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(Road Safety and Digitalization)
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THE INFLUENCE OF V-ISA TECHNOLOGY ON DRIVER BEHAVIOR ALONG CURVES WITH SIGHT LIMITATIONS

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Presentation Content

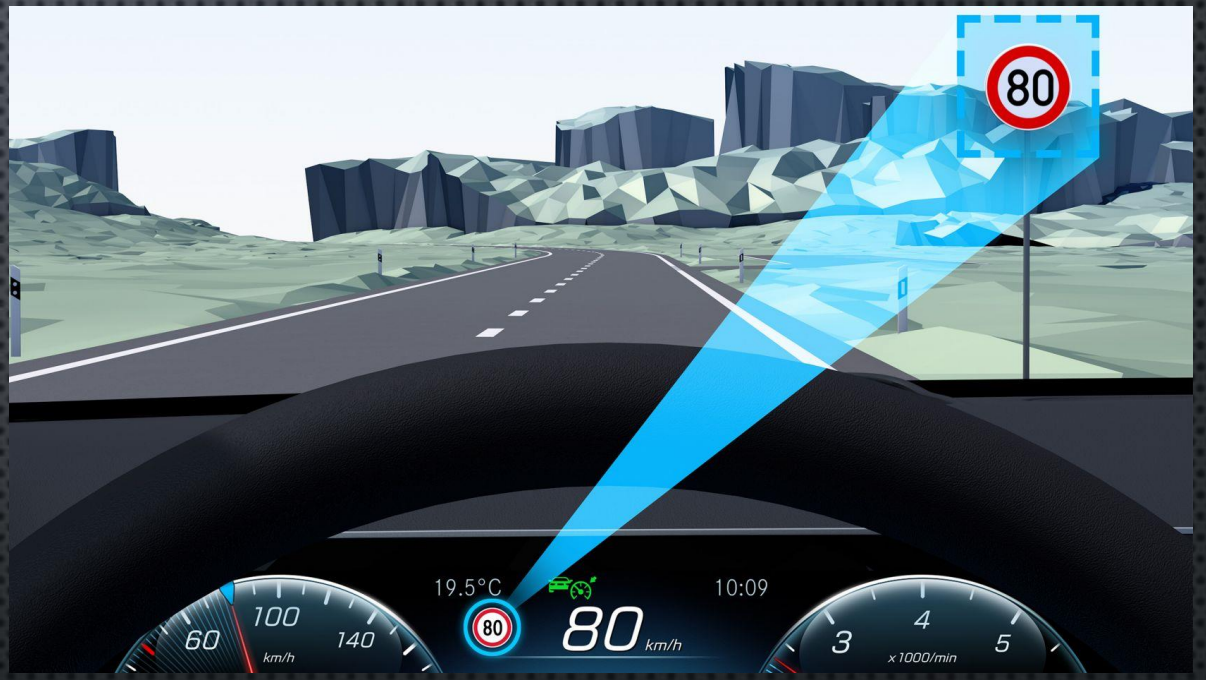
Introduction	• Intelligent Speed Adaptation (ISA) • Problem subjected to sight limitations
Novel ISA technology for vehicles	• V-ISA algorithm and functionality • V-ISA variants
Driving Simulator Experiments	• Experimental Design • Road Scenario and procedure
Results	• Longitudinal Behavior • Lateral Behavior
Conclusions	• Main outcomes • Future recommendations

Introduction

Intelligent Speed Adaptation (ISA)

- Current onboard vehicle Intelligent Speed Adaptation (ISA) system utilizes speed databases, or optical devices able to read the speed limit on vertical signs.

- The system uses this information to assist the driver in staying within the speed limit for enhanced safety.



