

A Review On Automatic Steering Control Using Tested PID Controller



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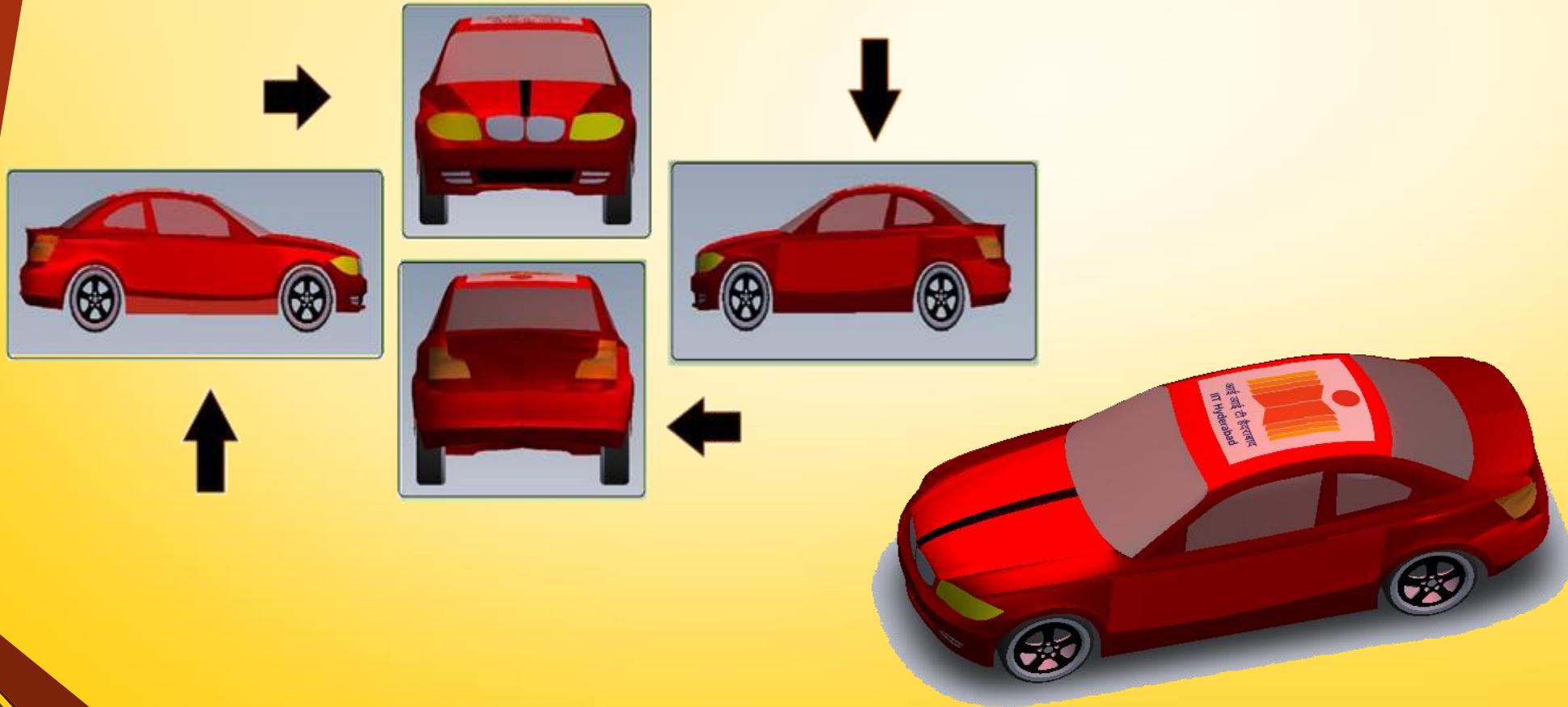
CONTENTS

- Introduction
- PID Controller
- Vehicle model
- CAR SIM
- Results
- References



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.

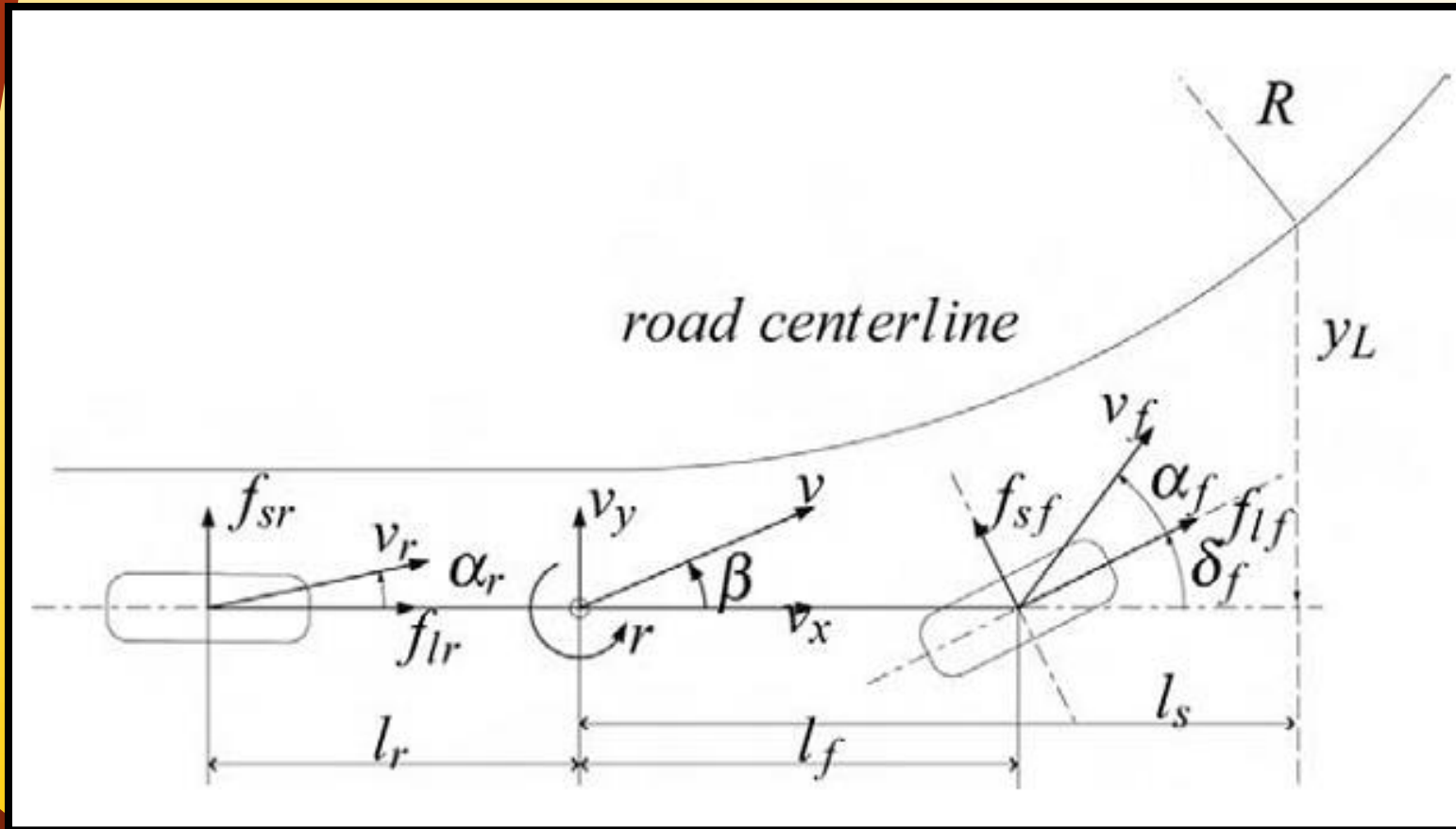
LANE KEEPING ASSIST

- 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 Radar 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

