Evaluating the Robustness of Integrated Control for Collision Mitigation with Oncoming Vehicles with Respect to Steering Effort

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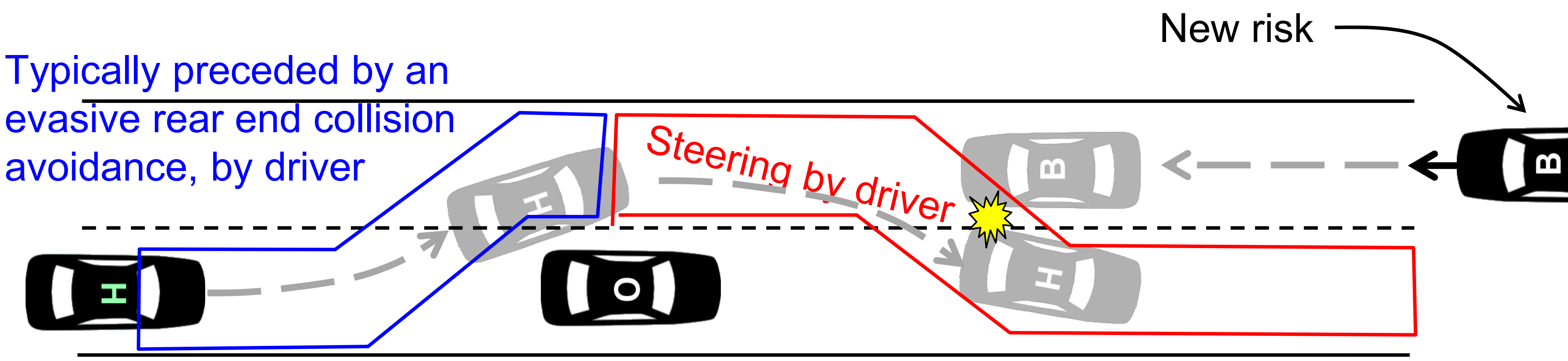
Avoidance of oncoming obstacle



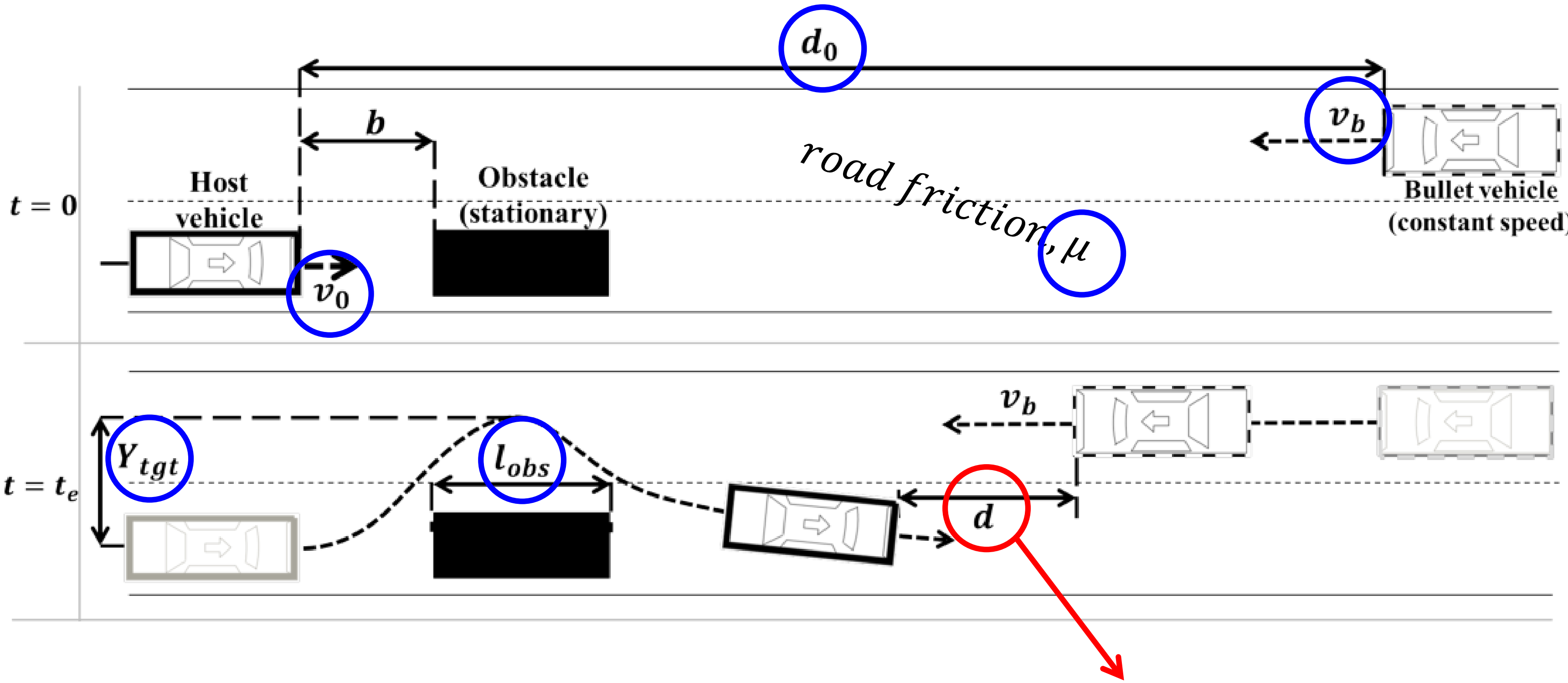
…this work is about how we can help driver safely back to the original lane