Source: https://www.mercedes-benz.co.uk/

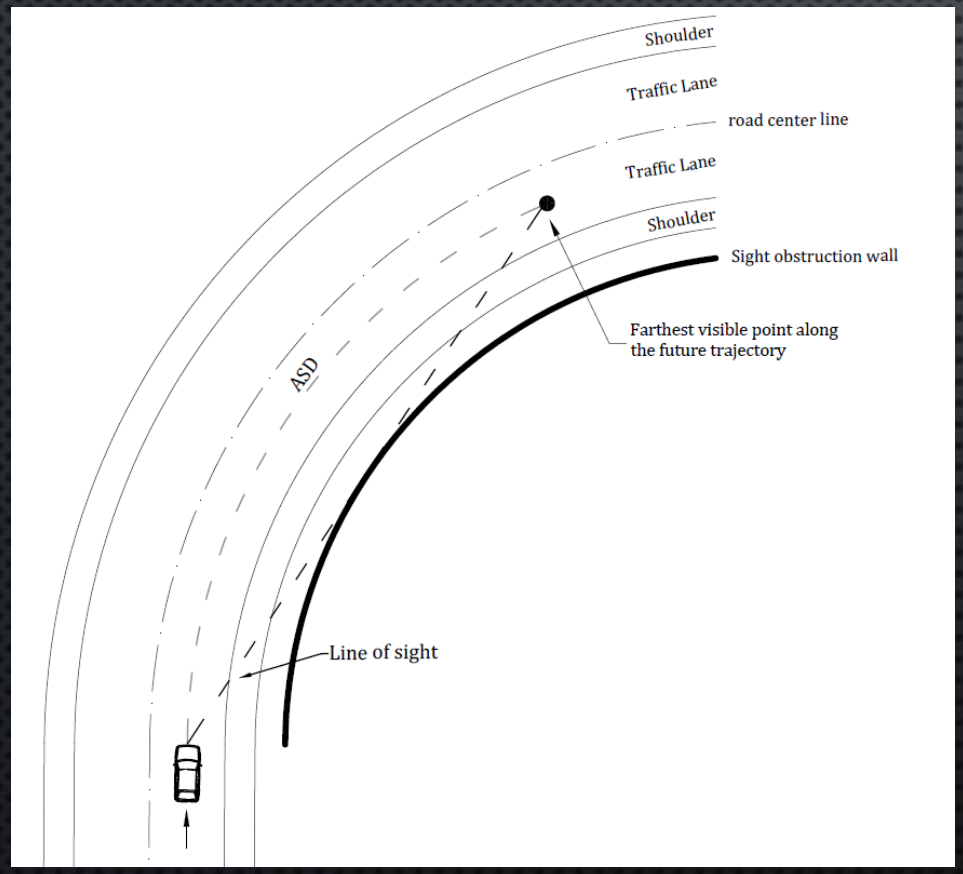
- The functionality of current ISA might be limited:
  - Posted speed does not reflect the actual limit due to unreliable traffic signals and/or,
  - Databases which need to be updated.

Problem Subjected to Sight Limitations

Available Sight Distance (ASD)

The longest distance that the driver can see along the future vehicle path

Dependent Parameters: road curve radius; distance to sight obstruction.



Stopping Distance (SD)

Distance required to stop the vehicle in case of emergency

$$SD = v \cdot \tau + \frac{v^2}{2g\,(f \pm i)}$$

Dependent Parameters:
v = vehicle speed; τ = perception reaction time;
f = friction coefficient; i = road grade.

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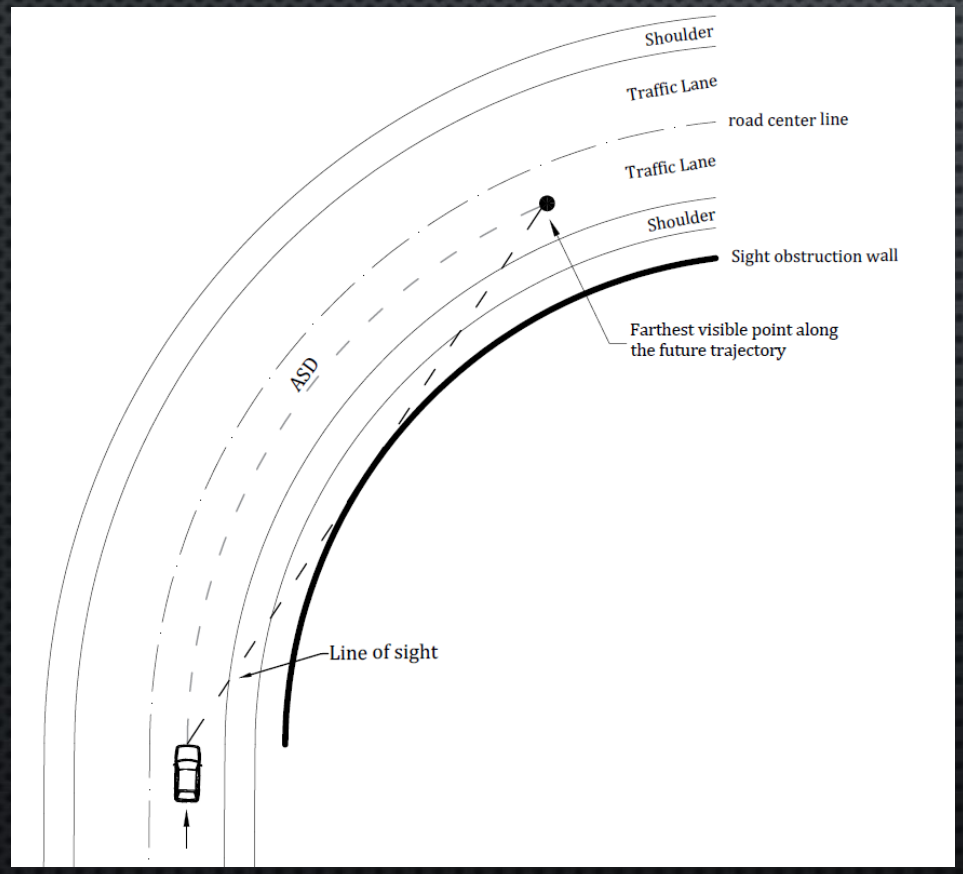

