A Review On Automatic Steering Control Using Nested PID Controller

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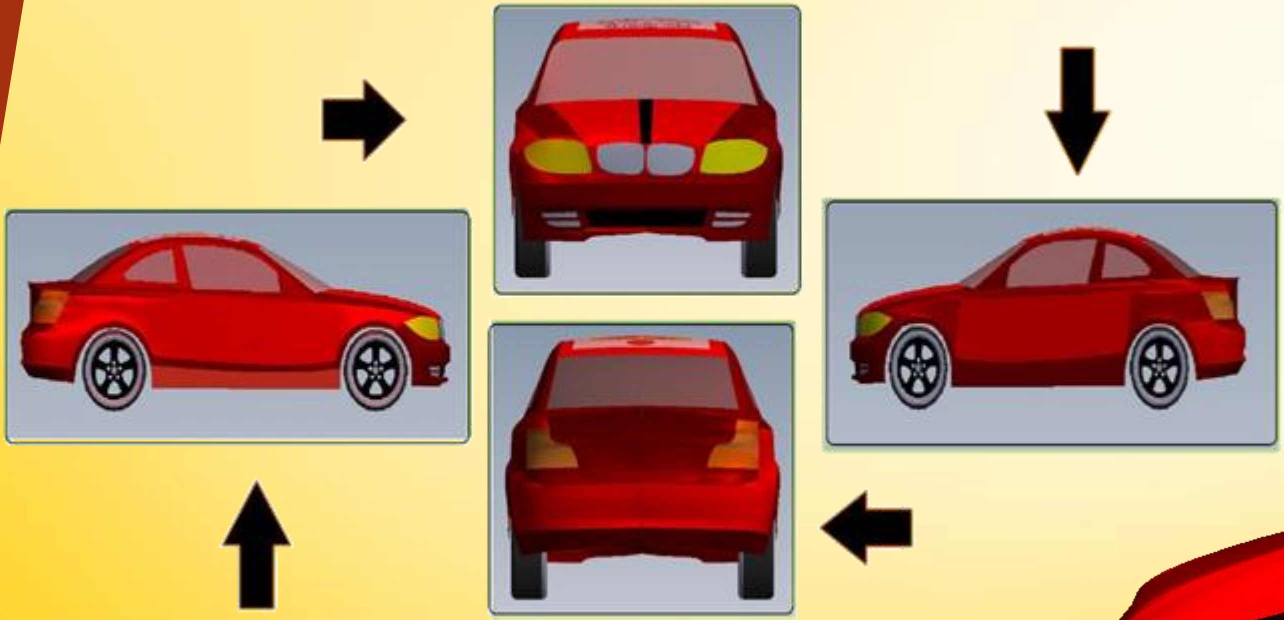
Vehicle model

Software Used- Solid Works



INTRODUCTION

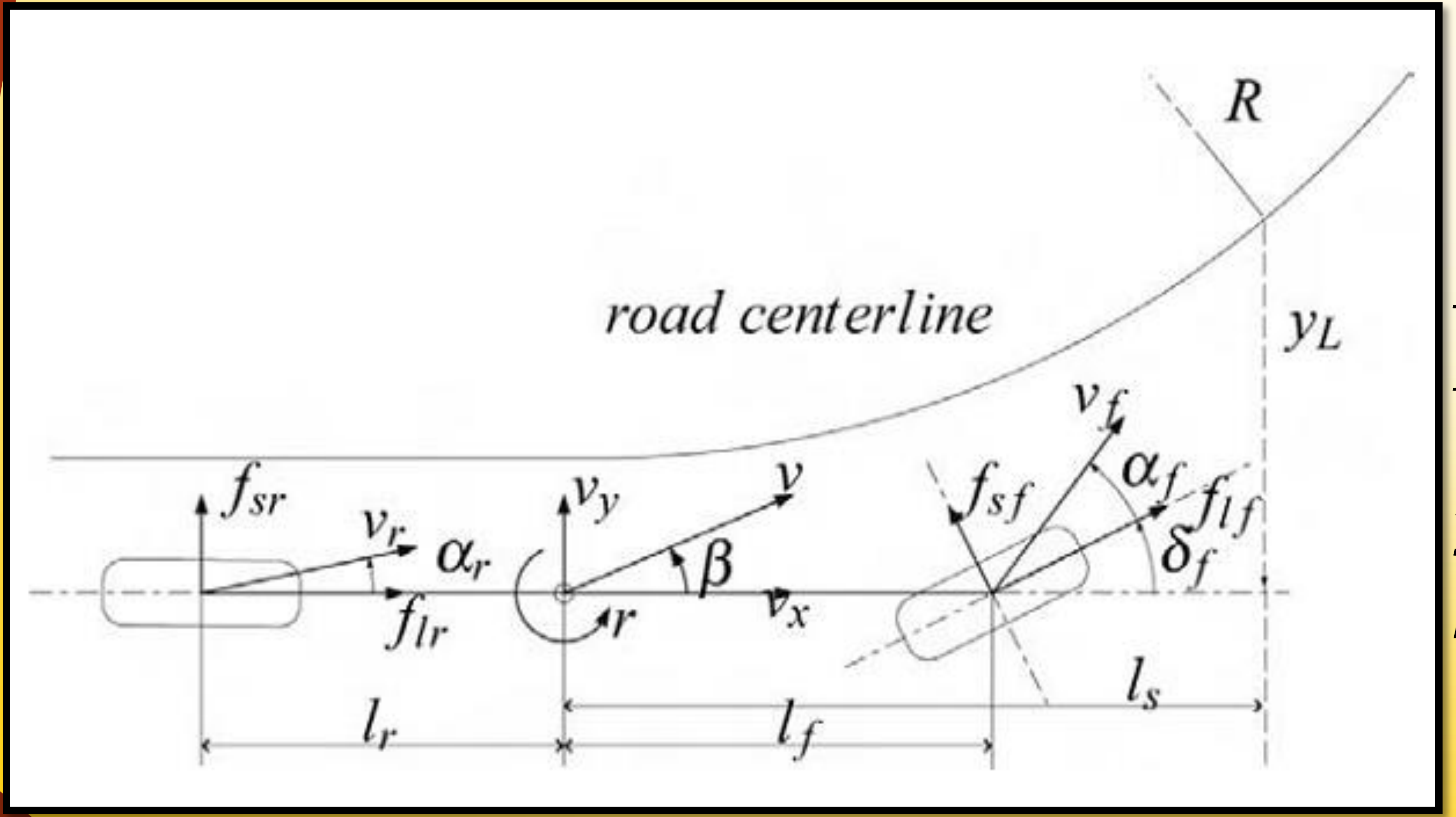
- The main aim of using active steering control is to increase safety and to reduce both accidents and drivers work load.
- According to the NHTSA survey 37% of all transportation fatalities in USA are caused by running of the road
- Lane Keeping Assist technology is designed to alert the driver when the system detects that the vehicle is about to deviate from a traffic lane which helps keep drivers with in the lane.

LANE KEEPING ASSIST

- The Lane Departure Warning
  - Alerts the driver when the vehicle starts to deviate from its lane with a warning buzzer, alert lamp and the application of a small counter-steering force to the steering wheel.
- Lane Keeping Assist
  - When the Rader Cruise Control is activated and the system senses the vehicle deviating from its lane, the system helps the car stay on course near the centre of the lane by continuously applying a small amount of counter-steering force.