Accident statistics

- According to NHTSA:
  - 15.000 such accidents in US
  - 40.000 people involved
  - Economic cost $943.000.000
  - 32.000 functional years lost
- Numbers are per year based on 2004 statistics

[1] M. Yanagisawa, J. D. Smith, and W. G. Najm, “Pre-Crash Scenario Typology for Crash Avoidance Research,” Apr. 2007.

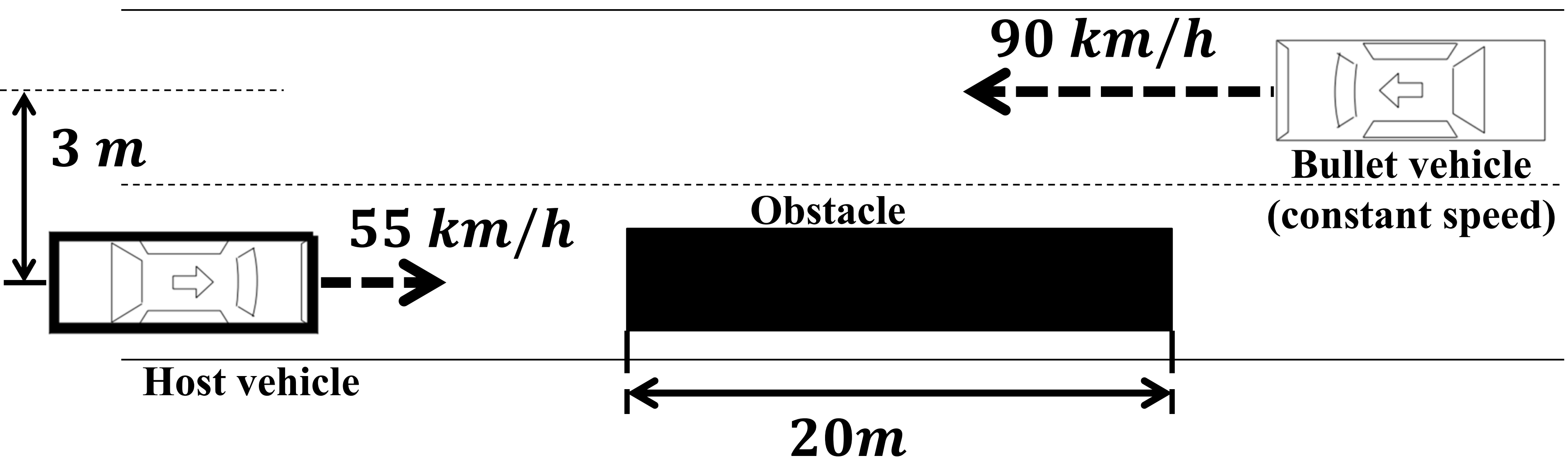