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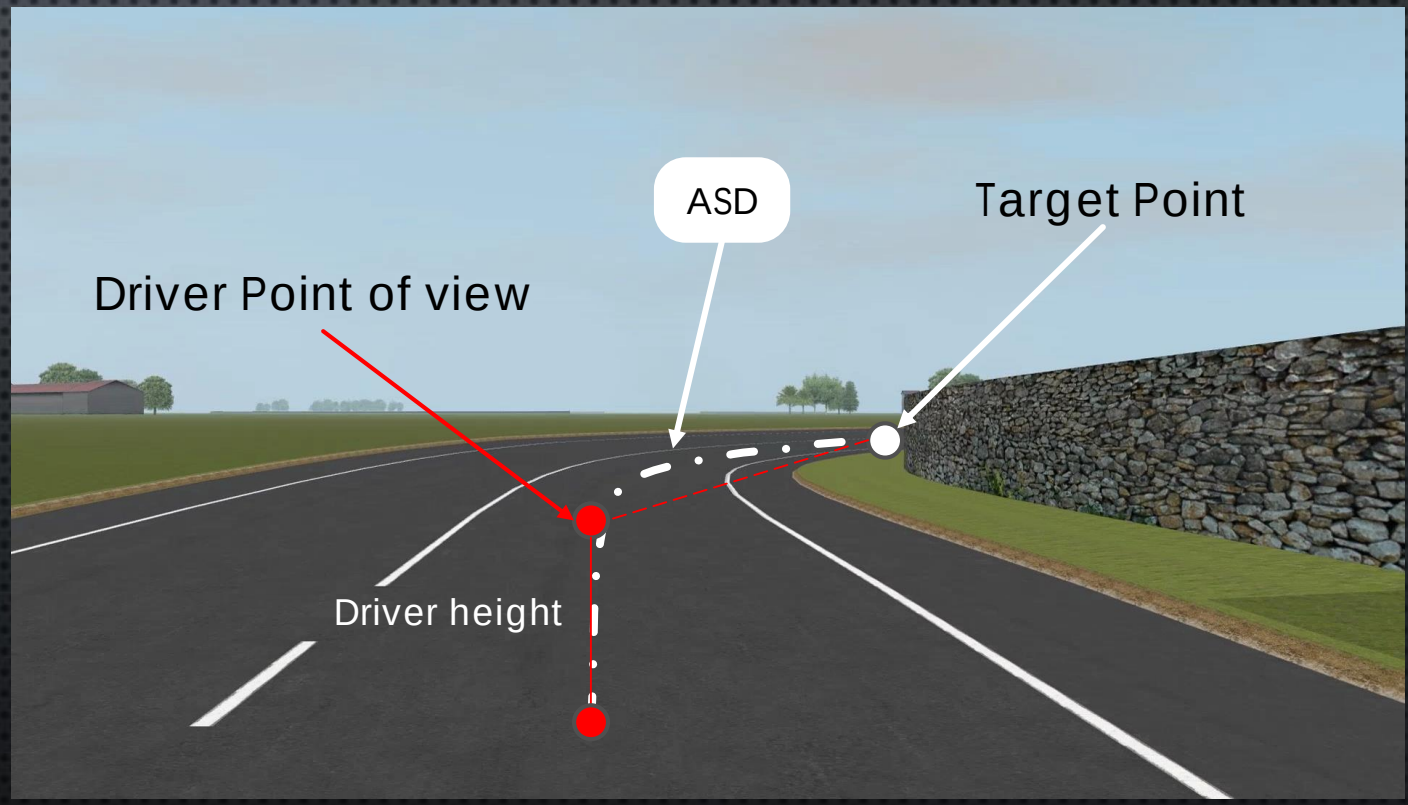