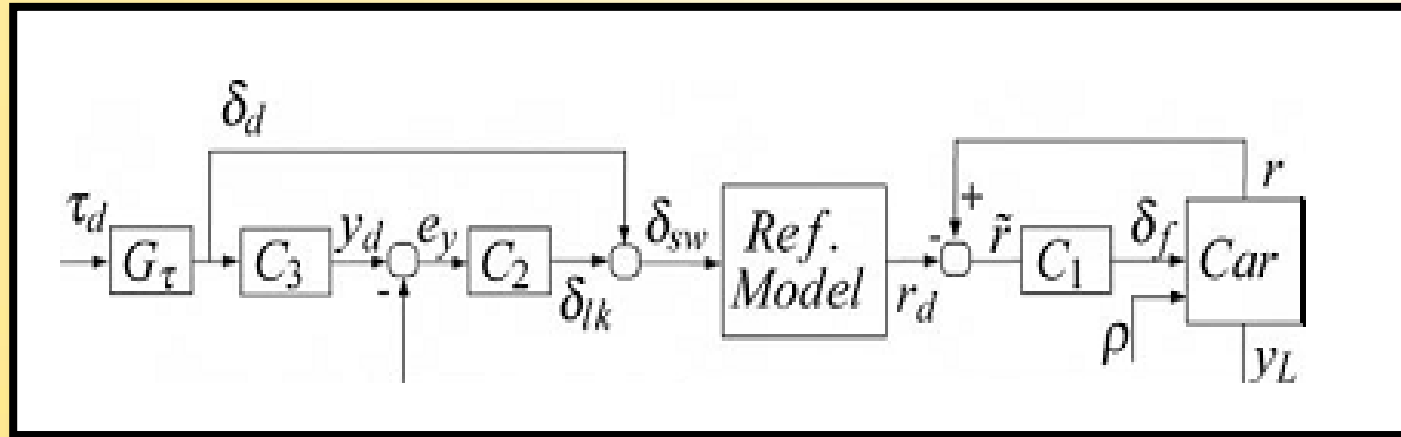


SINGLE TRACK VEHICLE MODEL



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)

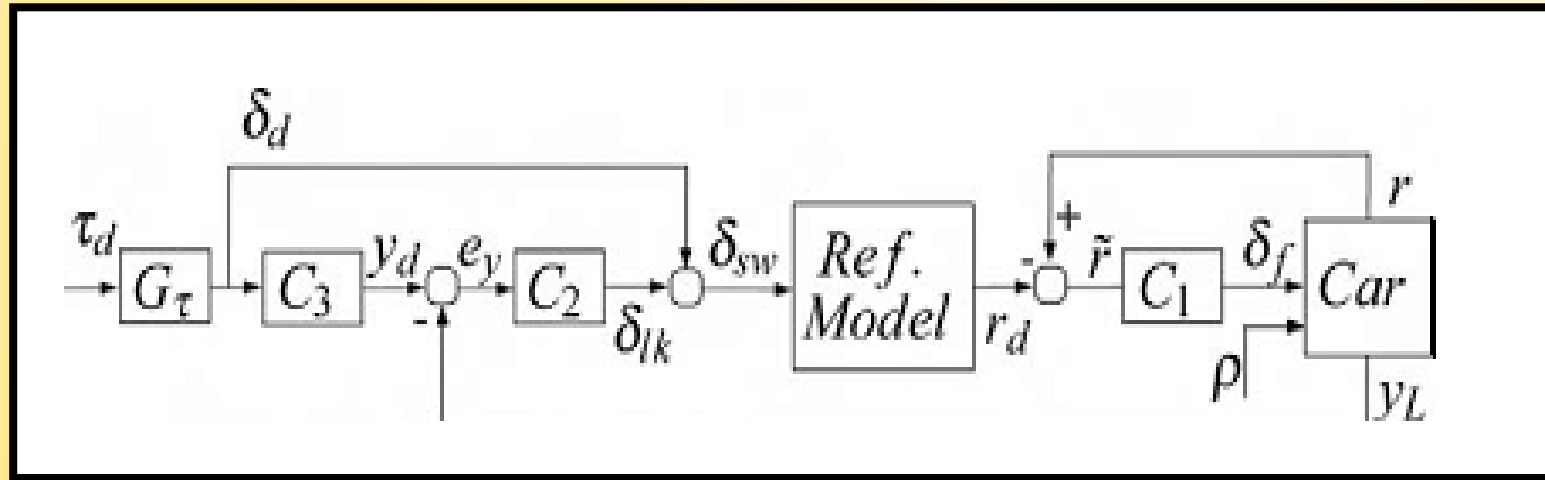


- C1- PI Active front steering control is designed on the basis of yaw rate error ($r-r_d$)
 - r - Yaw Rate
 - r_d - Yaw rate reference (Input by either Driver/ Autonomous lane keeping system)

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

α_0 -Additional State introduced by dynamic control

INTEGRATED DRIVER AND CONTROL SCHEME(PID)