Parameterized scenario and objective



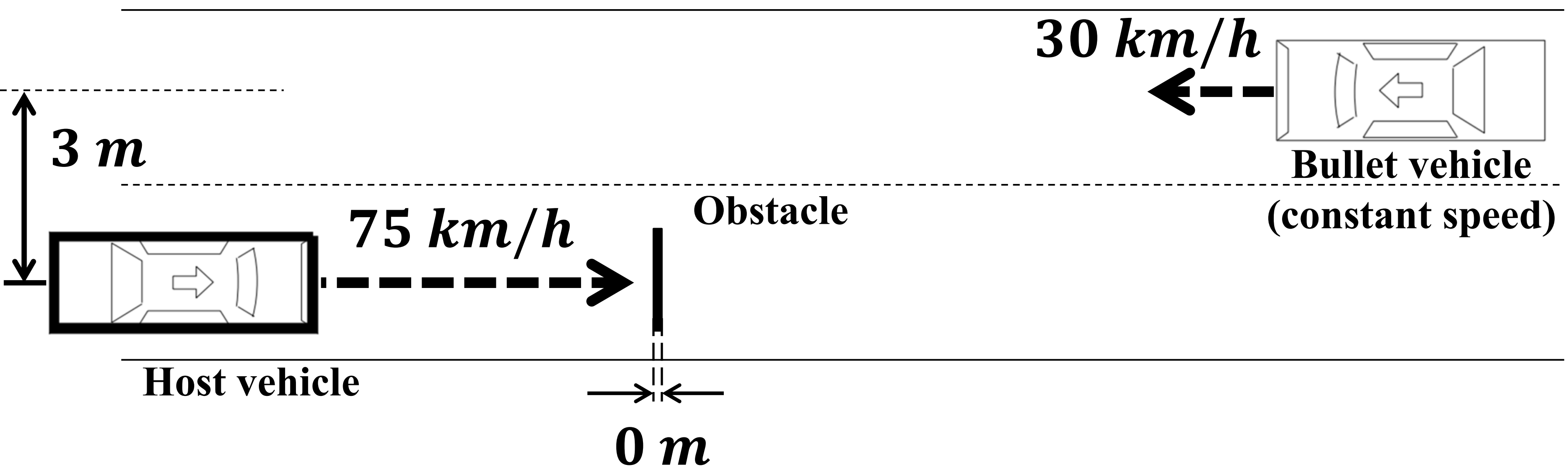
d **= DistanceMargin, used as objective (to maximise)**

Simulations

Scenario A


90 km/h
3 m
Bullet vehicle
(constant speed)
Obstacle
55 km/h
Host vehicle
20m

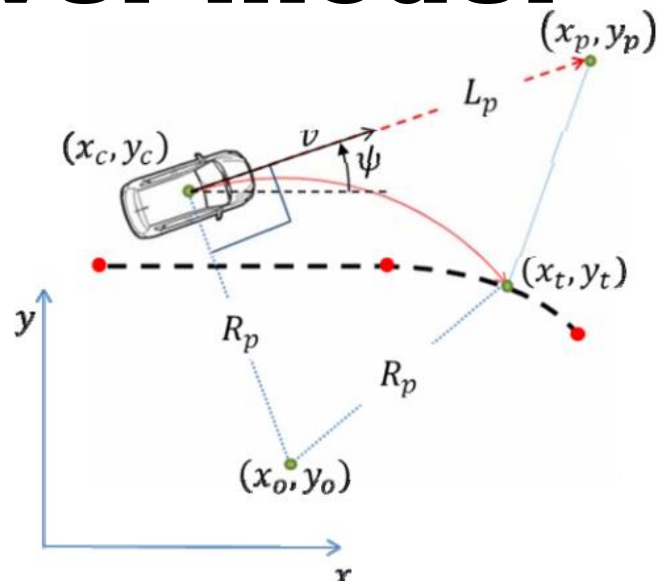
Scenario B



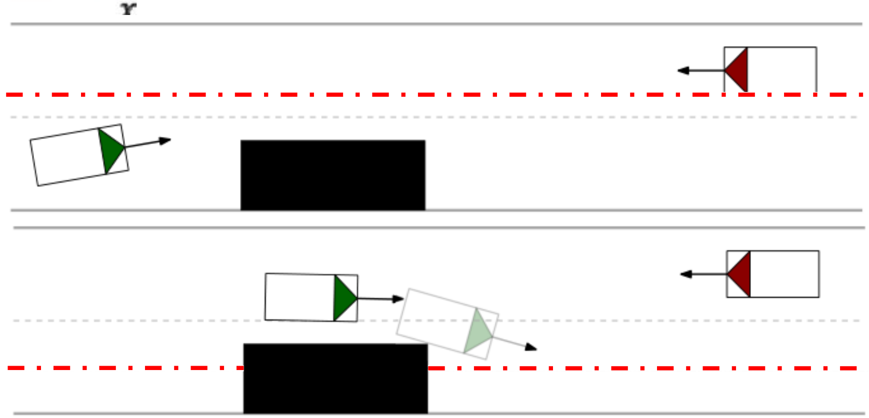
(representing for e.g., pedestrian, wild animal, etc)