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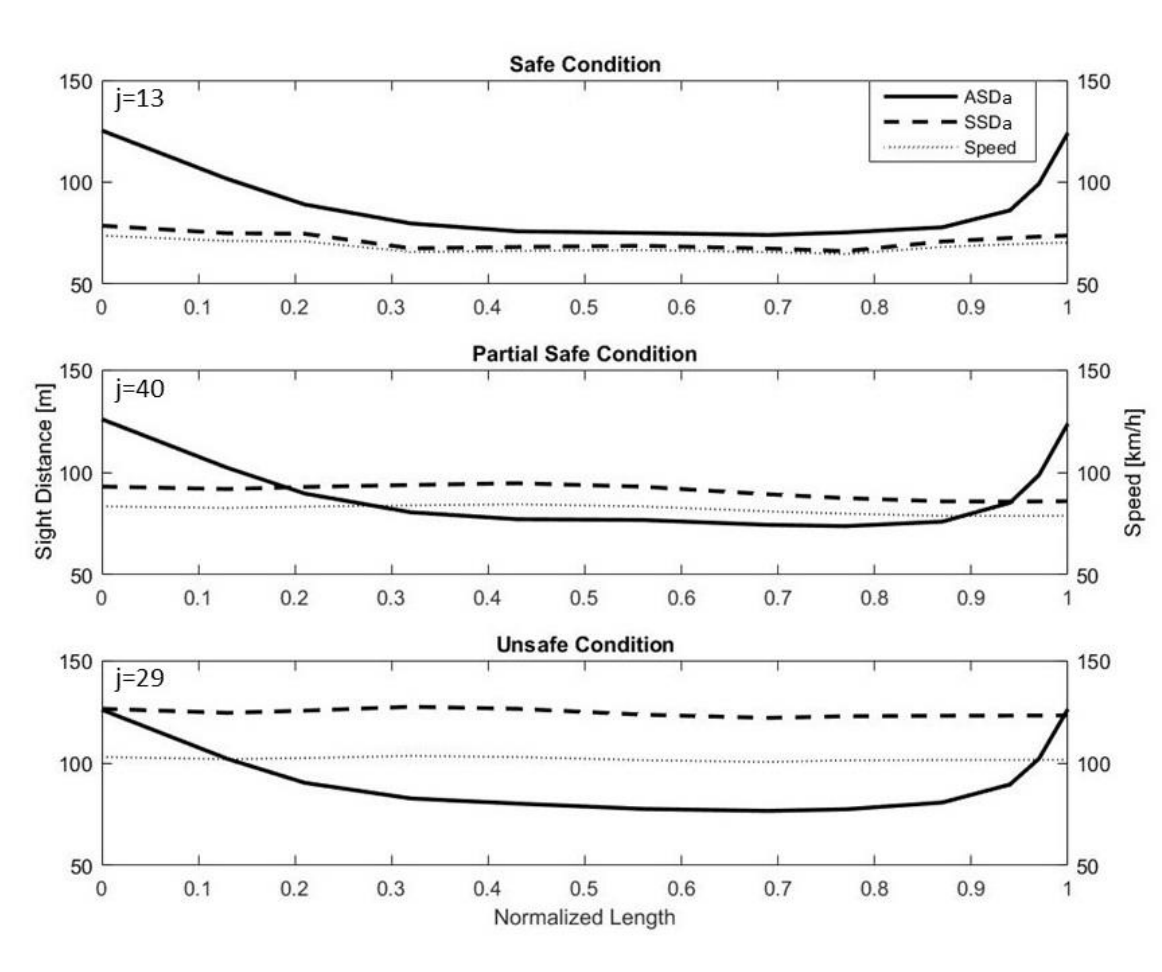
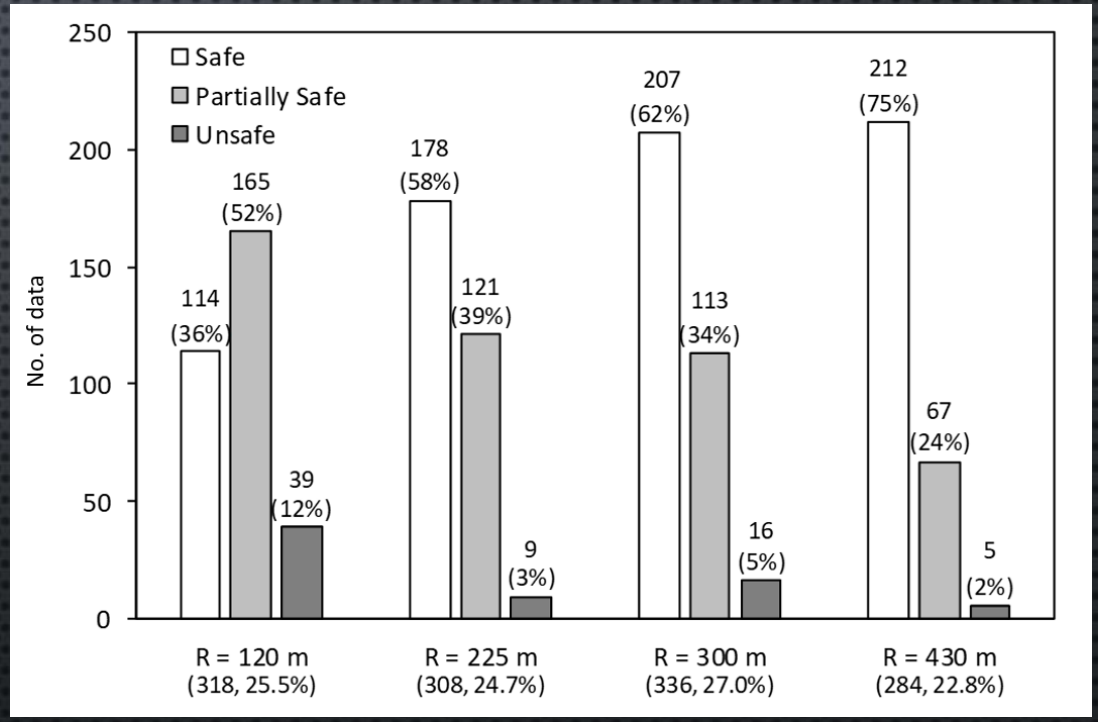