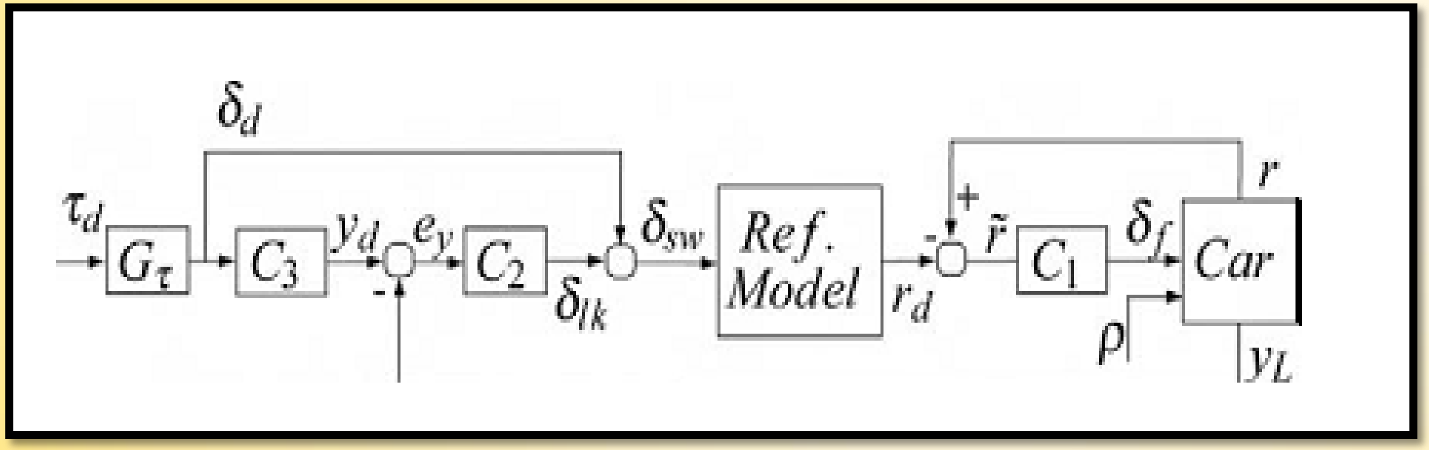
Motivation Video on Automatic Steering Control

SINGLE TRACK VEHICLE MODEL



δ- Steering Angle
α-Side Slip Angle
f_s-Lateral Forces
f_l-Longitudinal Forces
y_L-Lateral Offset
β-Vehicle side slip angle

INTEGRATED DRIVER AND CONTROL SCHEME(PID)

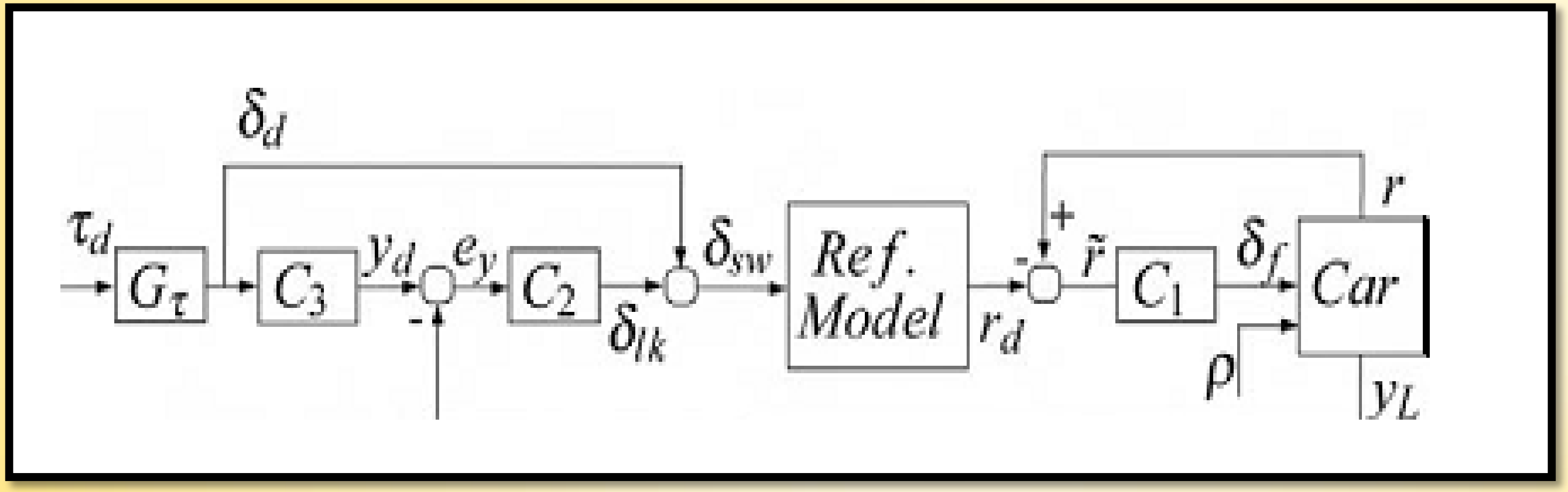


- C1- PI Active front steering control is designed on the basis of yaw rate error ($r-r_d$)
  - r- Yaw Rate
  - r_d- Yaw rate reference (Input by either Driver/ Autonomous lane keeping system)

$$C1 = -K_{P1}(r - r_d) - K_{I1}\alpha_0$$

α_0-Additional State introduced by dynamic control

INTEGRATED DRIVER AND CONTROL SCHEME(PID)

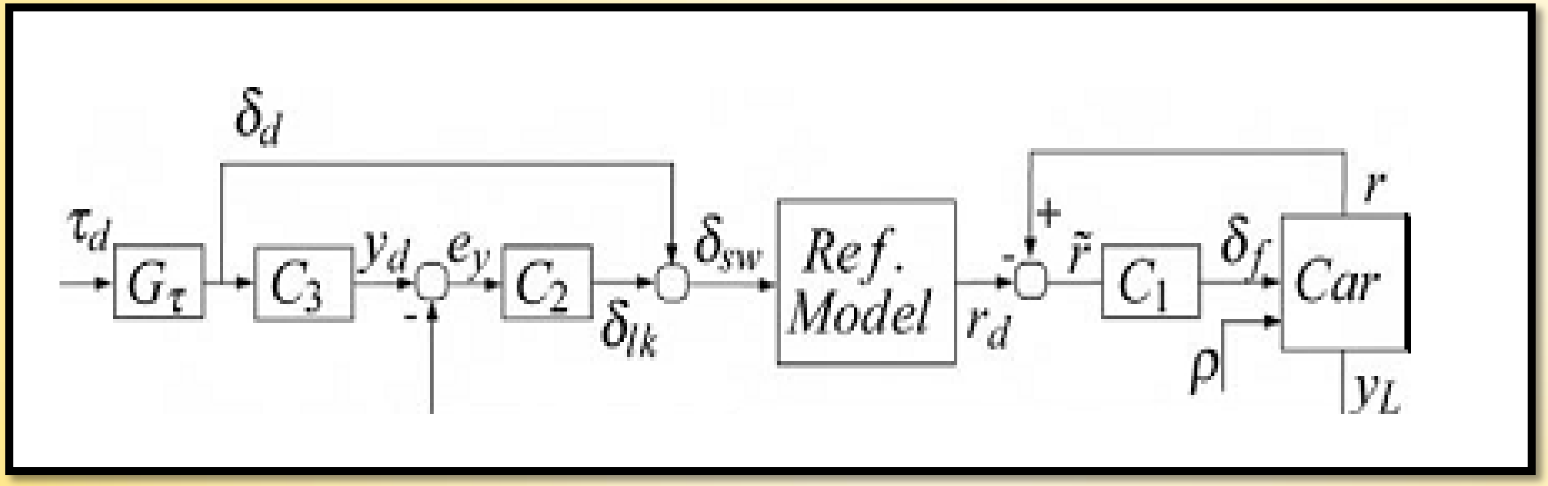


- C2- Acts as PID controller
  - Lateral offset measurement
  - It generates yaw rate signal based on y_L
  - Active when τ_d=0

$$C_2 = -K_{P2}e_y - K_{I2}\alpha_2 - K_{I3}\alpha_1 - K_d e_{yd}$$

  - α_i – Additional State introduced by dynamic control
  - e_{yd} –Lateral offset

INTEGRATED DRIVER AND CONTROL SCHEME(PID)



- C3- To obtain full control of vehicle
  - Active when $\tau_d \neq 0$
  - Goal is to keep e_y=0
  - Automatic Lane changing is never switched off

$$C_3 = K\bar{P}_0$$

$$\bar{P}_0 = \frac{(d_3 s^3 + d_2 s^2 + d_1 s + d_0)}{s^2(-s^3 + c_2 s^2 + c_1 s + c_0)}$$