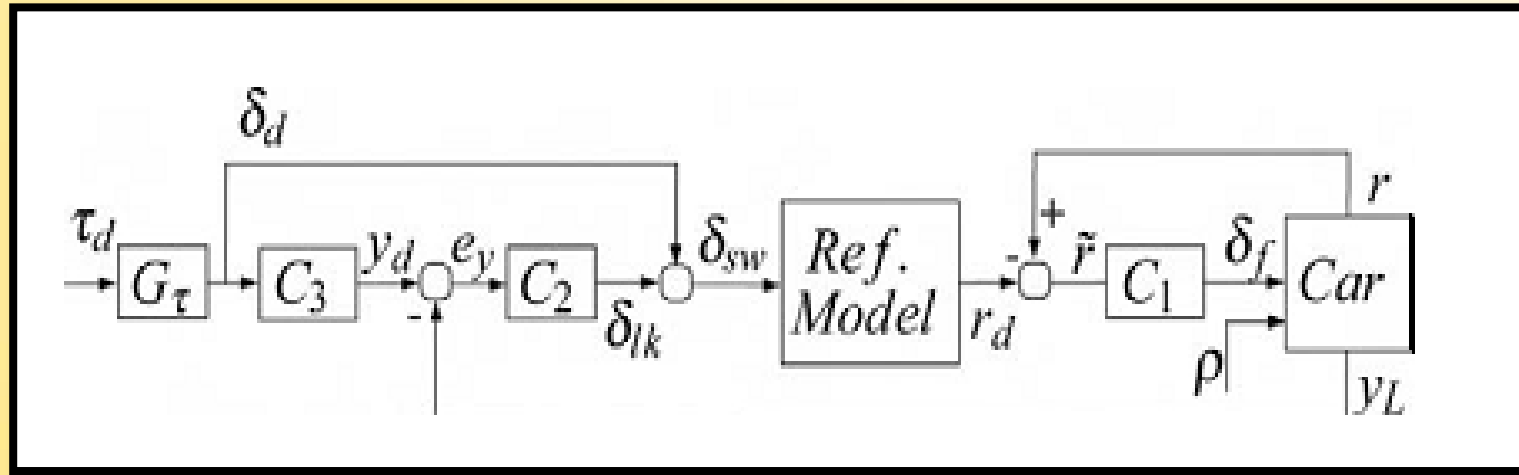
- C2- Acts as PID controller

- Lateral offset measurement
- It generates yaw rate signal based on y_L
- Active when $\tau_d=0$

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

- 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

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

$$\bar{P}_0 = \frac{(d_3s^3 + d_2s^2 + d_1s + d_0)}{s^2(-s^3 + c_2s^2 + c_1s + c_0)}$$

$\bar{P}_0$ -Transfer function between r_d & y_L
K-Design Parameter

VEHICLE MODEL

➤ Equation of Motion

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

➤ 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

File Edit Datasets Libraries Go To View Tools Help

Back Forward Home Previous Next Duplicate Undo Redo Lib Tool Parsfile

Run106
10-15-2013 11:29

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Sidebar Refresh Help Lock

A speed target can be calculated along a path while staying within given limits of lateral and longitudinal acceleration.

One of the most important uses of the Speed (Closed loop) Using Path Preview is to produce realistic driving speed schedules reflecting real highway driving performance levels.

In this example, a car maintains its lane position while accelerating and

CarSim Run Control: Lane Ke

Animator: Camera Setup: 180 de

Vehicle: Assembly: D-Class, Se

Procedures: Lane Keeping, Nor

Test Specifications

Vehicle configuration: Ind_Ind

D-Class, Sedan

Procedure

Lane Keeping, Normal Driving

Show more options on this screen

Run Control: Built-In Solvers

Run Math Model

Models:

☒ Write all available outputs

Some buttons are dimmed because the data set is locked

Results (Post Processing)

Animate

180 deg. Azimuth, 15 deg. El., Veh. Ref.

Plot

Show more plots: 0

☐ Set run color

☐ Overlay animations and plots with other runs

carSIM
MECHANICAL SIMULATION.

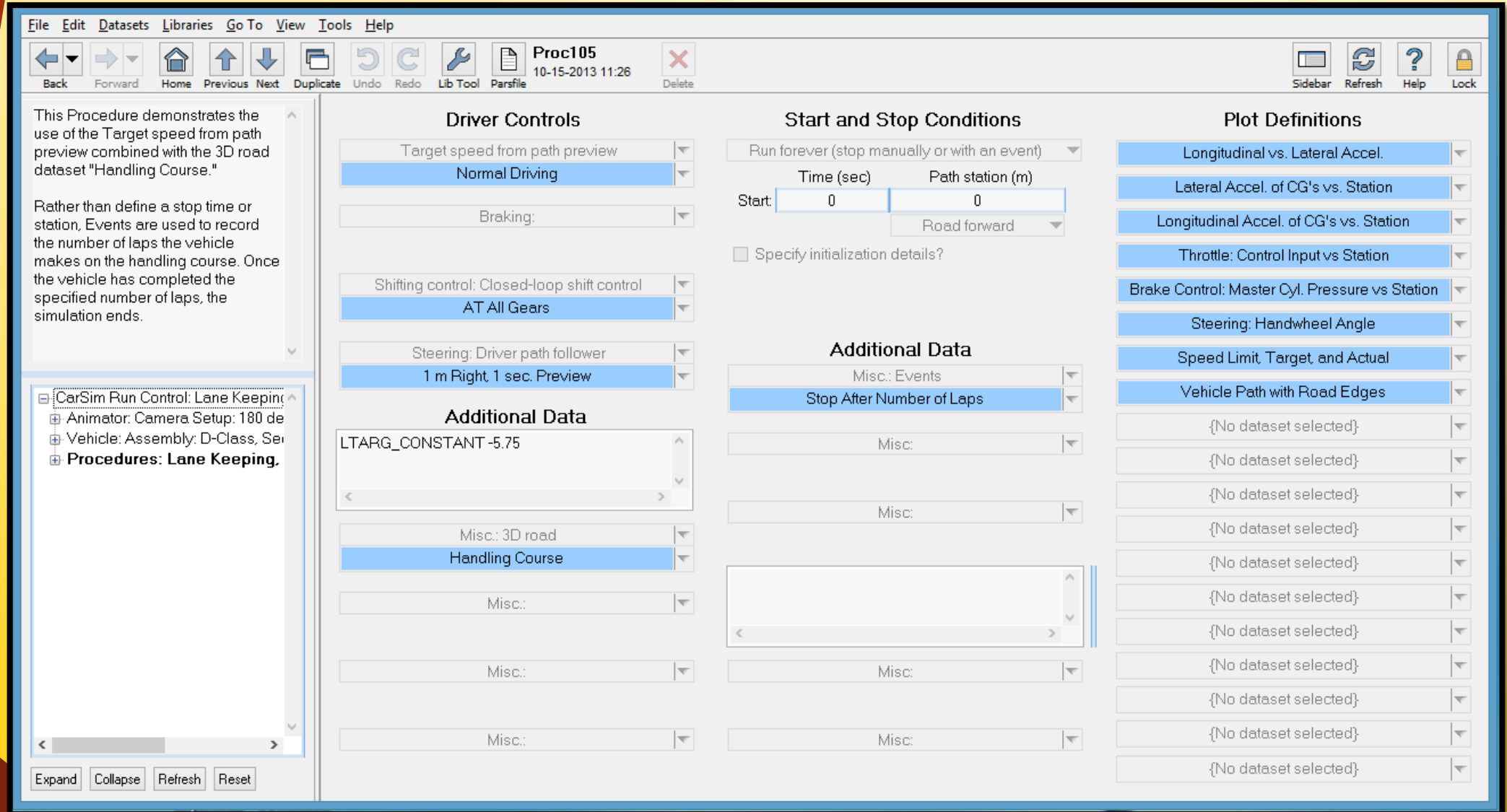


D-Class, Sedan
{ CS D-Class }

View

Echo file with initial conditions

CARSIM SIMULATION



CARSIM SIMULATION

File Edit Datasets Libraries Go To View Tools Help

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Sidebar Refresh Help Lock

In daily highway driving drivers limit themselves to fairly low acceleration levels. Here we use a maximum of 0.3 G's in all directions.