Illustration of ASD and SD profiles along a road curve

Safe Condition:

$$SD\ (v, f, i) \leq ASD(s)$$



1240 total number of observations

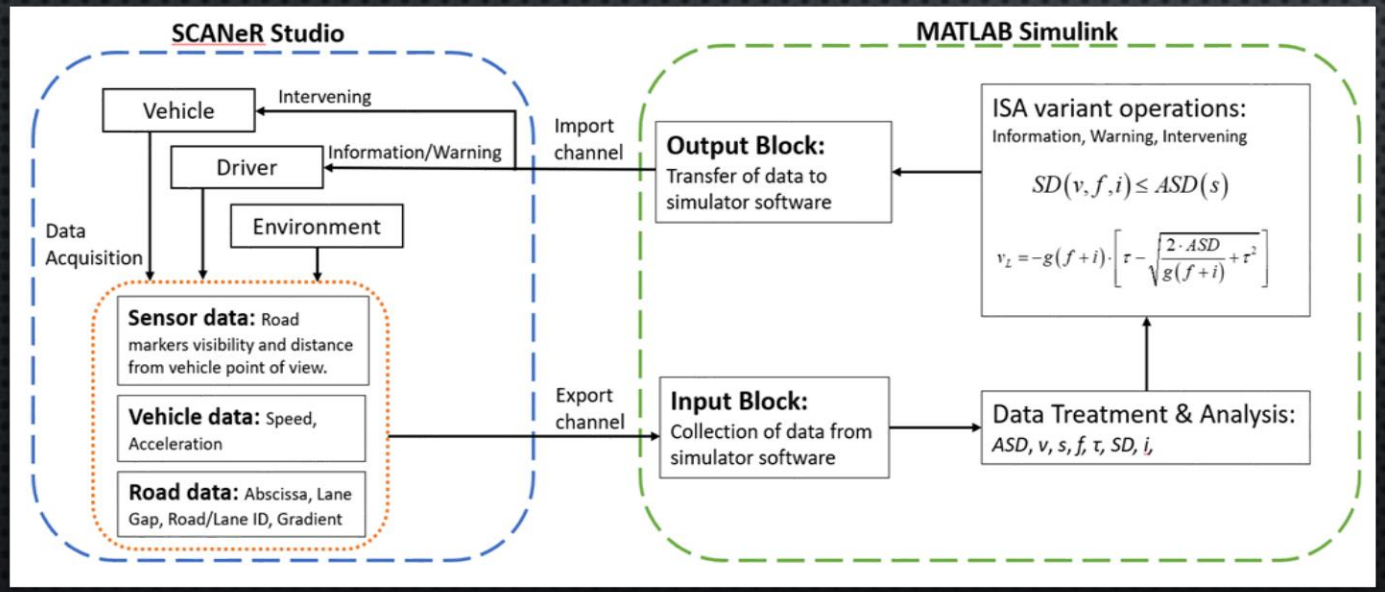
Bassani, M., Hazoor, A., & Catani, L. (2019).
What's around the curve? A driving simulation experiment on compensatory strategies for safe driving along horizontal curves with sight limitations.
Transportation research part F: traffic psychology and behaviour, 66, 273-291.

Intelligent Speed Adaptation for Visibility (V-ISA)