$\overline{P_0}$-Transfer function between r_d & y_L
K-Design Parameter

VEHICLE MODEL

- Equation of Motion

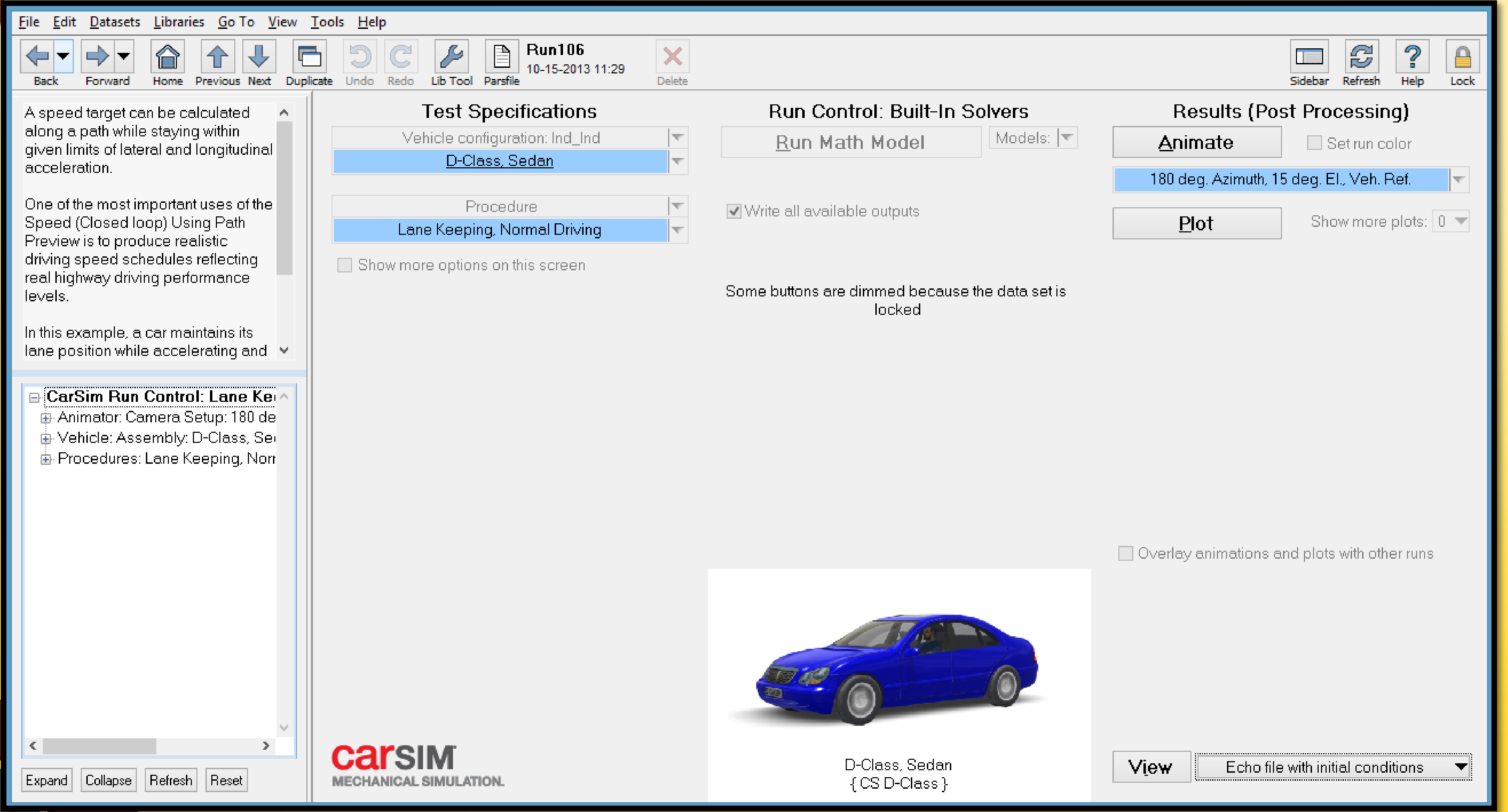
$$m(\dot{v}_x - rv_y) = f_{lf}\cos\delta_f + f_{sf}\sin\delta_f + f_{lr}$$
$$m(\dot{v}_y + rv_x) = f_{lf}\sin\delta_f - f_{sf}\cos\delta_f - f_{sr}$$
$$J\dot{r} = l_f(f_{lf}\sin\delta_f - f_{sf}\cos\delta_f) + l_r f_{sr}$$

- In linearized form

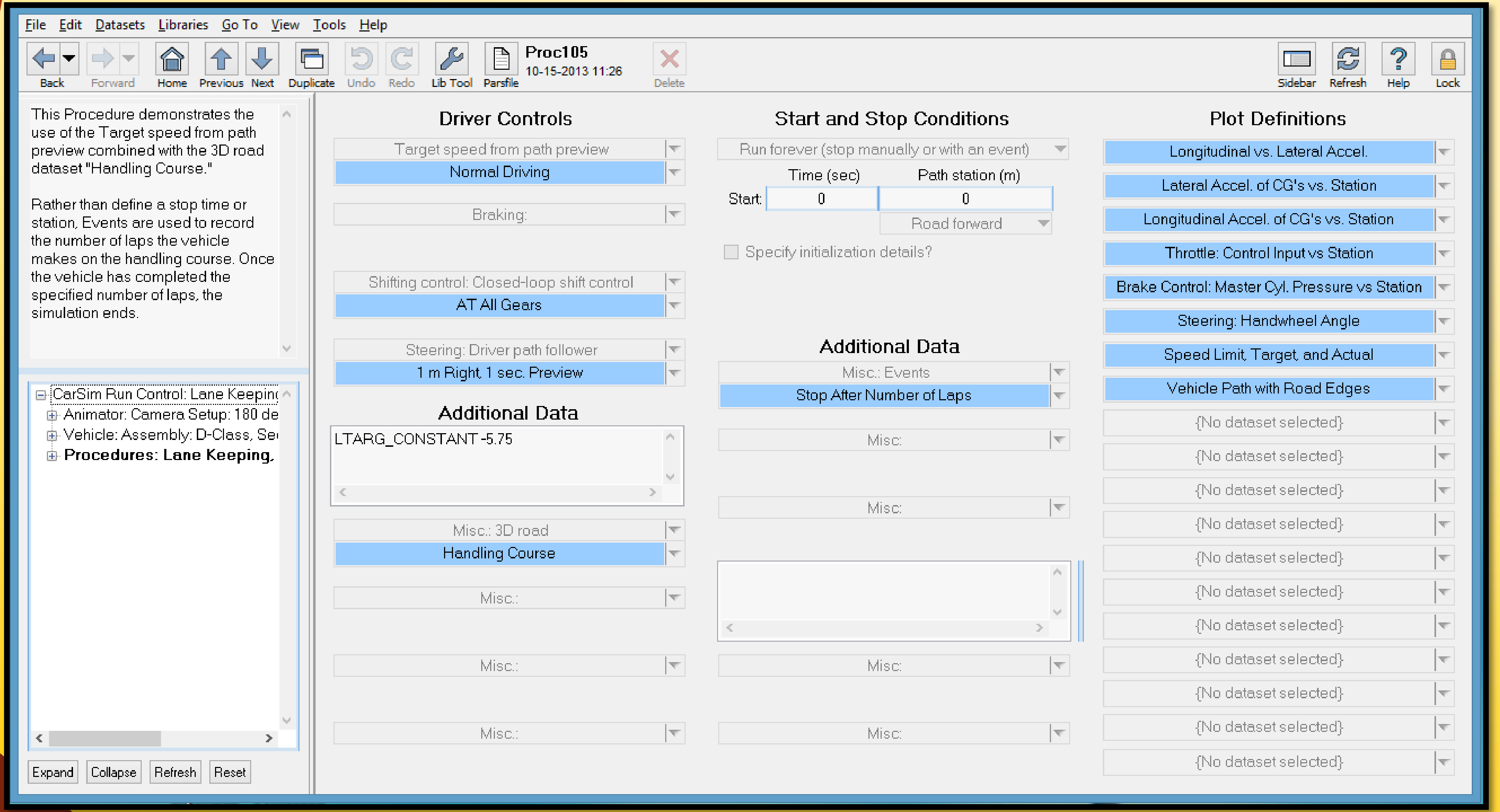
$$\begin{bmatrix}\dot{\beta}\\ \dot{r}\\ \dot{\psi}\\ \dot{y}_L\end{bmatrix} = \begin{bmatrix}a_{11} & a_{12} & 0 & 0\\ a_{21} & a_{22} & 0 & 0\\ 0 & 1 & 0 & 0\\ v & l_s & v & 0\end{bmatrix}\begin{bmatrix}\beta\\ r\\ \psi\\ y_L\end{bmatrix} + \begin{bmatrix}b_1\\ b_2\\ 0\\ 0\end{bmatrix}\delta_f + \begin{bmatrix}0\\ 0\\ -v\\ 0\end{bmatrix}\rho$$