Driver model

- Single point preview curvature model



- Combined with ”line-jump” reference path

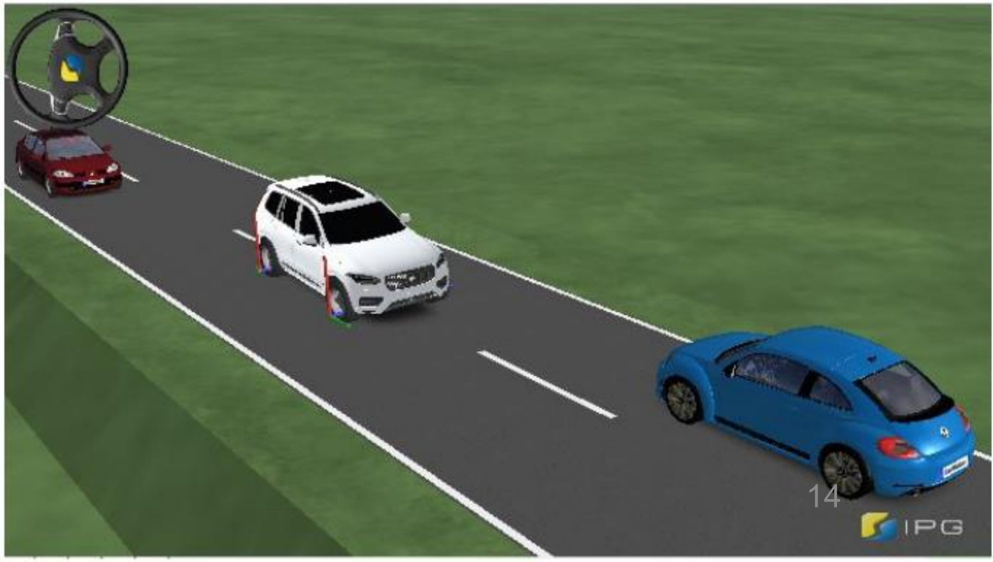


Note: **Driver steering effort** needs to be judged. Here: $\max(|\dot{\delta}|)$