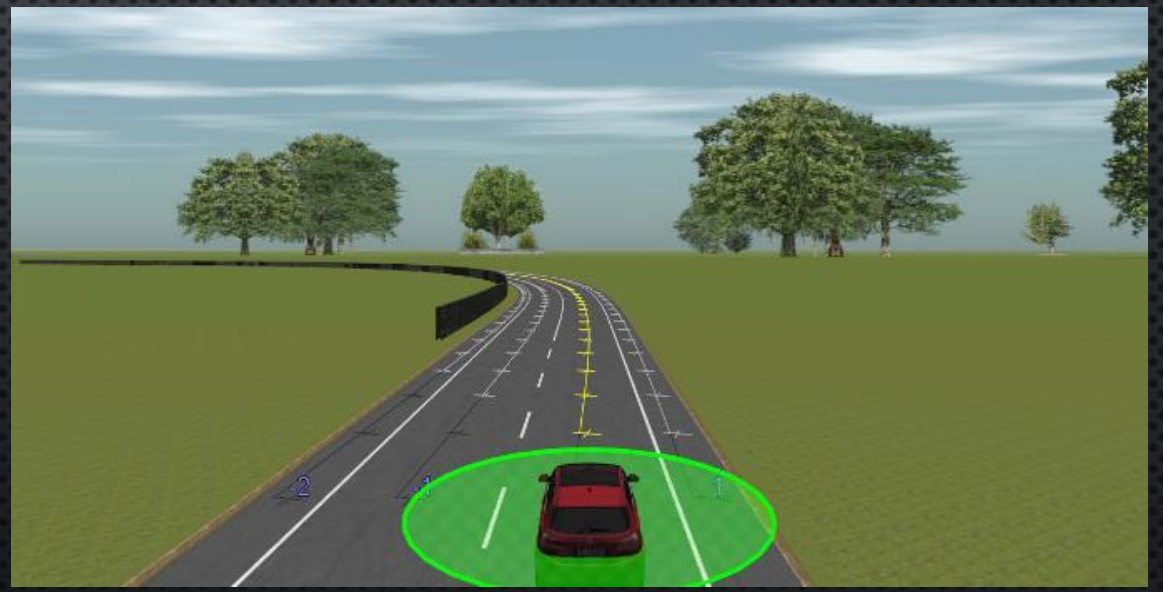
V-ISA functionality

The V-ISA functionality is based on an algorithm developed in MATLAB Simulink by referring to the following condition:

$$SD\ (v, f, i) \leq ASD(s)$$



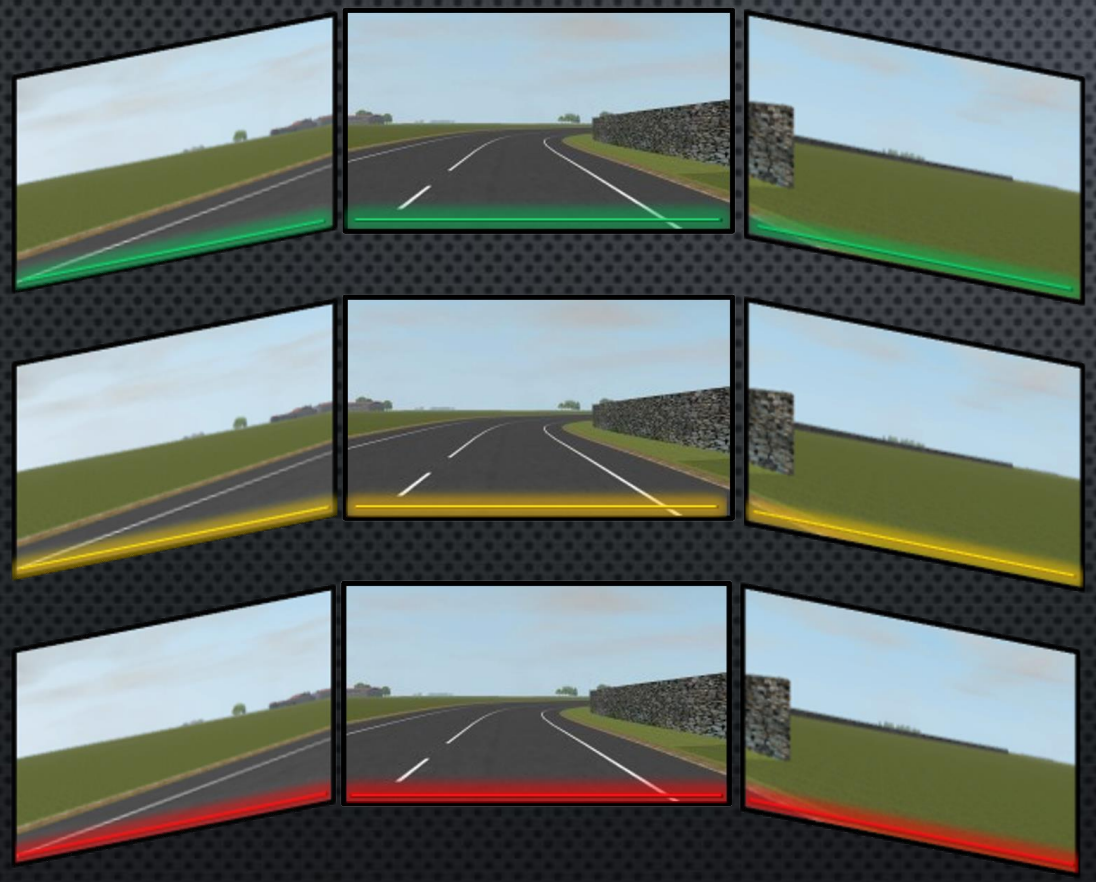
Co-simulation framework



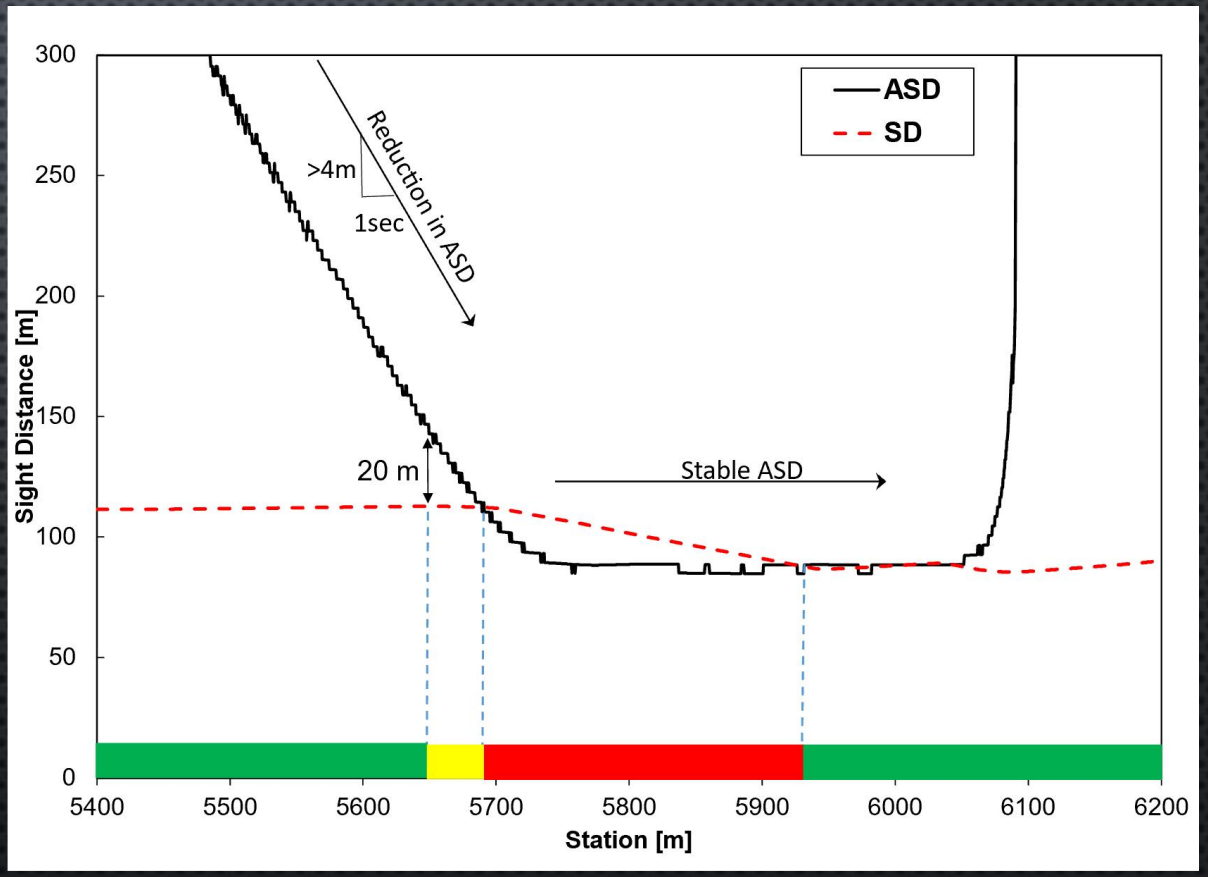
Road points detection in the SCANeR Studio™ Simulated Environment

V-ISA Variant – Information

Enables drivers to maintain a safe speed via visual information.