- a_{ii}, b_i-Physical Parameters
- Depends on cornering stiffness

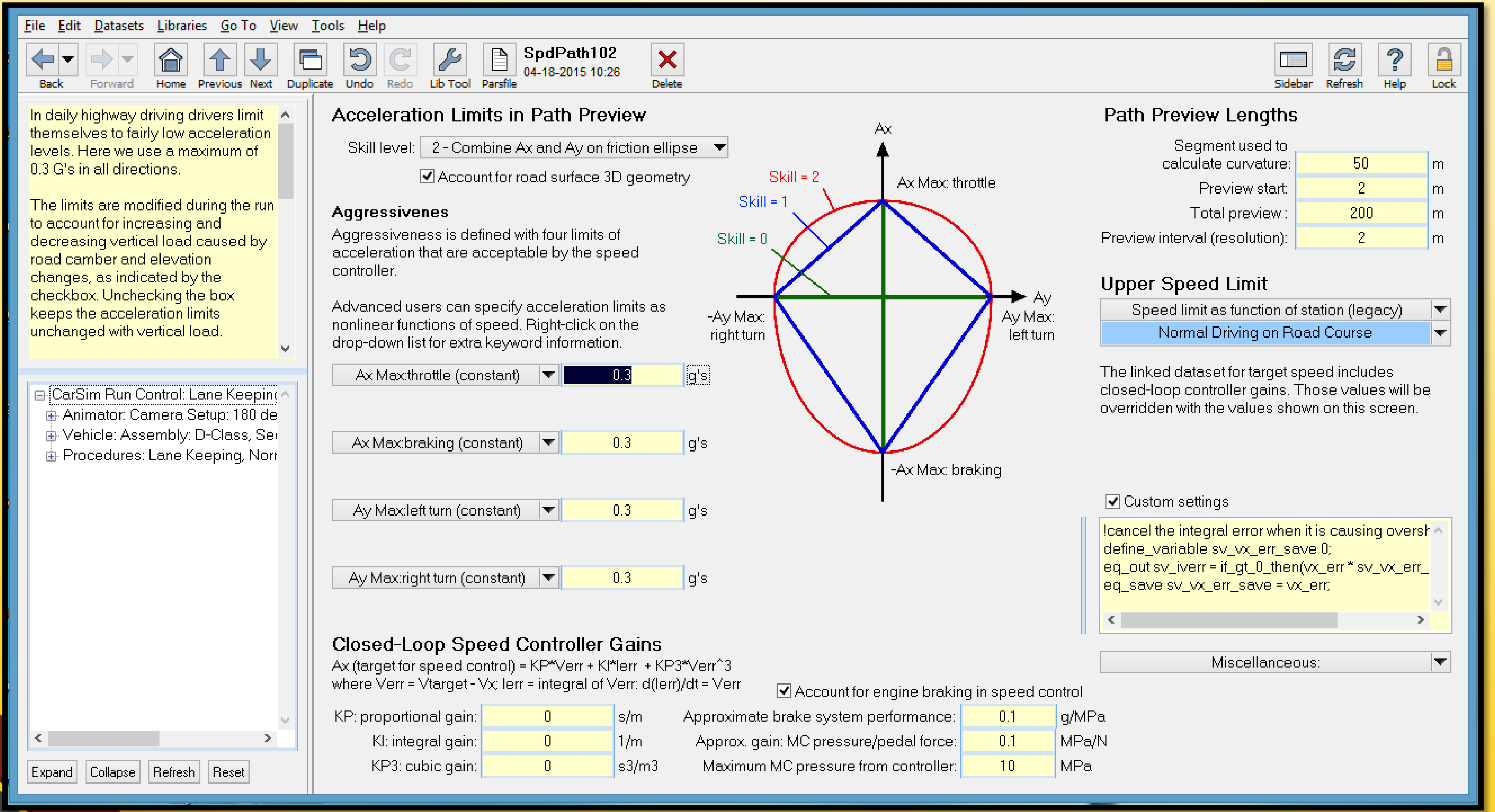
CARSIM SIMULATION



CARSIM SIMULATION

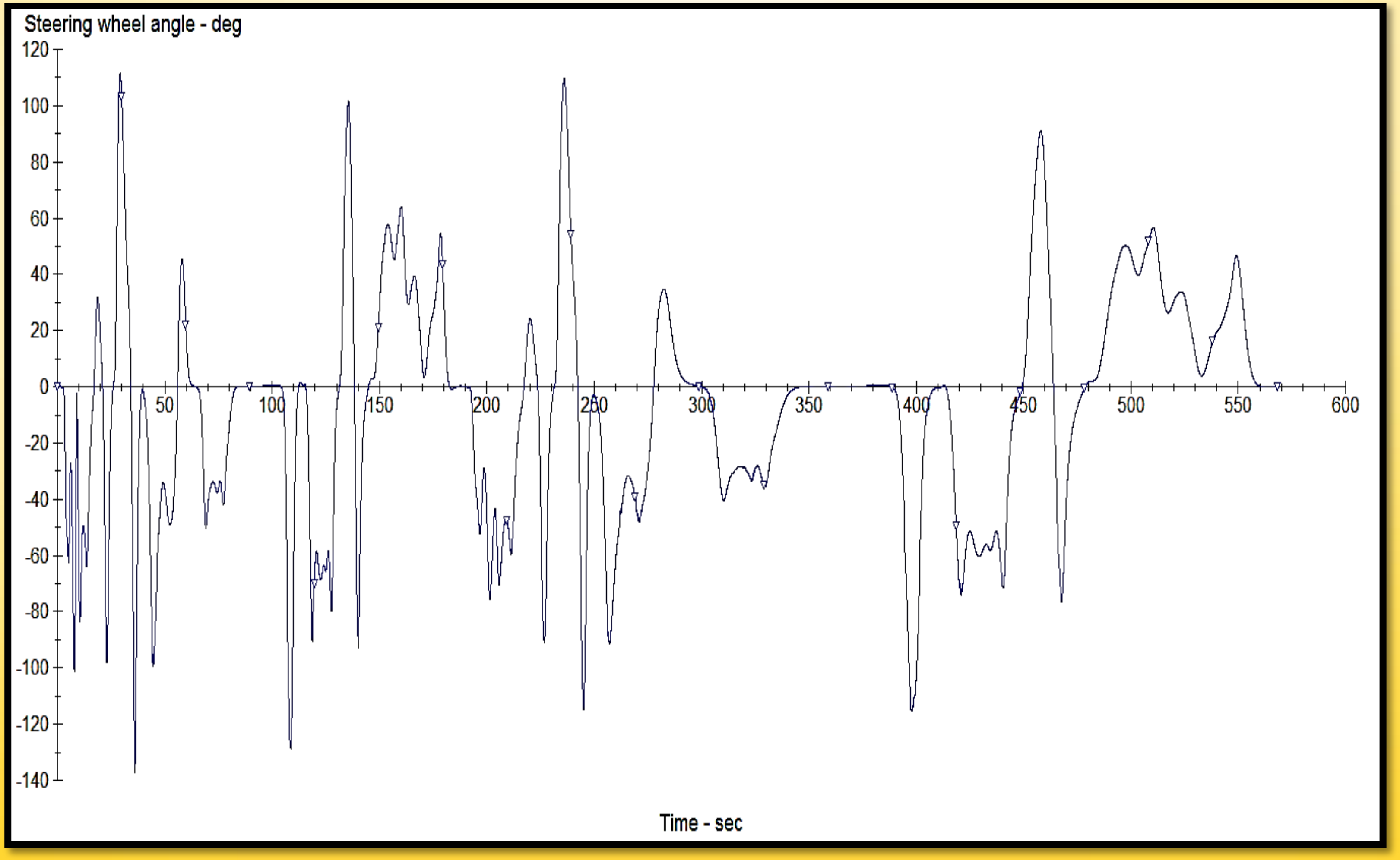