The limits are modified during the run to account for increasing and decreasing vertical load caused by road camber and elevation changes, as indicated by the checkbox. Unchecking the box keeps the acceleration limits unchanged with vertical load.

CarSim Run Control: Lane Keeping

- Animator: Camera Setup: 180 de
- Vehicle: Assembly: D-Class, Ser
- Procedures: Lane Keeping, Norr

Expand Collapse Refresh Reset

Acceleration Limits in Path Preview

Skill level: 2 - Combine Ax and Ay on friction ellipse

☒ Account for road surface 3D geometry

Aggressiveness

Aggressiveness is defined with four limits of acceleration that are acceptable by the speed controller.

Advanced users can specify acceleration limits as nonlinear functions of speed. Right-click on the drop-down list for extra keyword information.

Ax Max:throttle (constant) 0.3 g's

Ax Max:braking (constant) 0.3 g's

Ay Max:left turn (constant) 0.3 g's

Ay Max:right turn (constant) 0.3 g's

Closed-Loop Speed Controller Gains

A_x (target for speed control) = $K_P * V_{err} + K_I * I_{err} + K_{P3} * V_{err}^3$
where $V_{err} = V_{target} - V_x$; $I_{err} = \text{integral of } V_{err}$; $d(I_{err})/dt = V_{err}$

☒ Account for engine braking in speed control

KP: proportional gain: 0 s/m Approximate brake system performance: 0.1 g/MPa

KI: integral gain: 0 1/m Approx. gain: MC pressure/pedal force: 0.1 MPa/N

KP3: cubic gain: 0 s3/m3 Maximum MC pressure from controller: 10 MPa

Path Preview Lengths

Segment used to calculate curvature:	50	m
Preview start:	2	m
Total preview:	200	m
Preview interval (resolution):	2	m

Upper Speed Limit

Speed limit as function of station (legacy)

Normal Driving on Road Course

The linked dataset for target speed includes closed-loop controller gains. Those values will be overridden with the values shown on this screen.

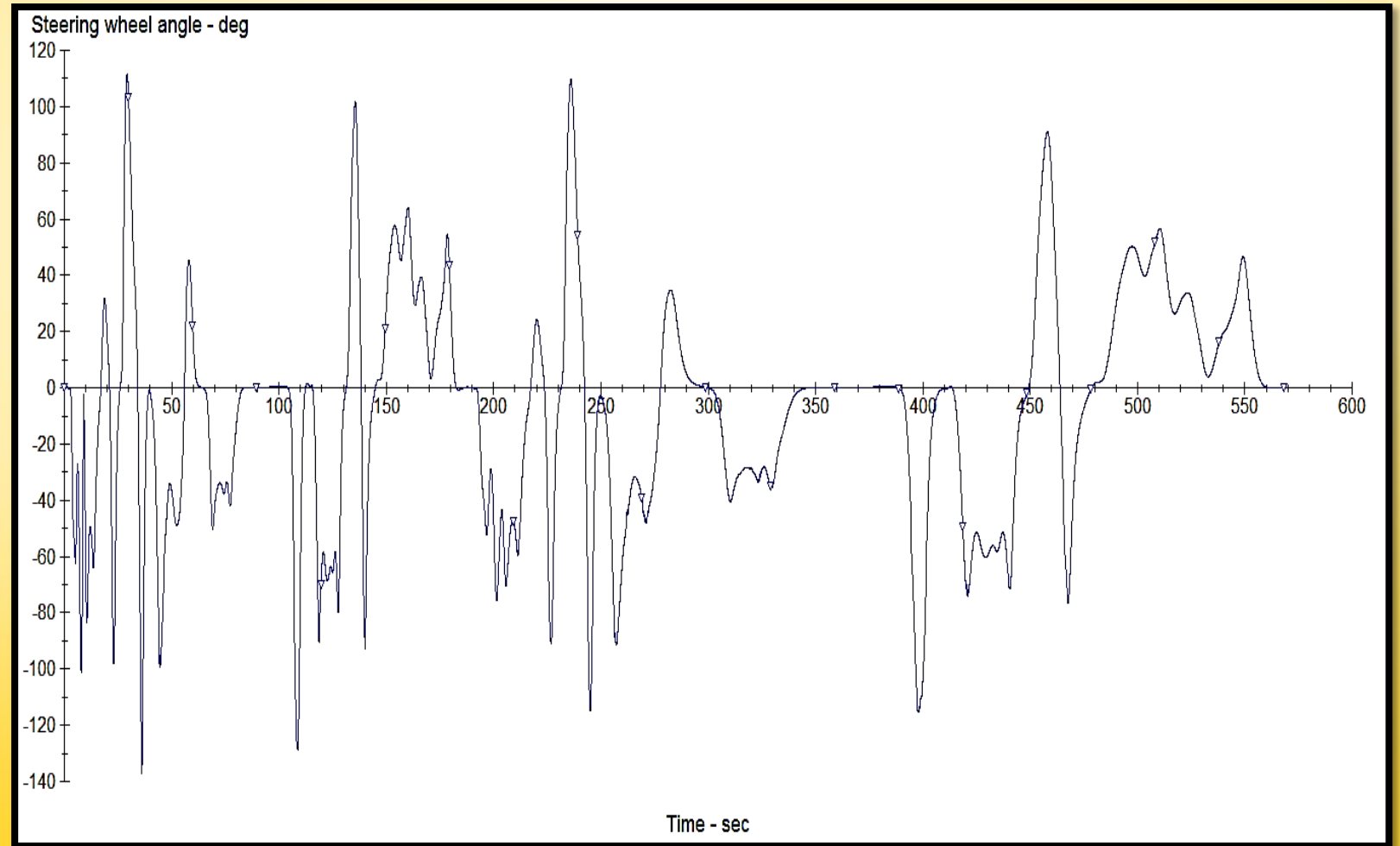
☒ Custom settings

```
lcancel the integral error when it is causing oversteer
define_variable sv_vx_err_save 0;
eq_out sv_iverr = if_gt_0_then(vx_err * sv_vx_err_
eq_save sv_vx_err_save = vx_err;
```

Miscellaneous:

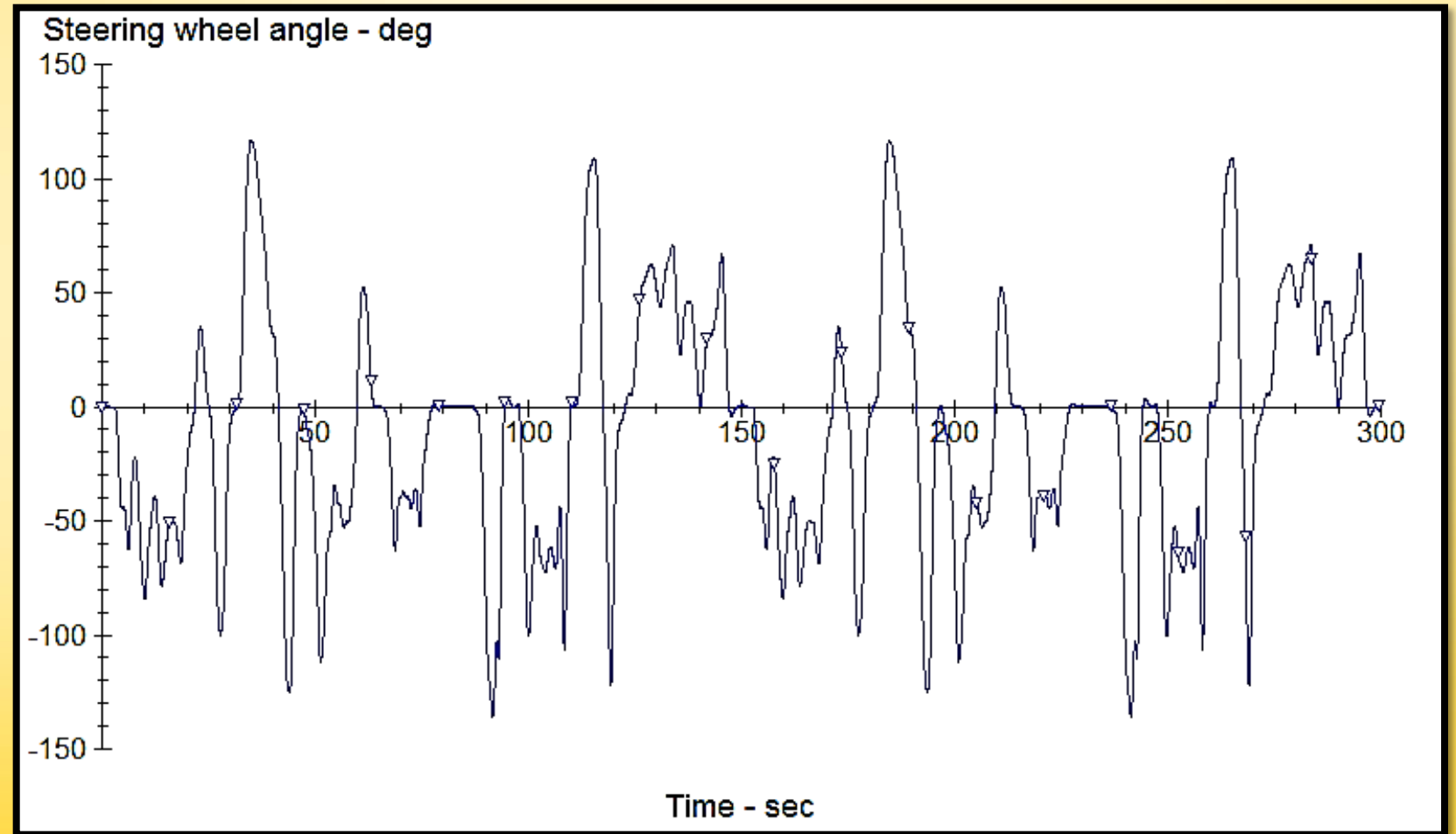
CARSIM RESULTS [Without PI]

- Steering Angle



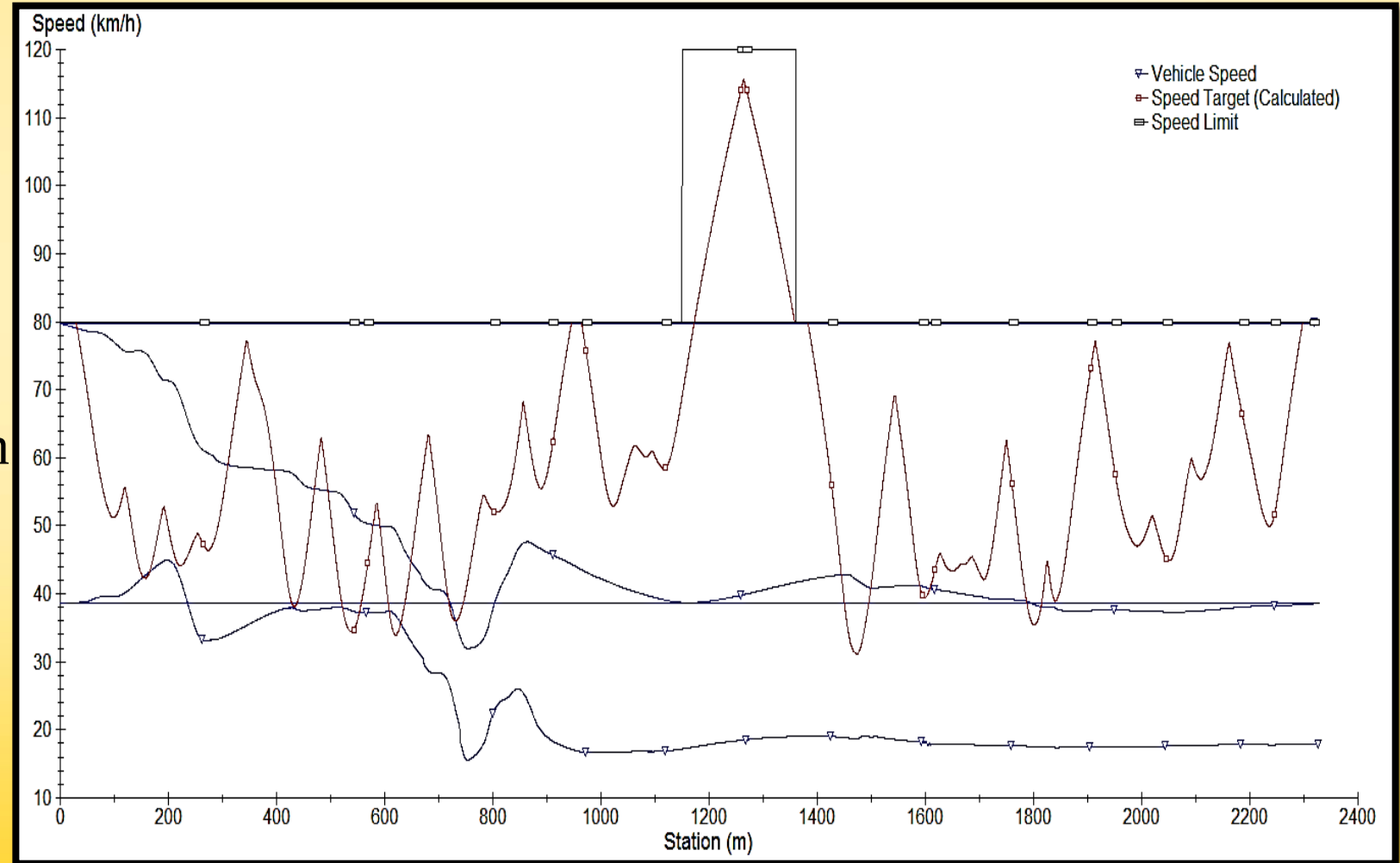
CARSIM RESULTS [With PI]

