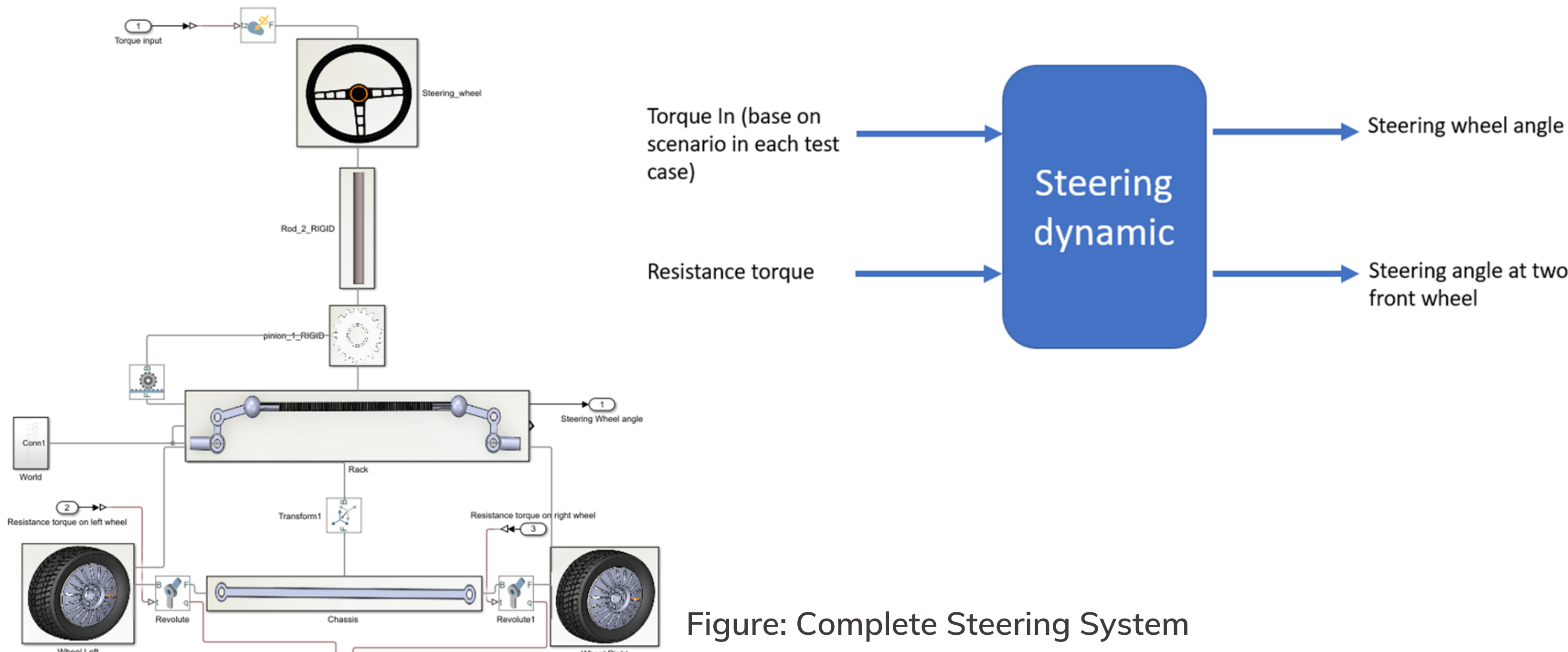
❖ Checking by algebraic method

$$\delta_i = \frac{\sin \alpha_i \cdot \sin \beta_i}{\sin(\alpha_i - \beta_i)} \cdot \frac{B_0}{L}$$