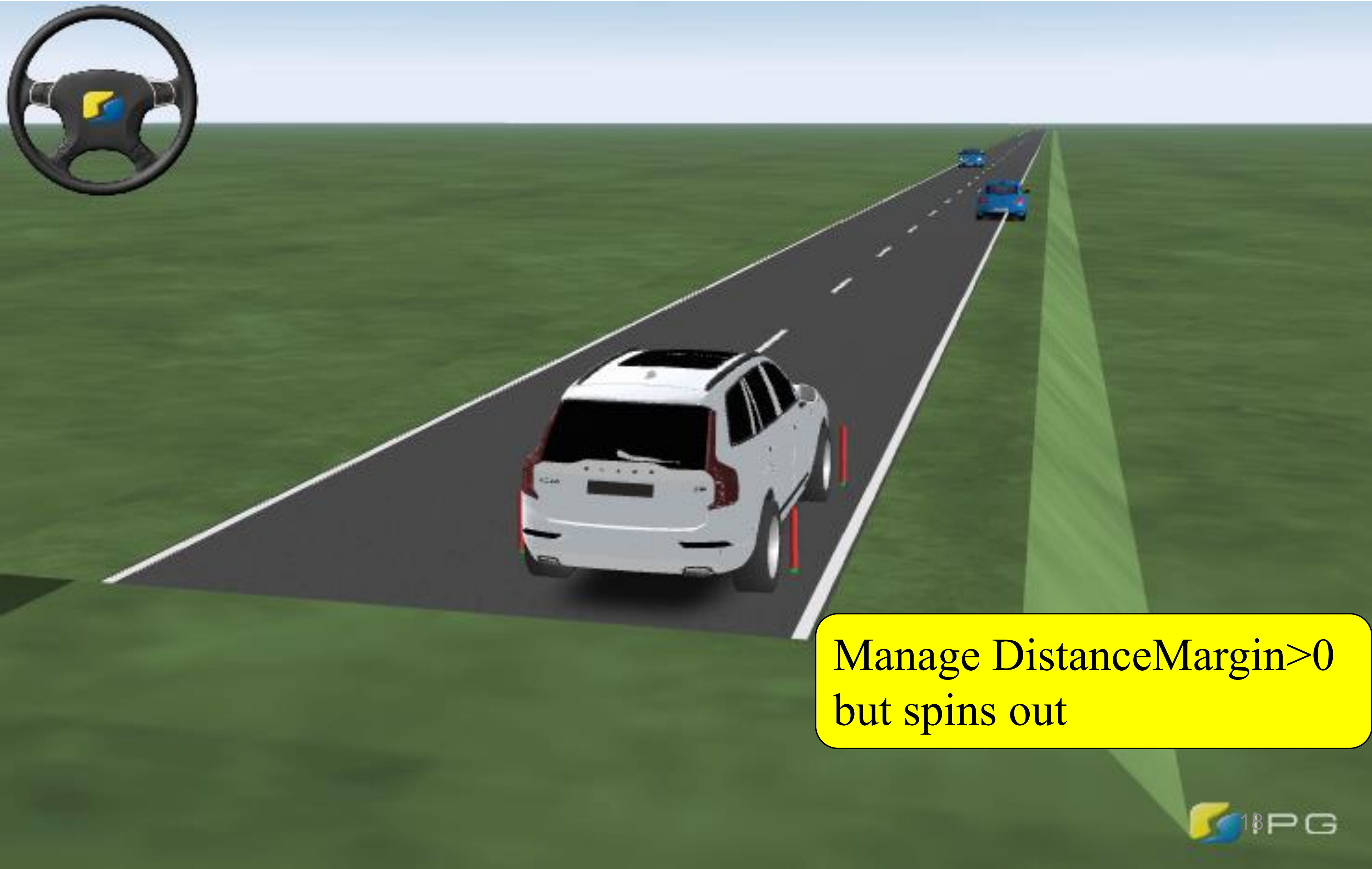
Vehicle model

- Validated Volvo XC90 vehicle model
- 6 actuators forces controlled
  - 4 wheel brake forces
  - 1 Engine front axle force (T8 driveline, 316 hp)