CARSIM SIMULATION



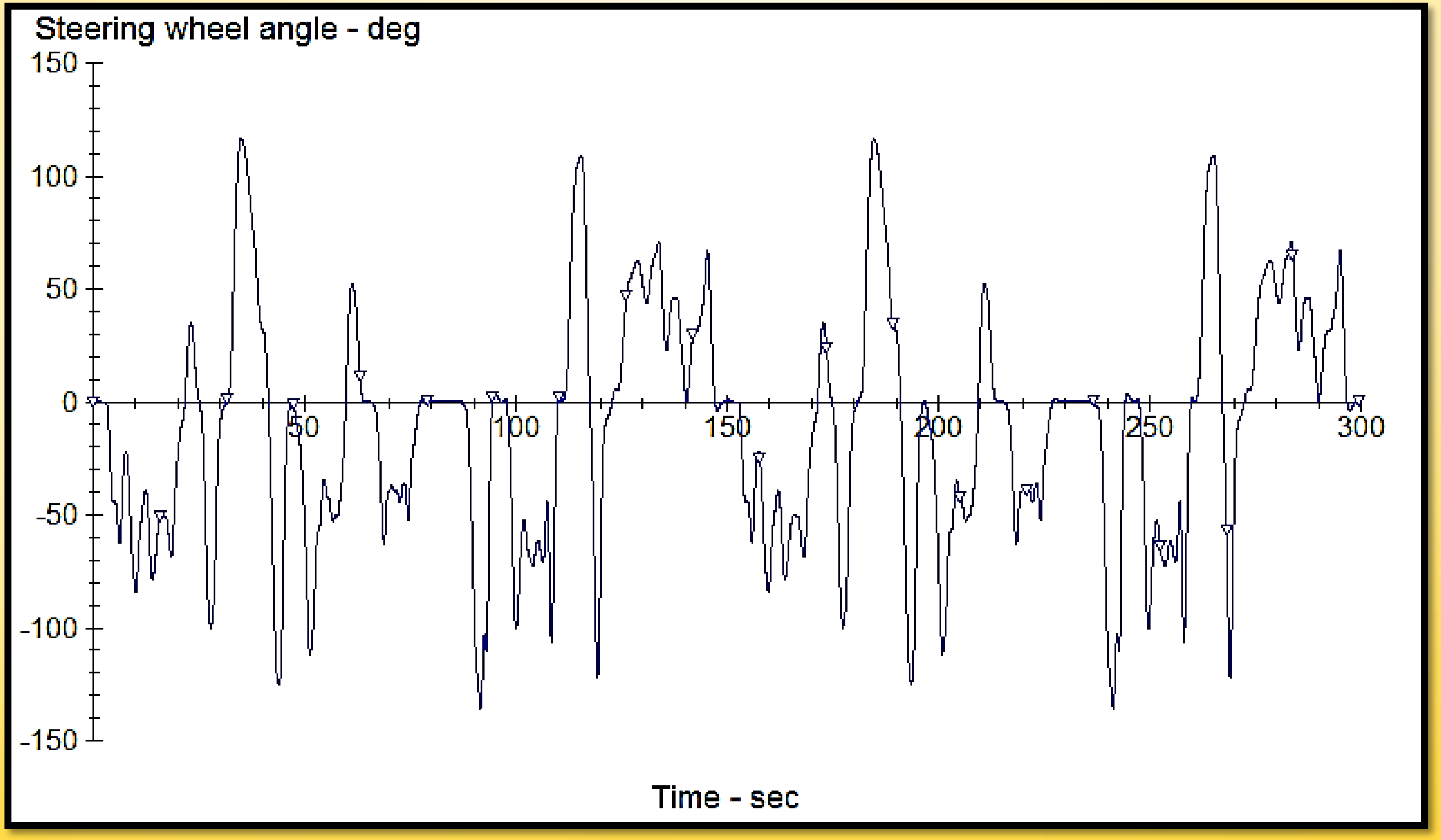
CARSIM RESULTS [Without PI]

- Steering Angle



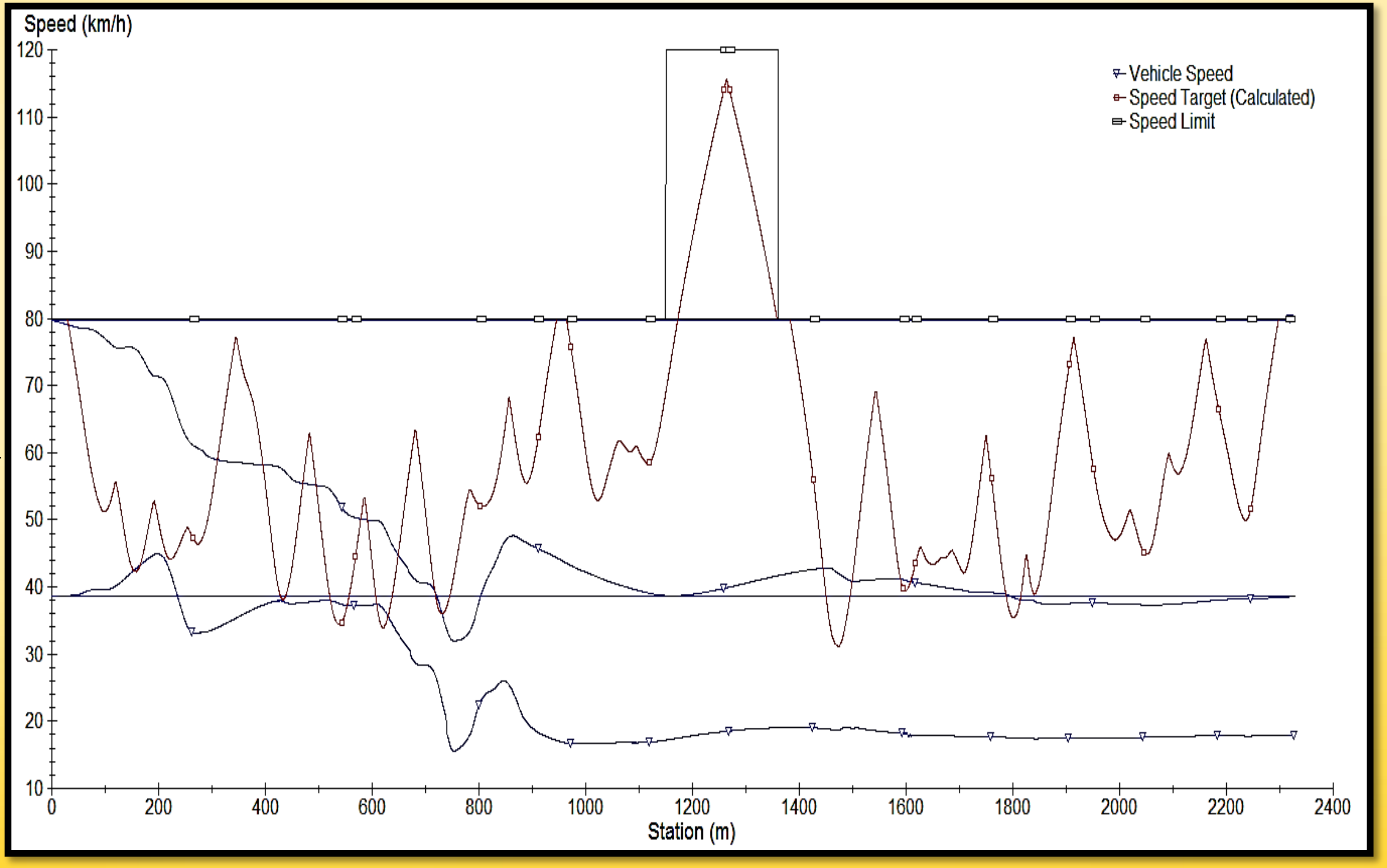
CARSIM RESULTS [With PI]