- Steering Angle



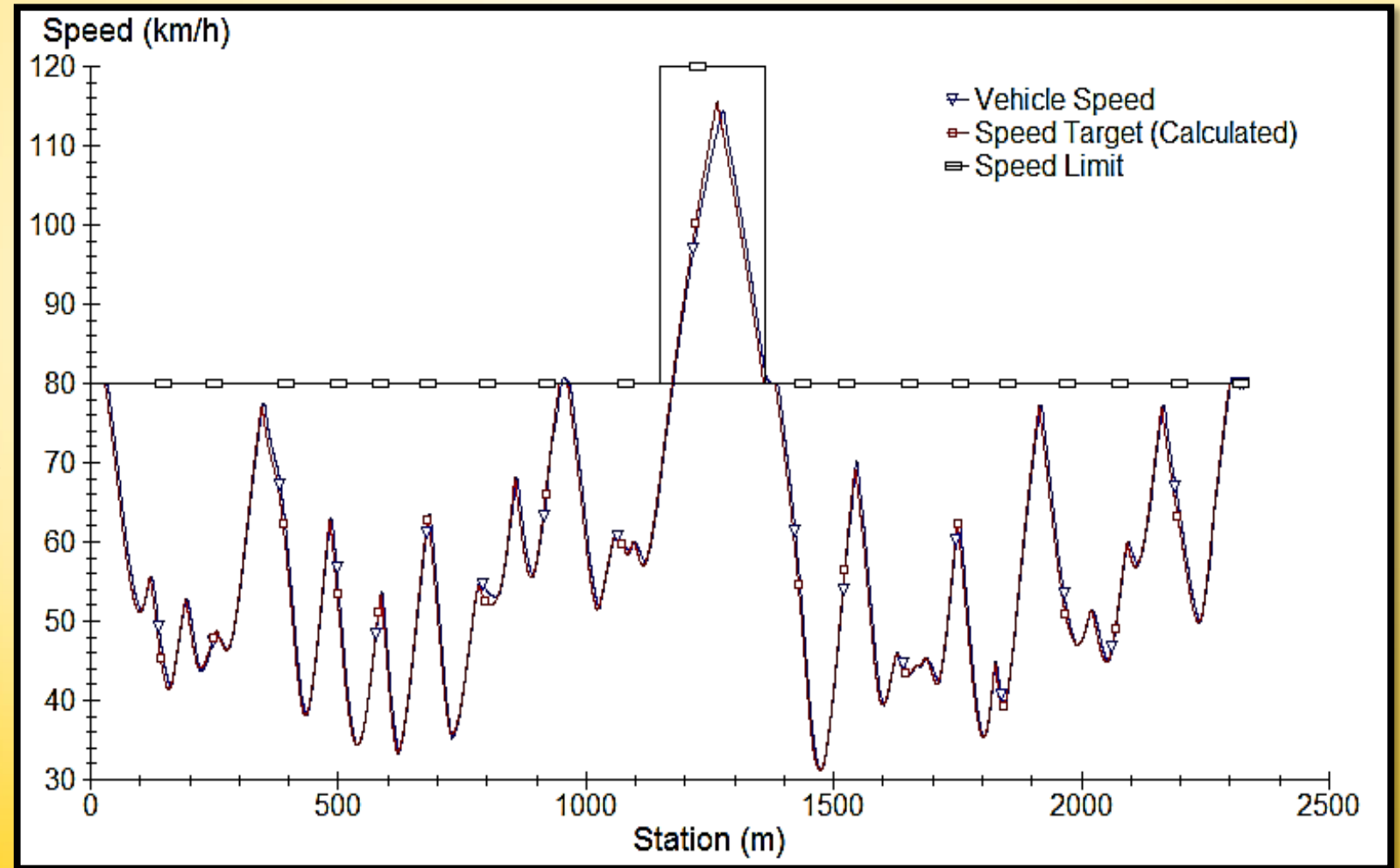
CARSIM RESULTS [Without PI]

- Speed Variation



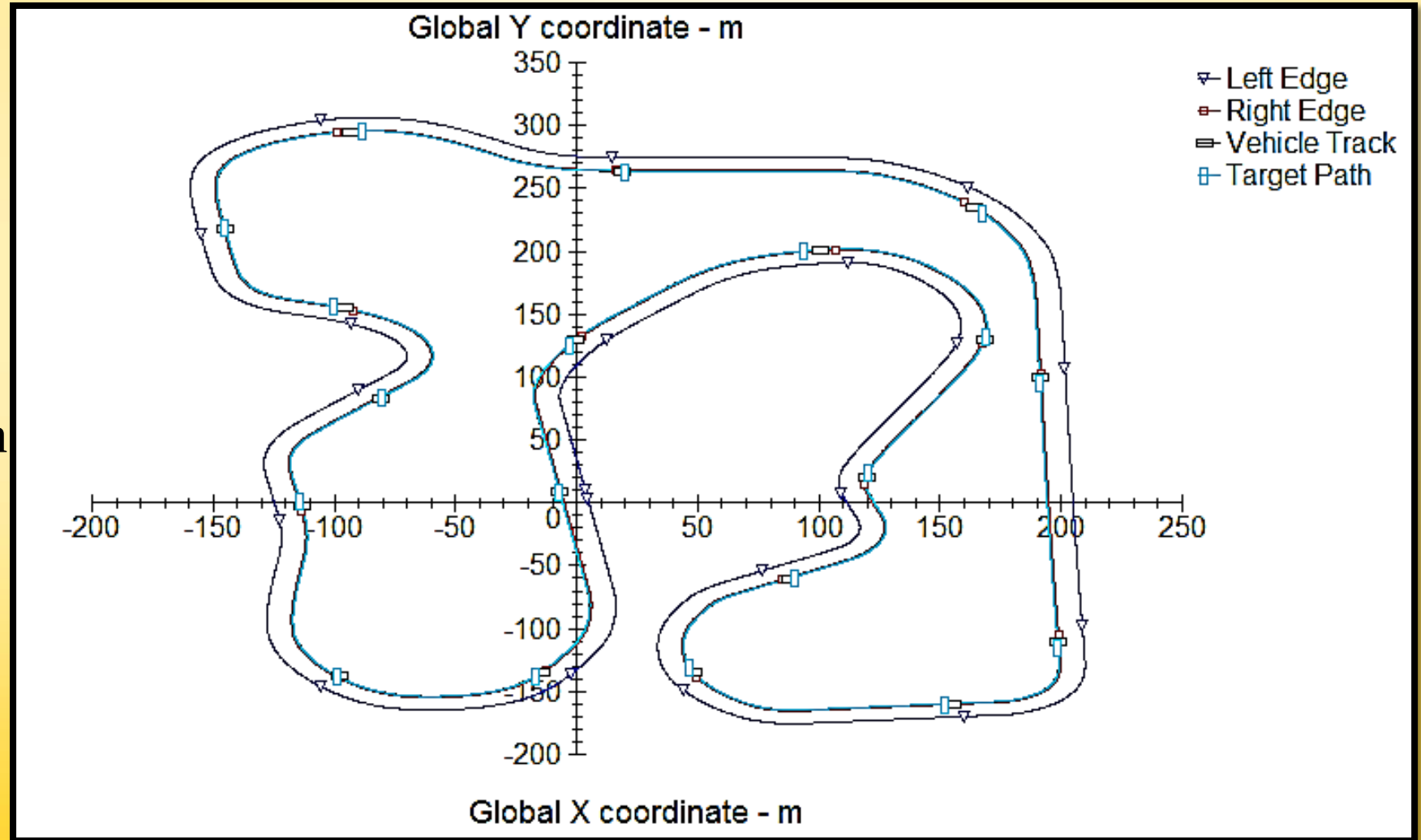
CARSIM RESULTS [With PI]