  - 1 Motor rear axle force (87 hp e-motor)
- Actuators' rate and amplitude limits are modelled

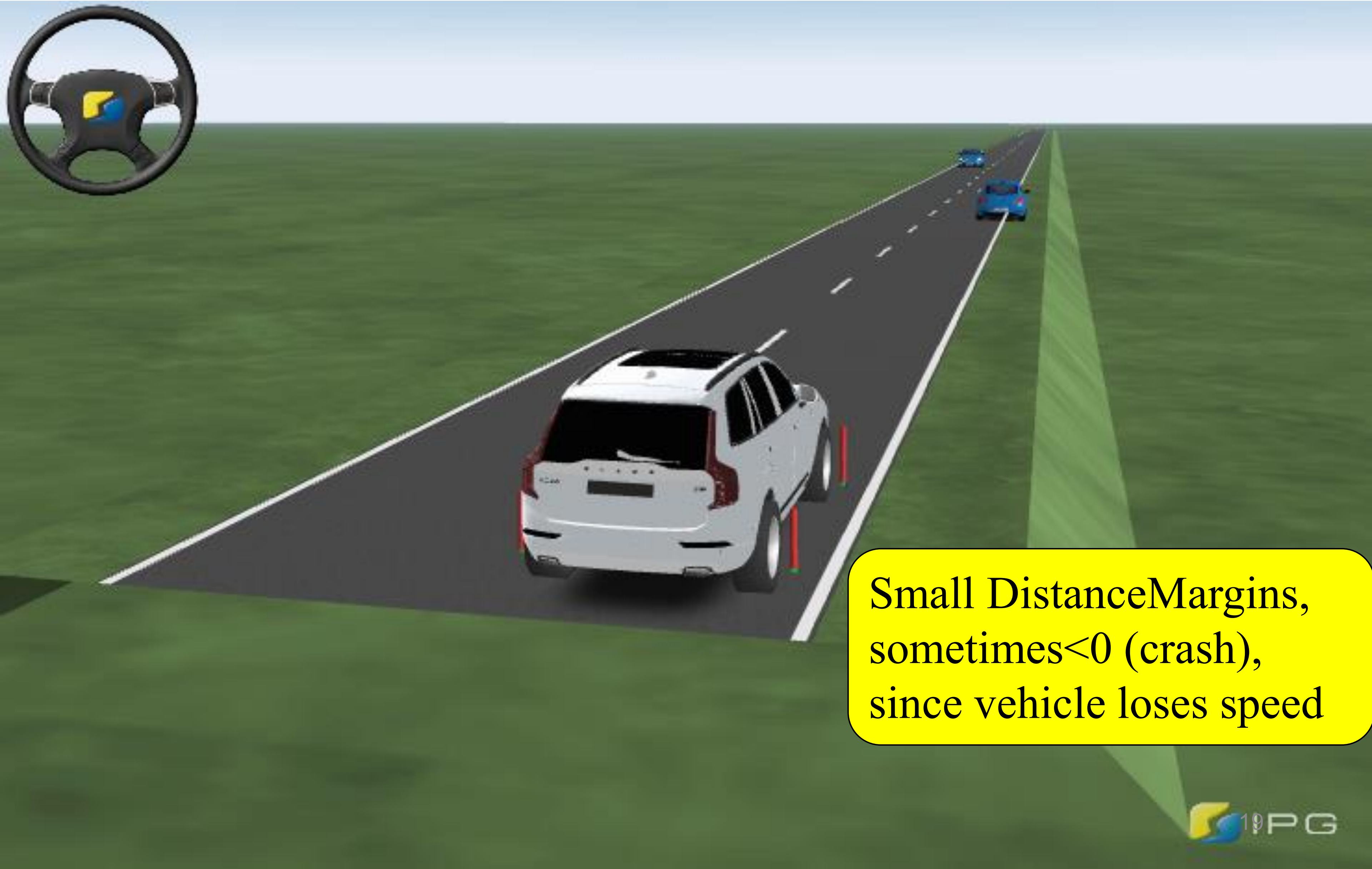
- **3 variants of control:**
  - **ESC**
  - **ESC & LongCtrl**
  - **LatCtrl & LongCtrl**