- Steering Angle



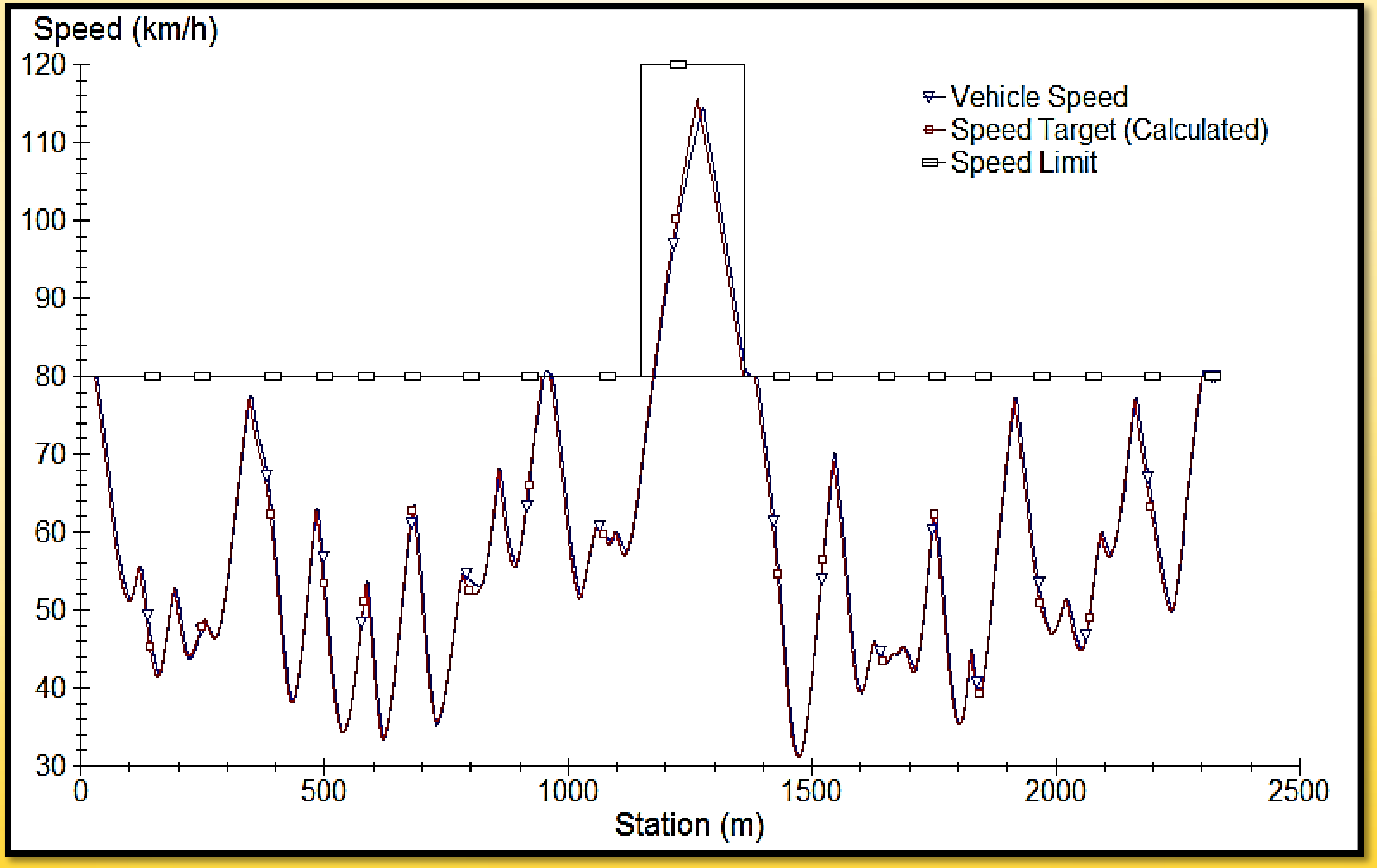
CARSIM RESULTS [Without PI]

- Speed Variation



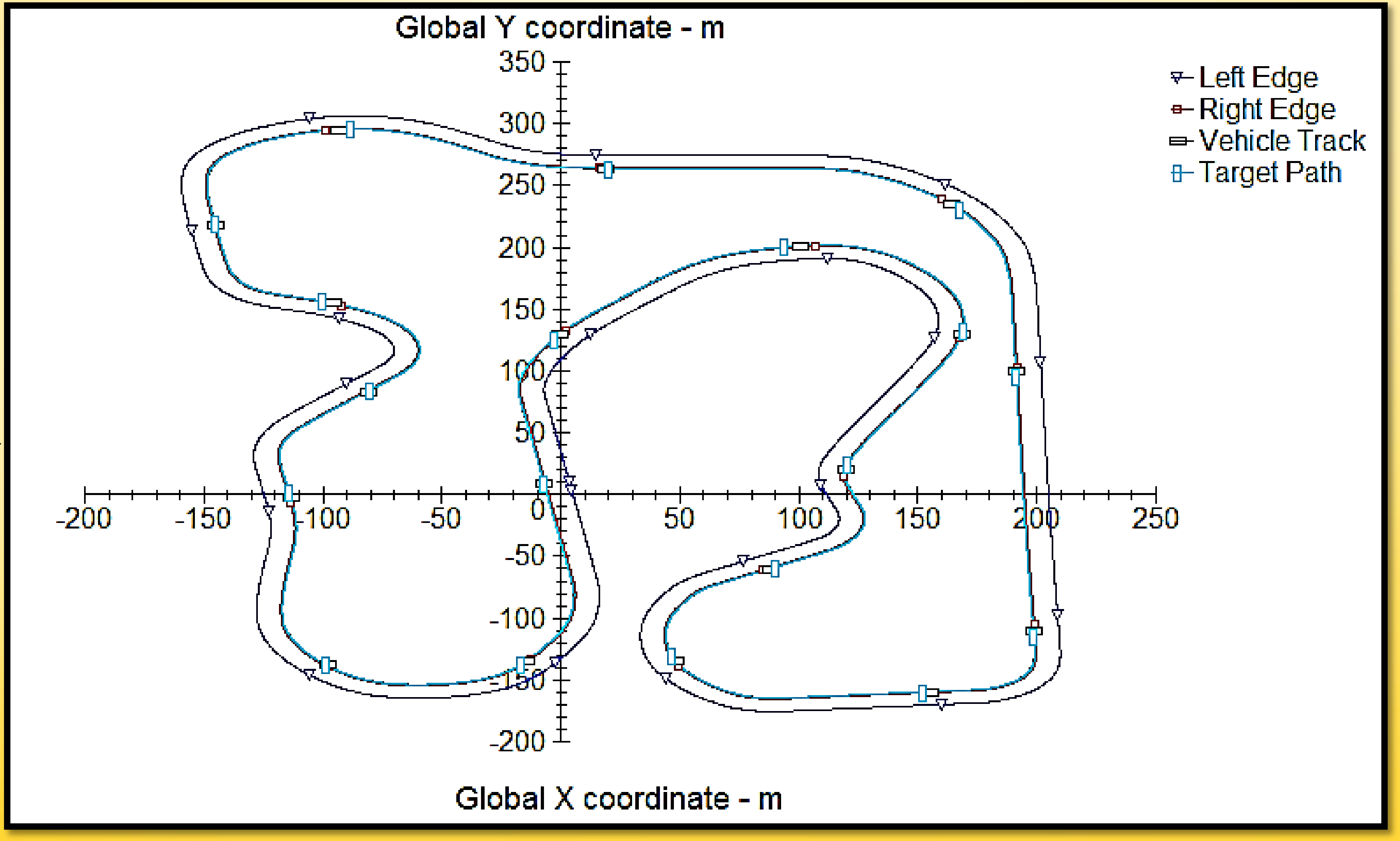
CARSIM RESULTS [With PI]