- Speed Variation



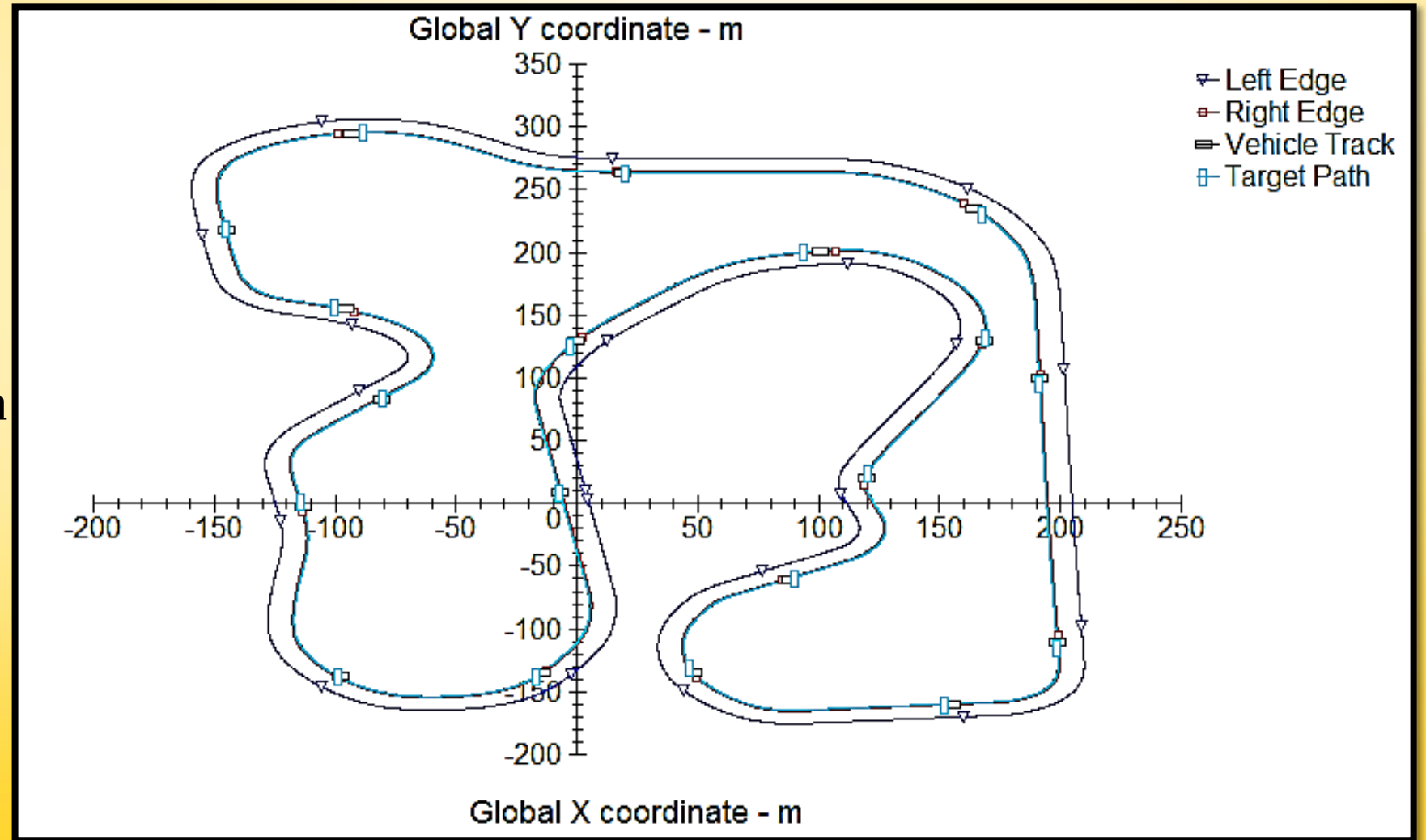
CARSIM RESULTS [Without PI]

- Track Motion



CARSIM RESULTS [With PI]