4 Implementation process



5 Matlab/Simscape modelling:



6 Specific results: Test case 1 : working in various speed

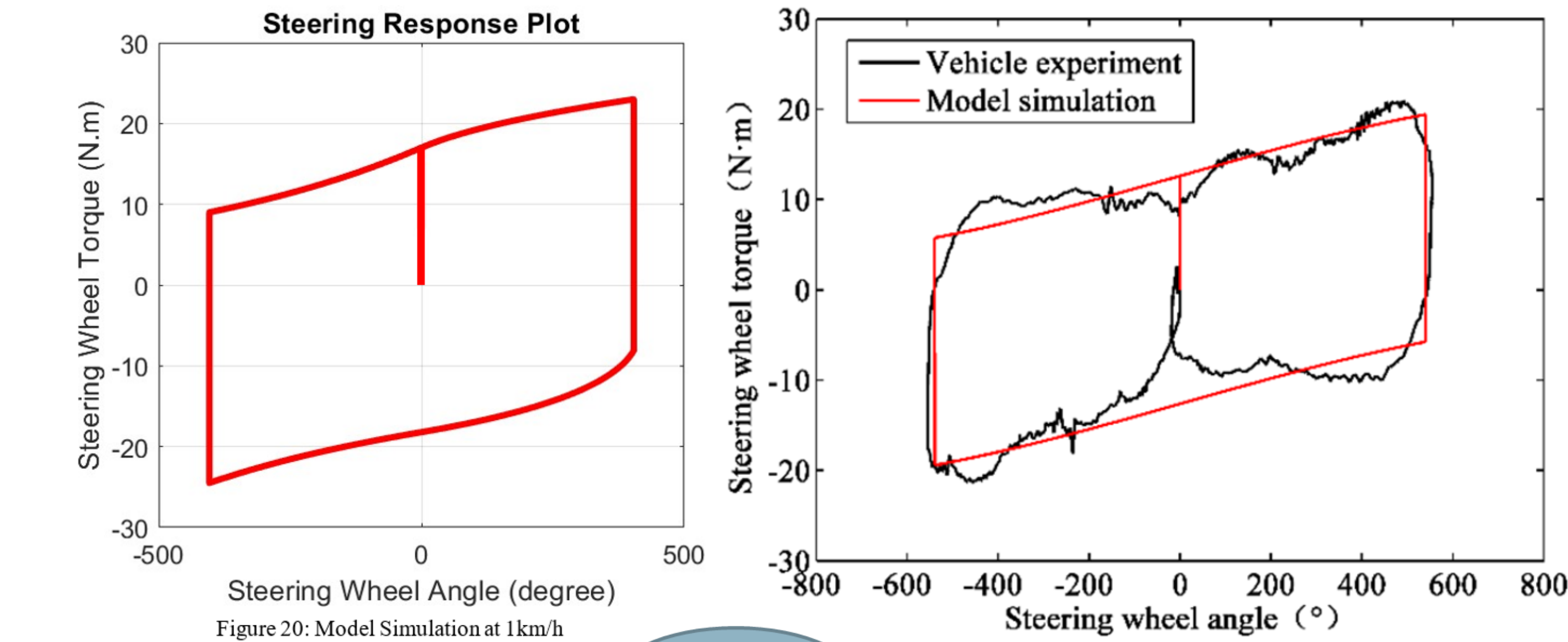


Figure : Simulation

Figure : Real vehicle testing

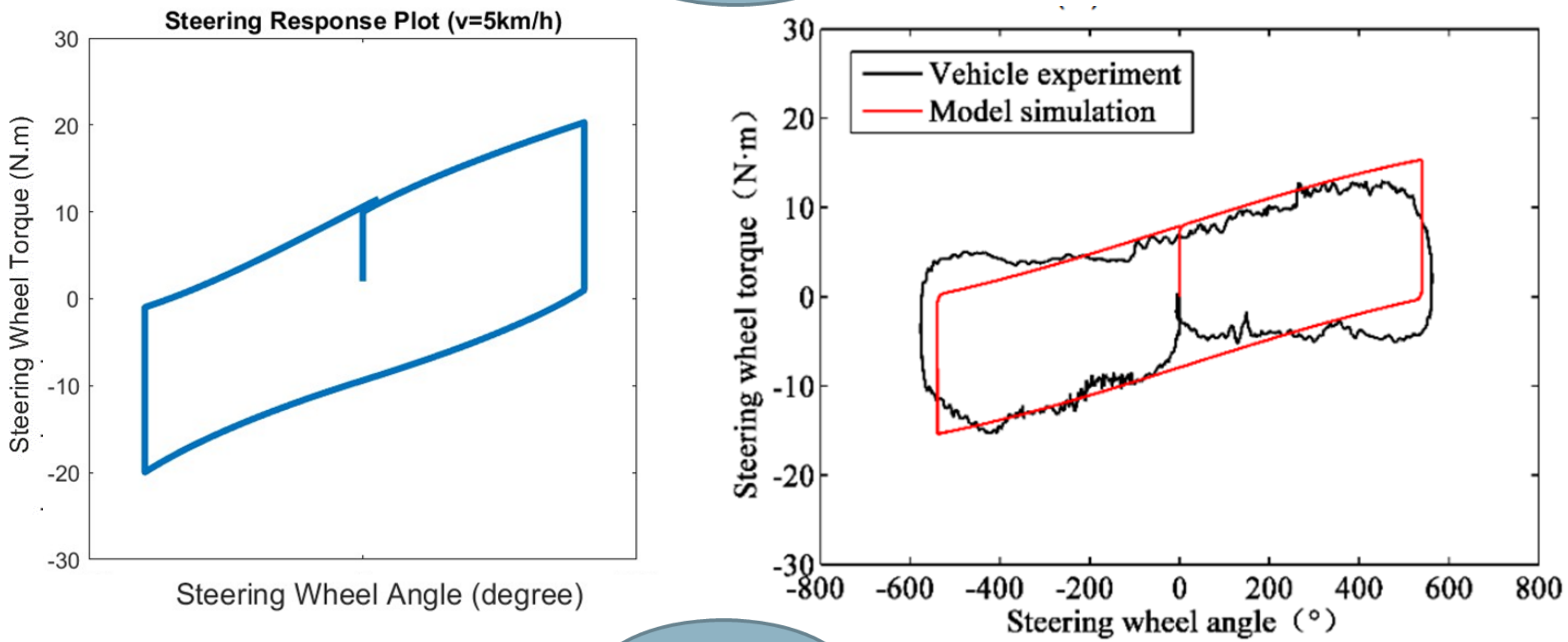


Figure : Simulation

Figure : Real vehicle testing

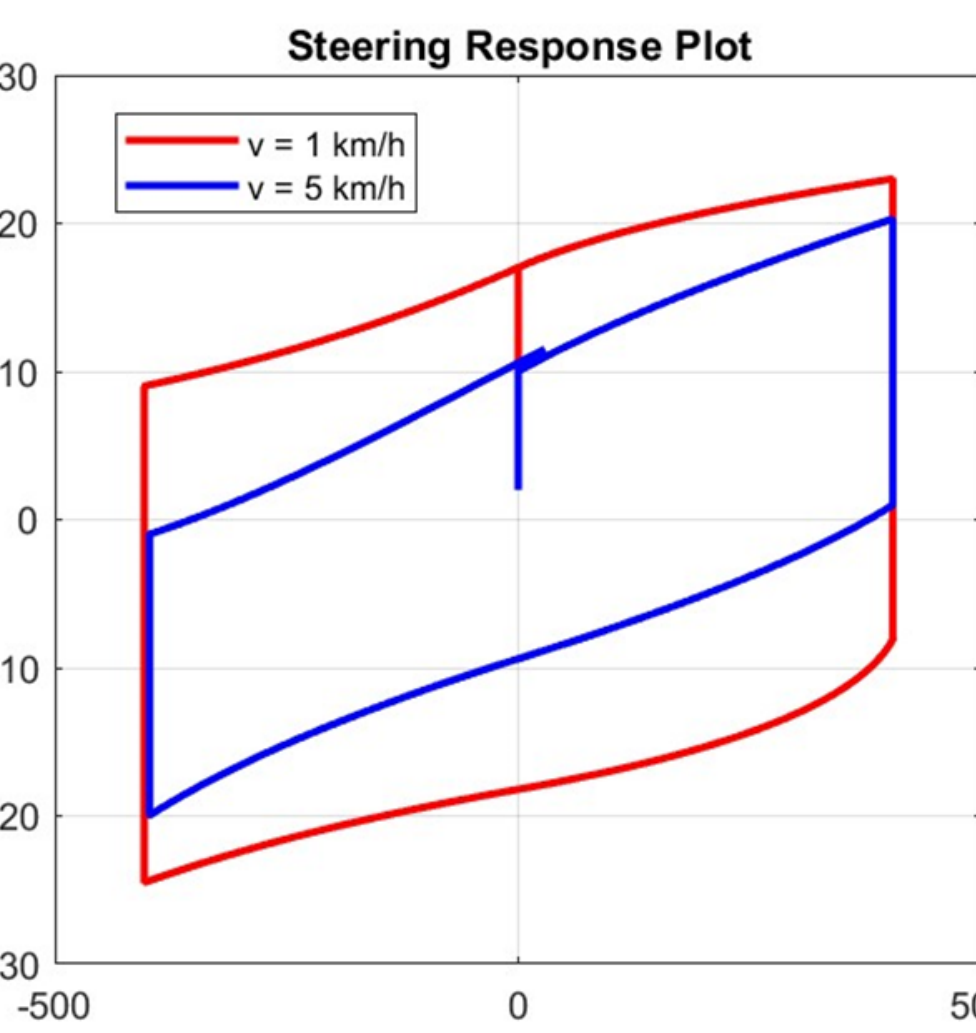


Figure : Comparison

Test case 2 : line-changing scenario

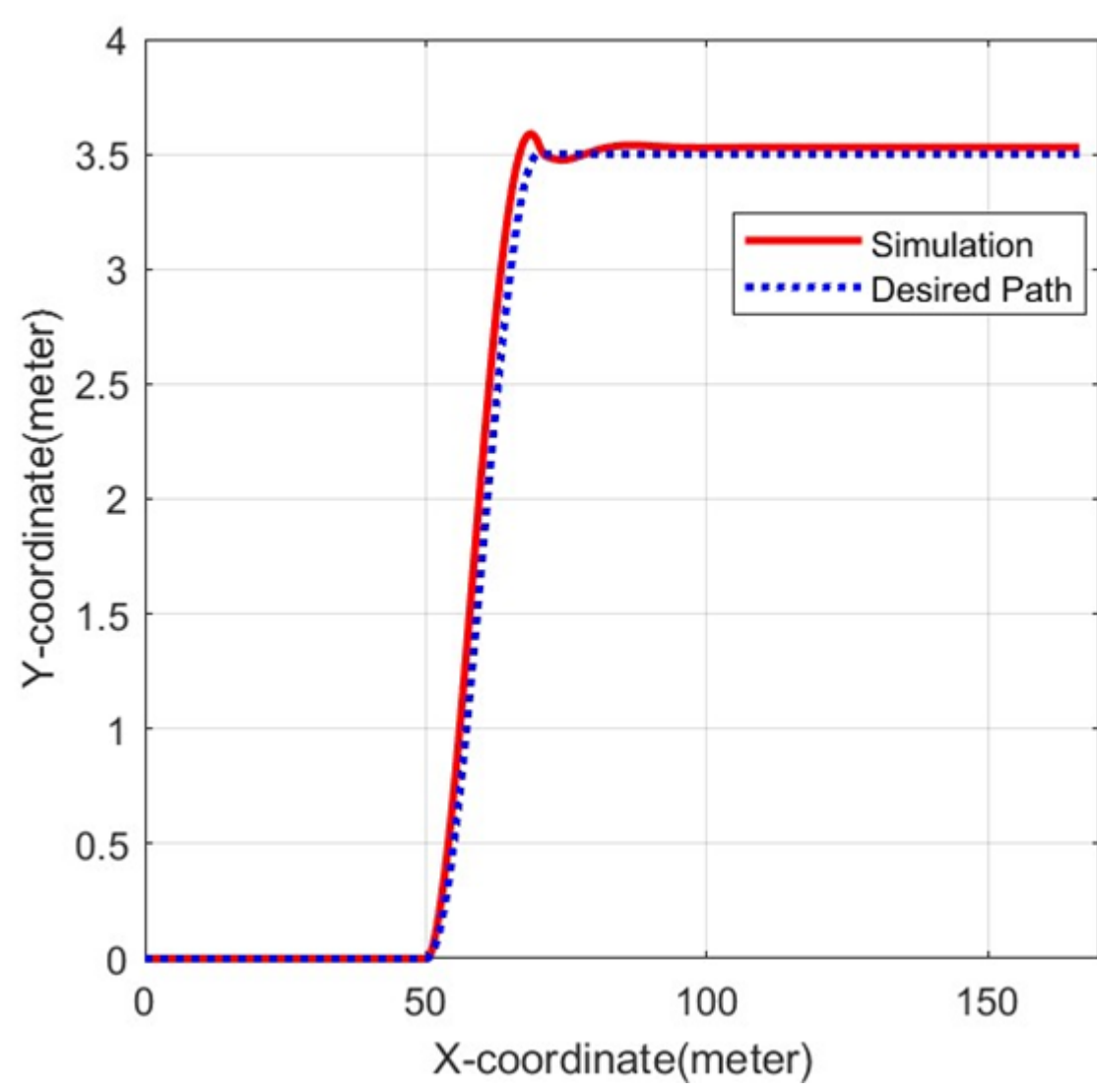


Figure: lane-changing scenario

The relationship between steering torque and vehicle speed is critical for designing and optimizing steering systems in vehicles. Studies have shown that steering torque decreases as vehicle speed increases due to factors like vehicle stability and steering system effectiveness. The simulation model has been confirmed as valid by comparing its results with data obtained from testing a real vehicle, supporting its accuracy in predicting steering system behavior.

The vehicle tracked the predefined path accurately with minimal error, validating the accuracy of the simulation model in Simscape. This is important for designing and optimizing vehicle control systems. The successful execution of the predefined path indicates that the simulation model is reliable and can be used confidently in future development.

The two test cases have successfully demonstrated the process of building an EPS model using Solidworks and Simscape, simulating its dynamic behavior in Matlab/Simulink with Simscape, and validating the model for the control of an equivalent electric-powered steering system.

7 Conclusion and future plan:

In conclusion, the objective of building and validating an EPS model using Solidworks and Simscape, and simulating its dynamic behavior in Matlab/Simulink with Simscape has been achieved. In order to improve the accuracy of the model, it is recommended to have more test cases in future testing and experimentation. After simulating the model with the parameters based on the VIOS vehicle, the study demonstrates the potential of simulation models in optimizing vehicle control systems.

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