- Speed Variation



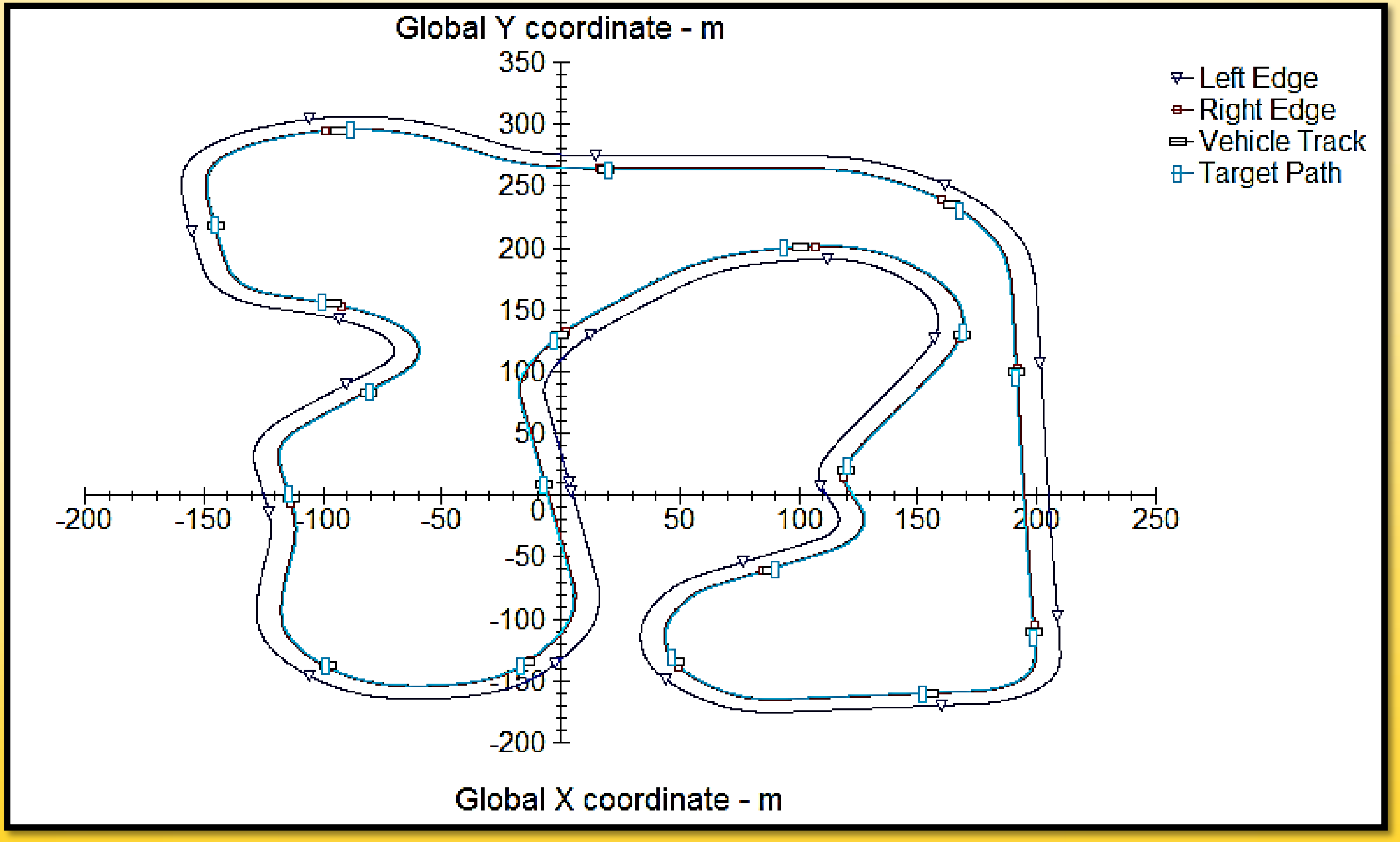
CARSIM RESULTS [Without PI]

- Track Motion

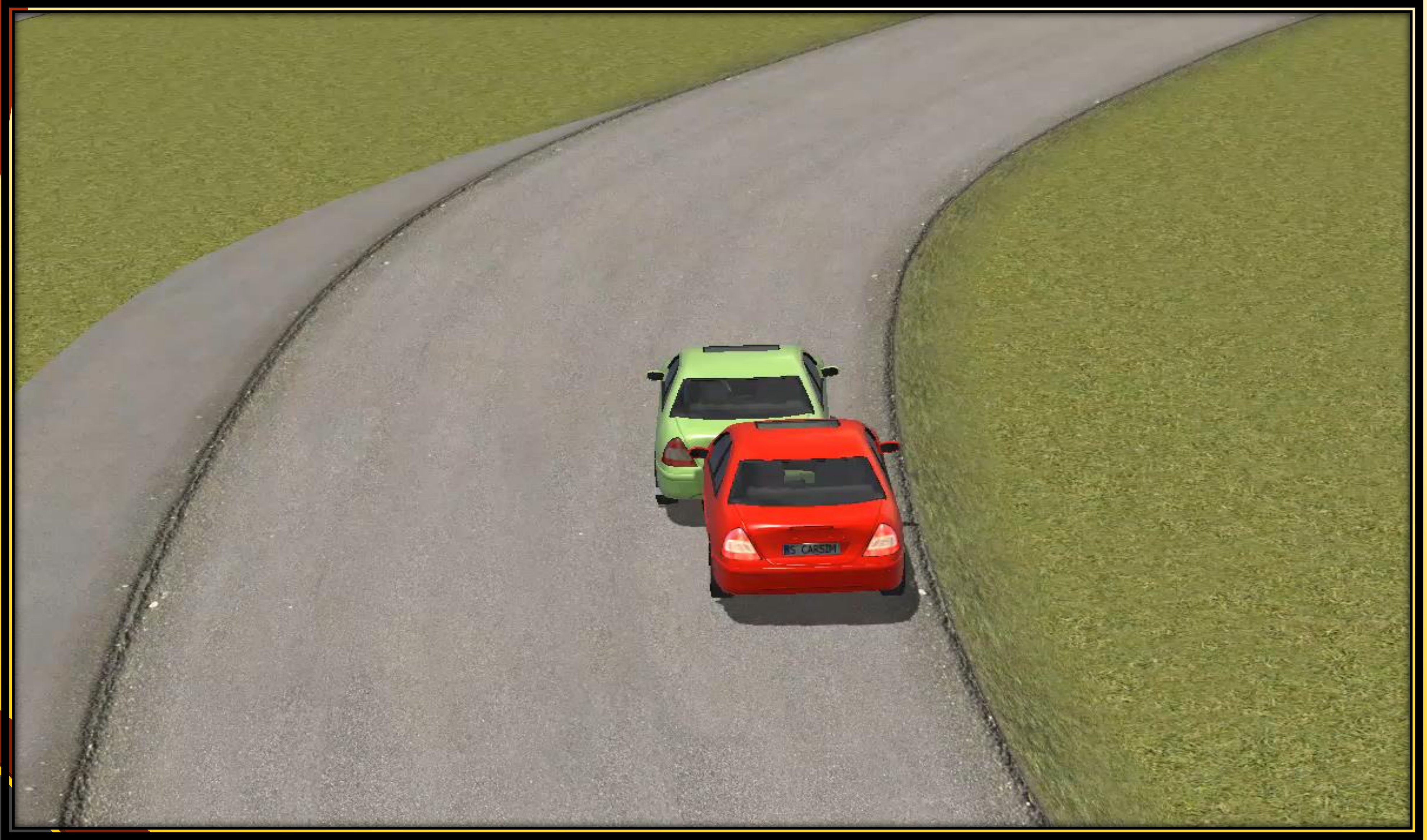


CARSIM RESULTS [With PI]