Steering only (not even ESC)

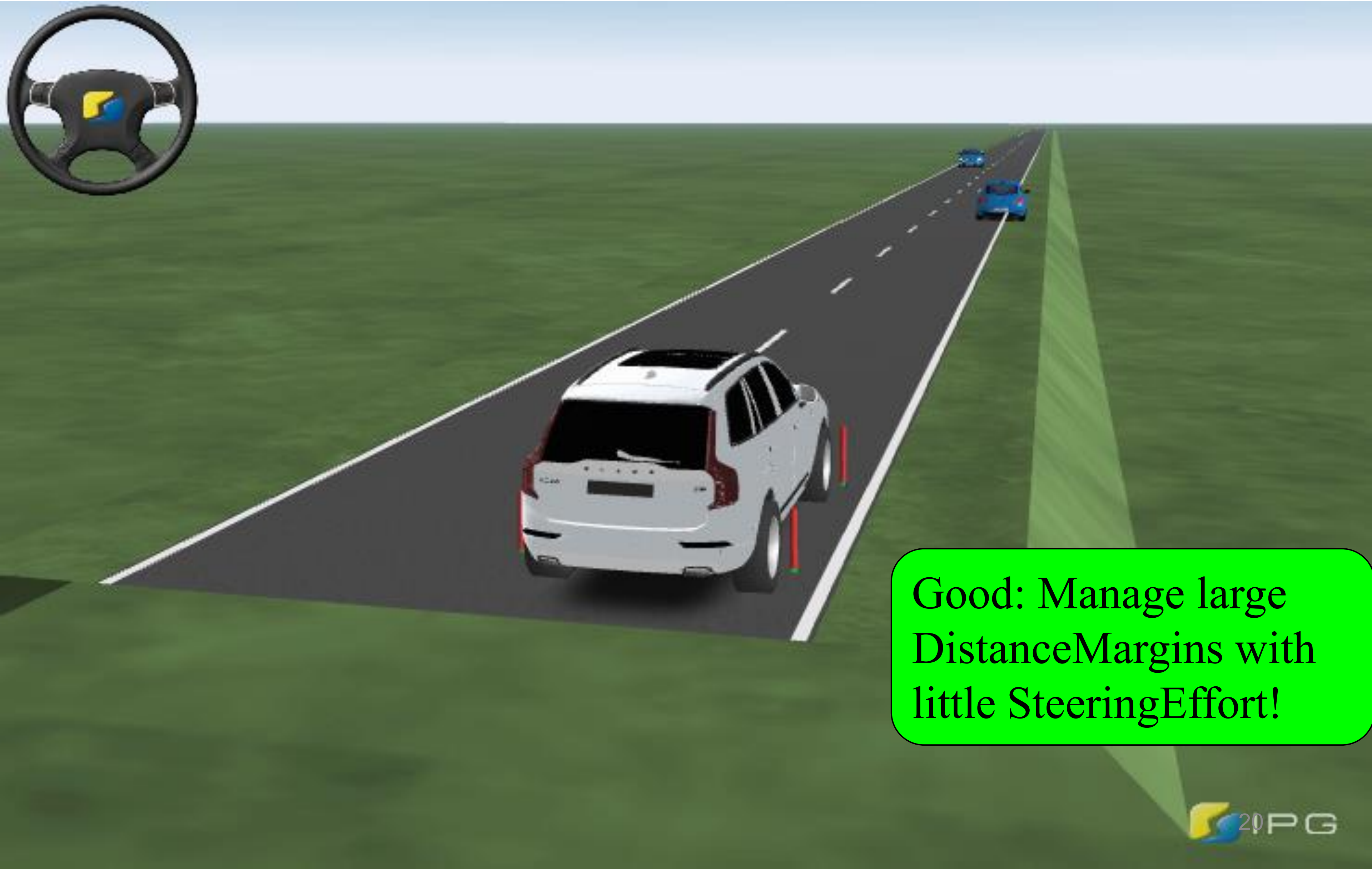


ESC only



Small DistanceMargins, sometimes<0 (crash), since vehicle loses speed

LatCtrl&LongCtrl

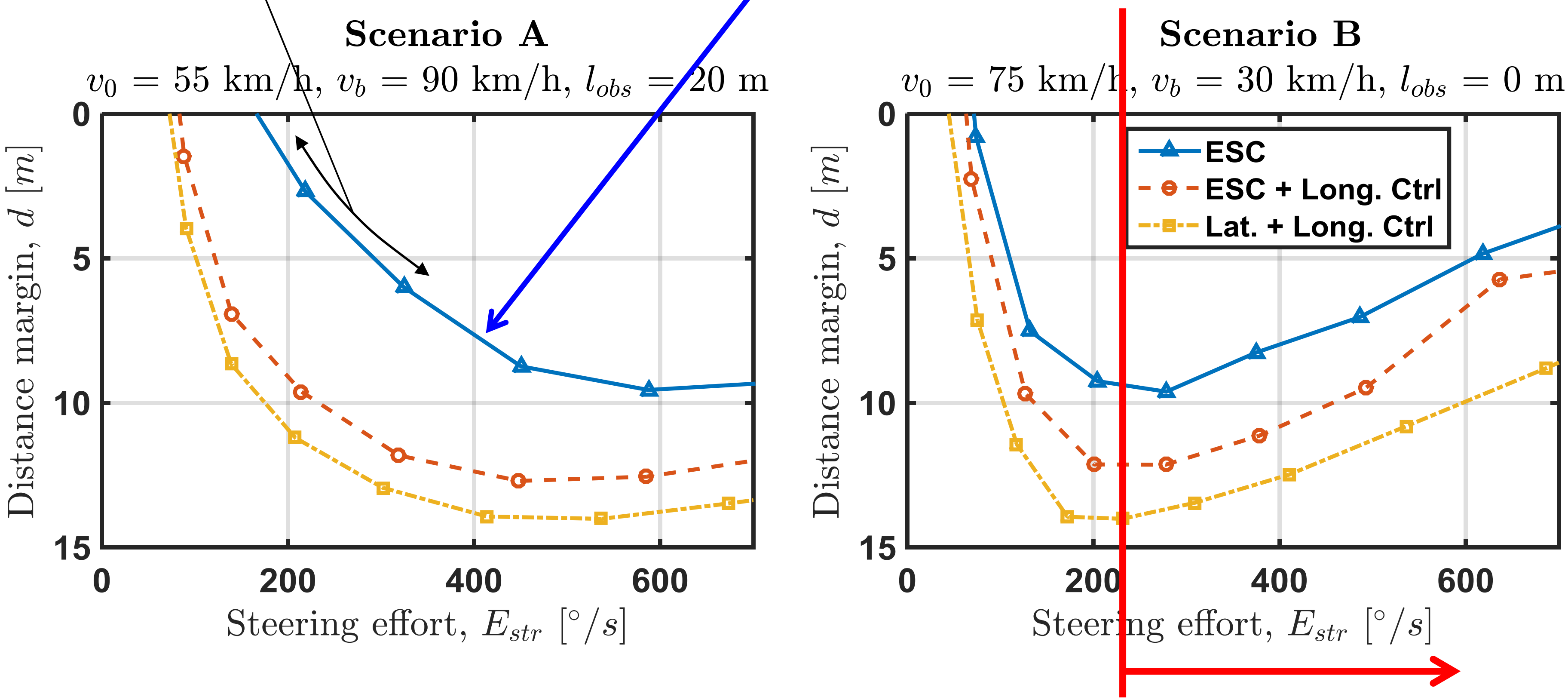


Good: Manage large DistanceMargins with little SteeringEffort!