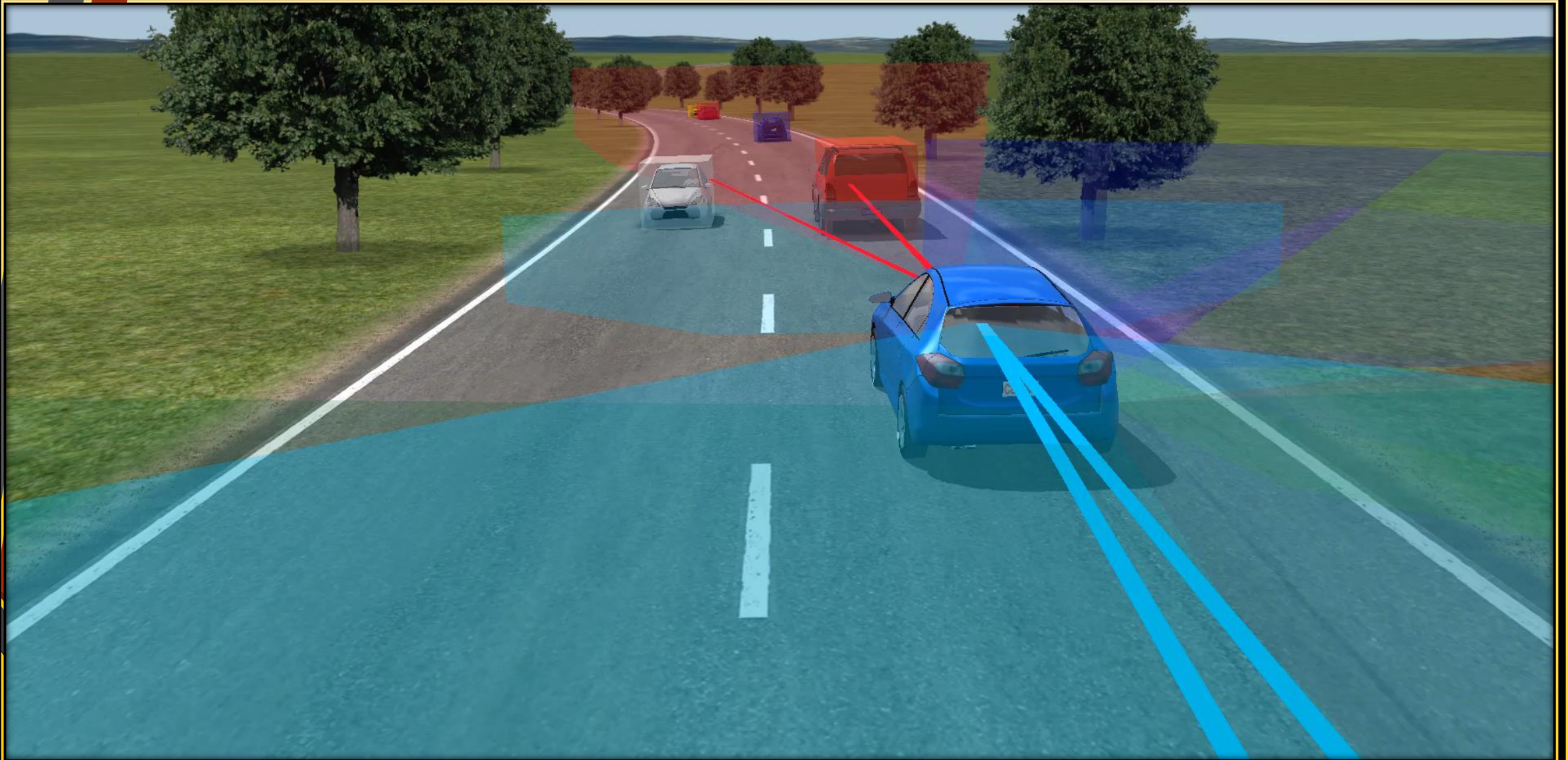
- Track Motion



CARSIM Video Result [With PI& Without PI]



Video on Automatic Steering Control

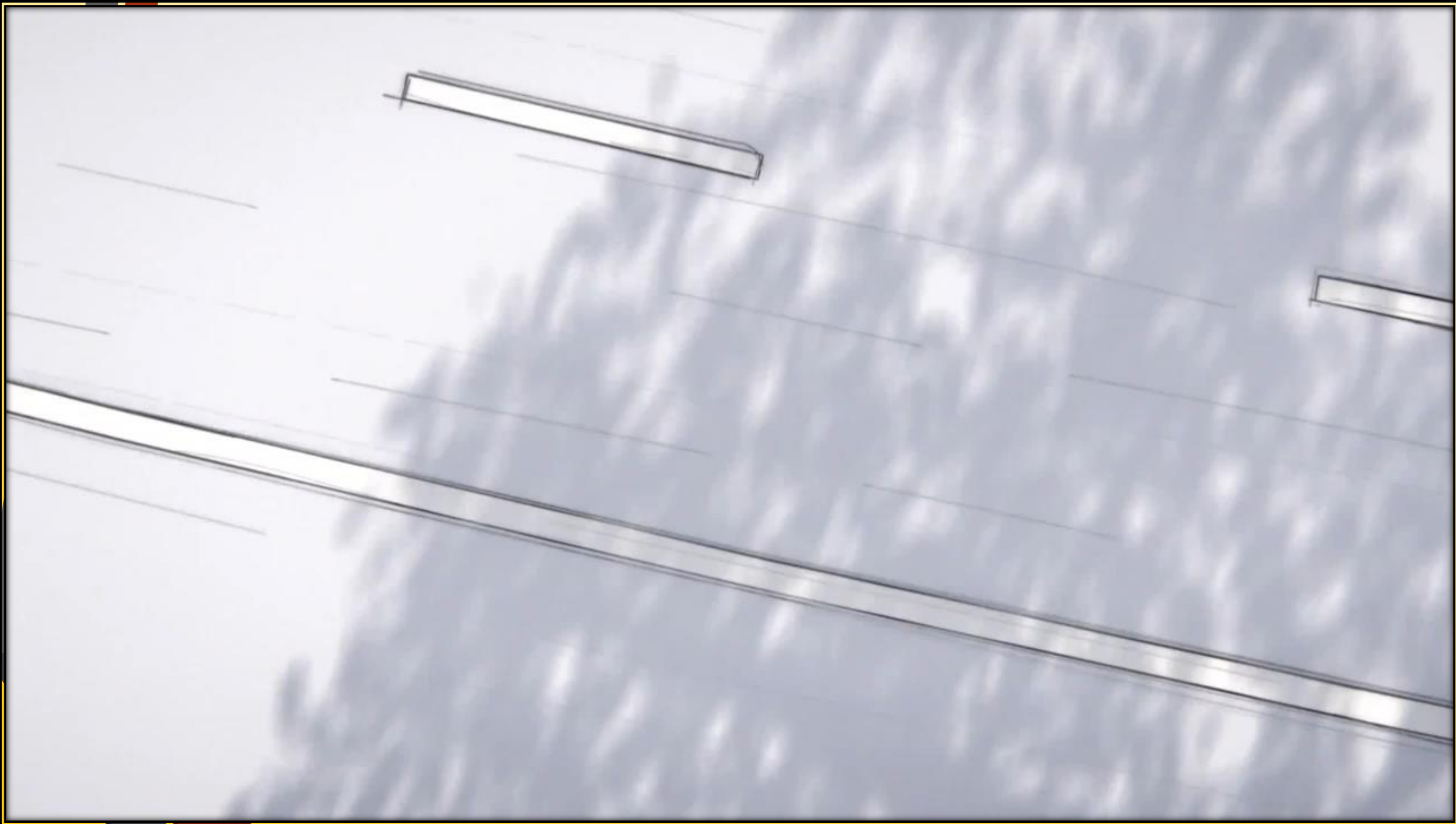


CONCLUSIONS

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

- **[A]** Riccardo Marino, Stefano Scalzi, Mariana Netto, Nested PID steering control for lane keeping in autonomous vehicles, Control Engineering Practice, Volume 19, Issue 12, December 2011, Pages 1459-1467.
- **[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 ...