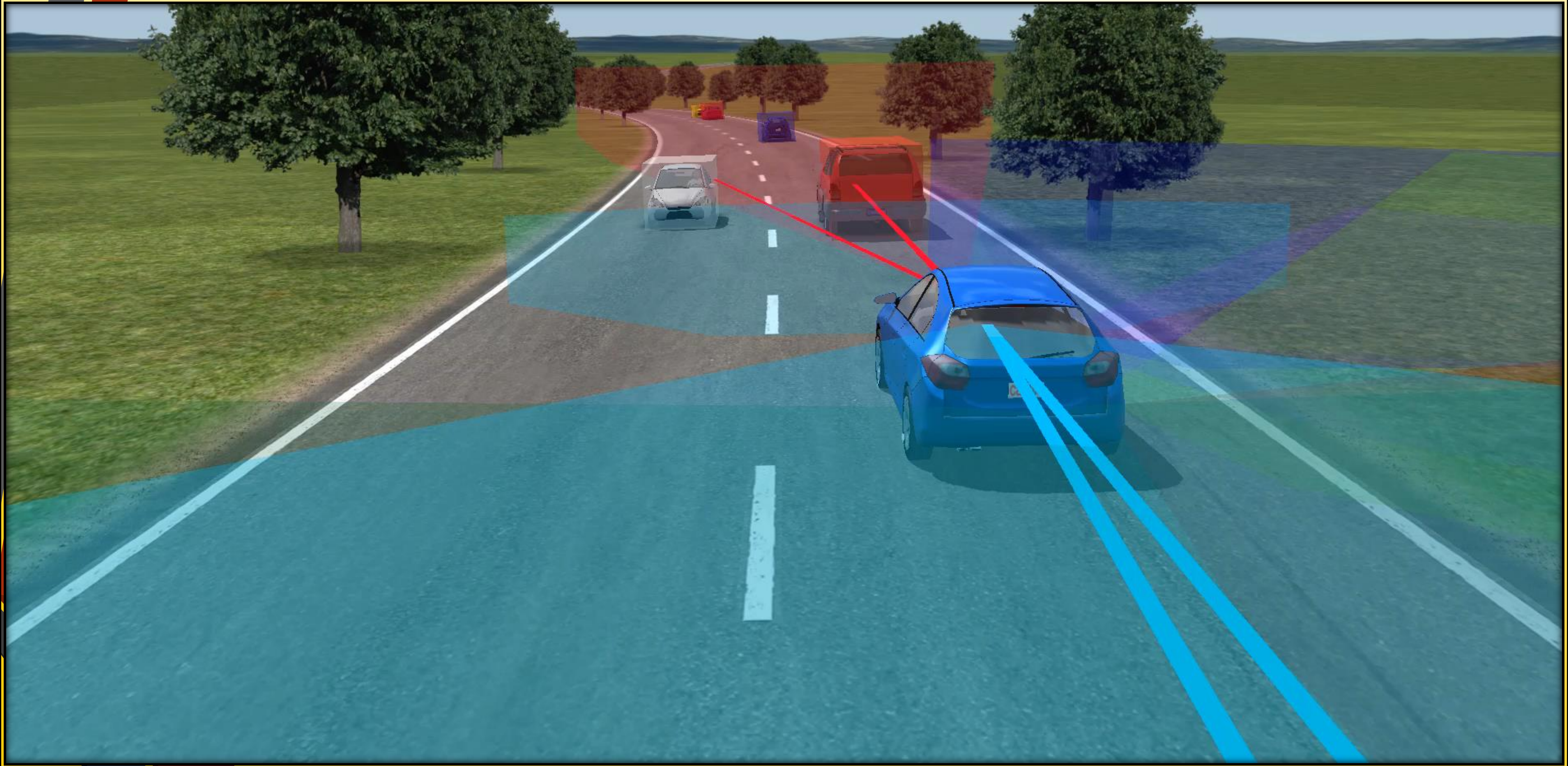
- Track Motion



CARSIM Video Result [With PI& Without PI]



Video on Automatic Steering Control



CONCLUSIONS

Several simulations, carried out on a standard CarSim vehicle model, confirm the robustness of the proposed control system. The simulations show reduced path following errors and new stable manoeuvres in comparison with the CarSim model predictive steering controller in the case in which the driver does not perform any action on the steering wheel (autonomous control).

REFERENCES

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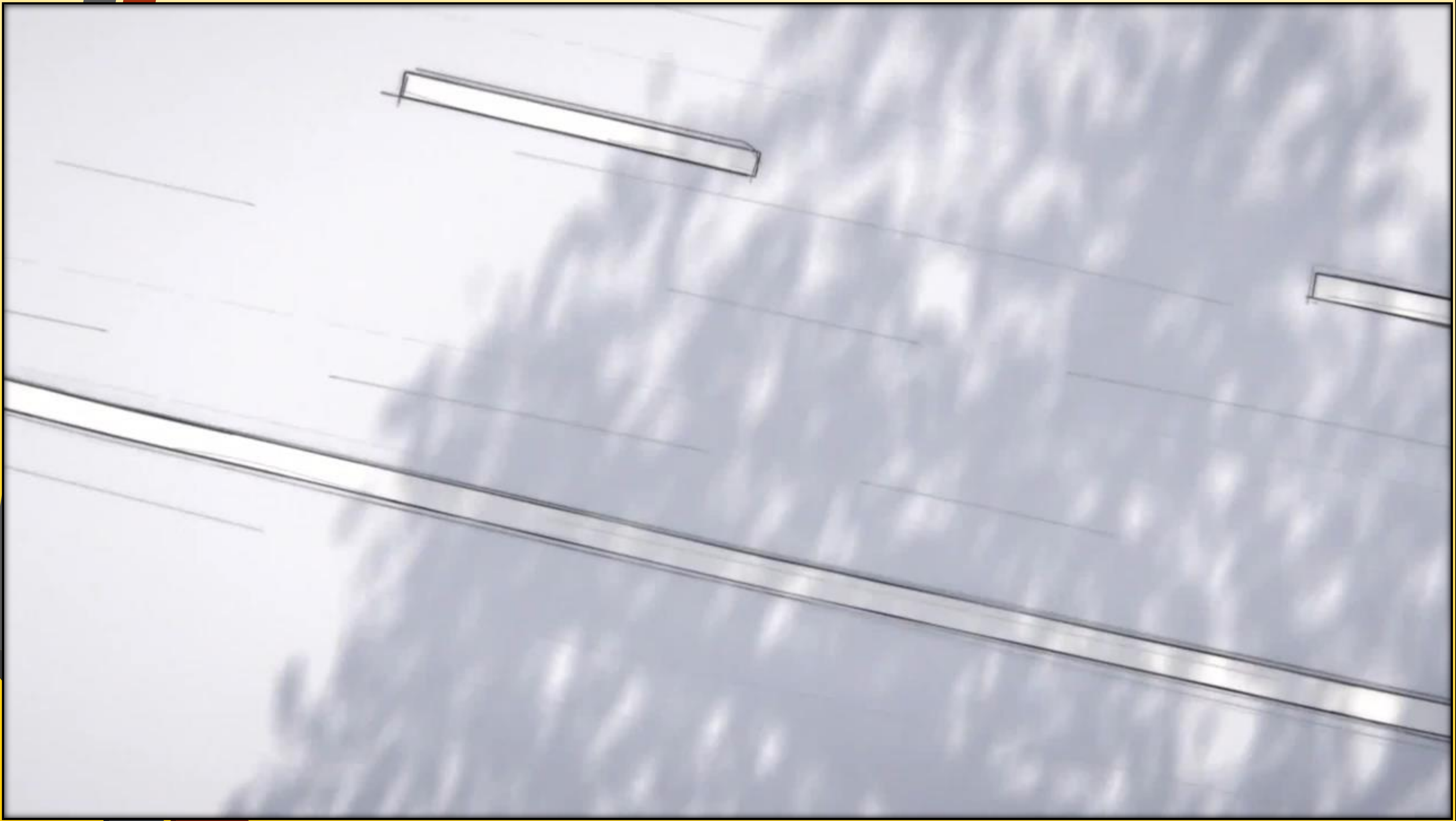
- **[B]** Marino, Riccardo, Stefano Scalzi, and Mariana Netto. "Integrated driver and active steering control for vision-based lane keeping." European journal of control 18.5 (2012): 473-484.
- **[C]** Pacejka, H. B. (2004). Tire and vehicle dynamics. Elsevier, Butterworth Heinemann.
- **[D]** https://www.carsim.com/downloads/videos.php
- **[E]**http://www.artc.org.tw/chinese/03_service/down.aspx?file_name=tw_knowledge_IA-97-0060.pdf&file_value=3



Thank You …