Analysis of multiple simulations

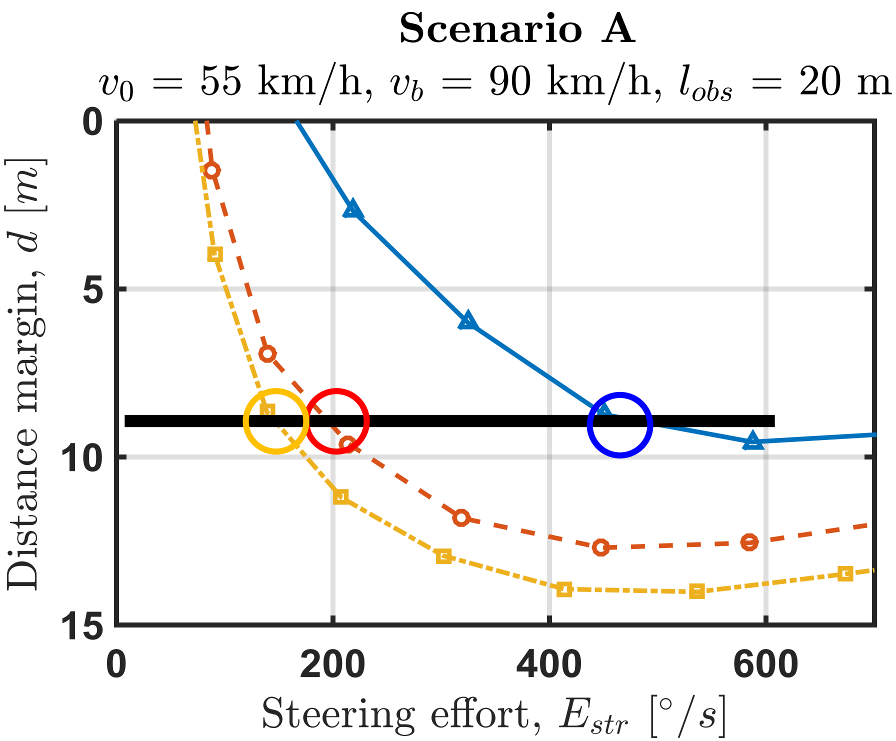
Driver model preview parameters were swept to generate each curve

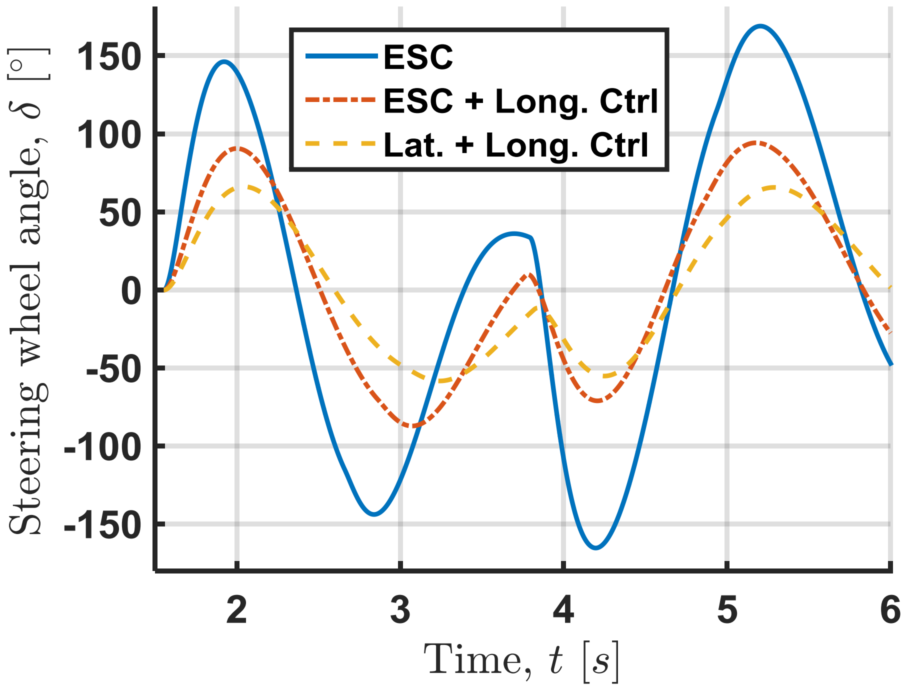
We see that ESC is particularly bad in Scenario A



Vehicle without ESC manage (DistanceMargin>0) but spins out

Scenario A, certain Distance Margin gives different Steering Effort





Conclusions

- ESC alone not enough, especially scenario A (long obstacle)
- ESC & LongCtrl:
  - Consistently improves stability
  - Limited improvement in robustness to steering effort
- LatCtrl & LongCtrl:
  - Consistently improves stability more
  - Significant improvement in robustness to steering effort
  - Risk of ”fighting the driver”

Future work

- Experiments
  - Verification of new control in real vehicle
    - (We have tested in real vehicle, but only with manual acceleration/deceleration)
  - Validation of driver model
    - (Does driver and control really ”fight”?)
- Can steering torque assist help?
- ”Function design”, integration with other functions, especially pedals and ”Automated driving HMI”

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- Academic version of Carmaker was supplied by **IPG**

Thanks for your attention