Driver interaction with feedback modality

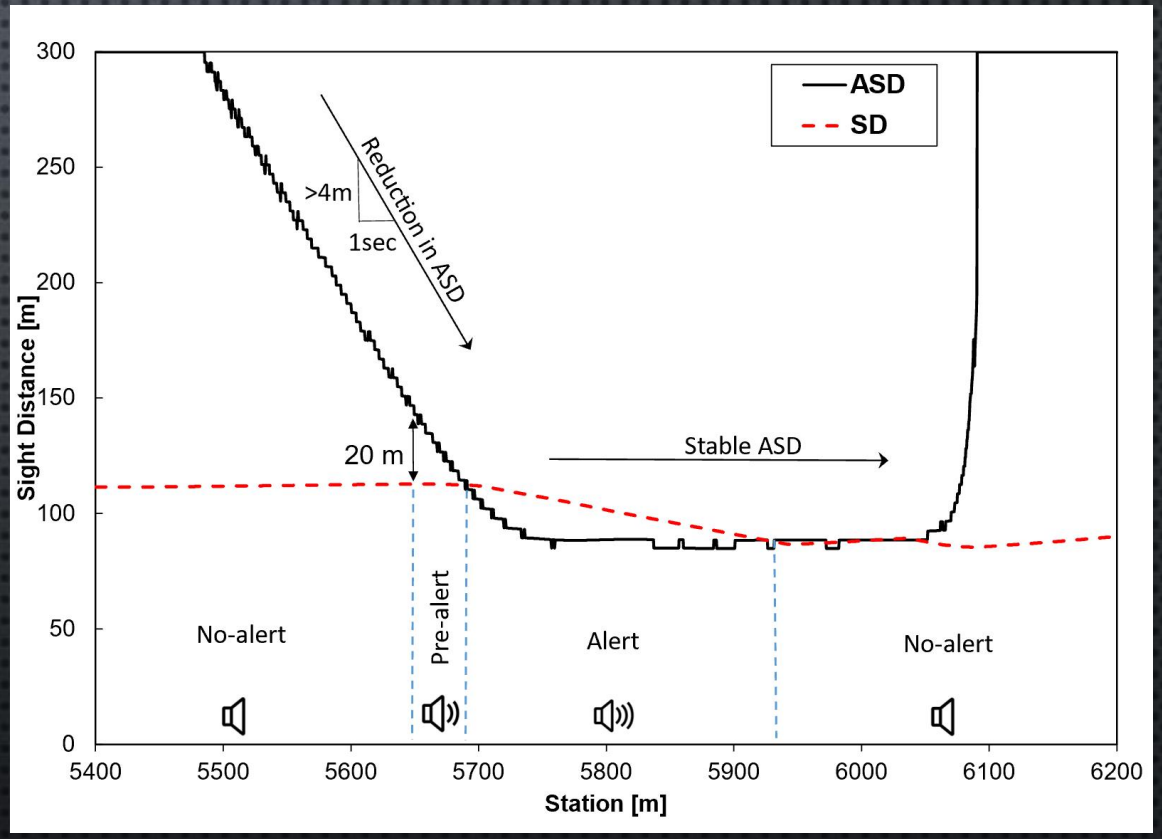


Real-time data processing in V-ISA Simulink model

V-ISA Variant – Warning

Enables drivers to maintain a safe speed via acoustic warning whenever the vehicle exceeds the speed limit.

Driver interaction with feedback modality

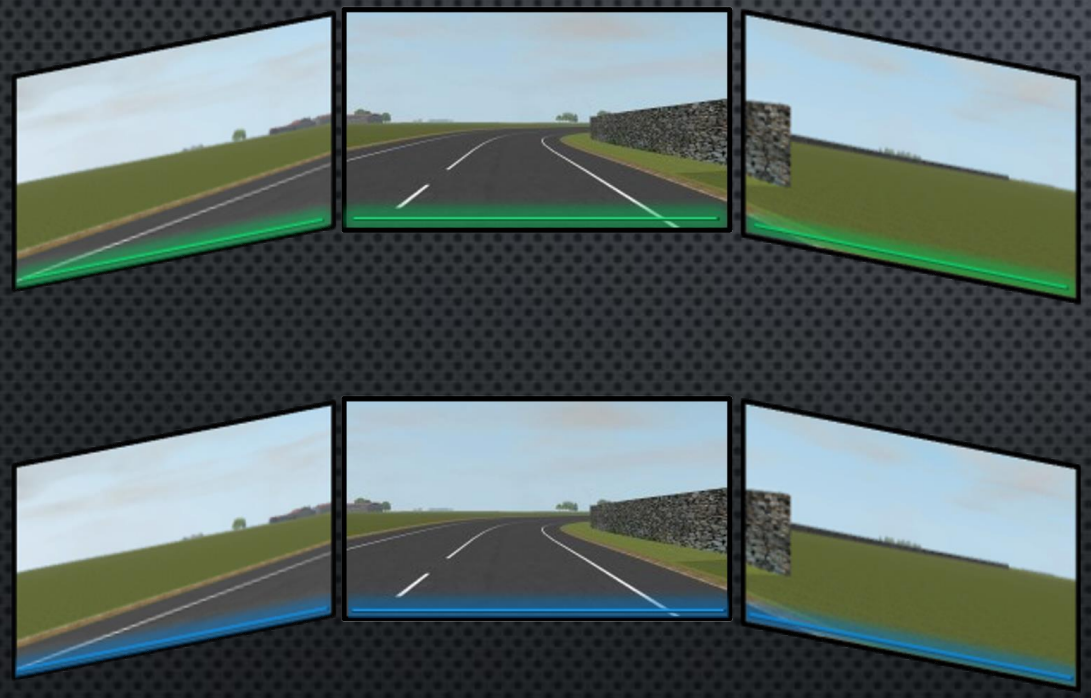


Real-time data processing in V-ISA Simulink model

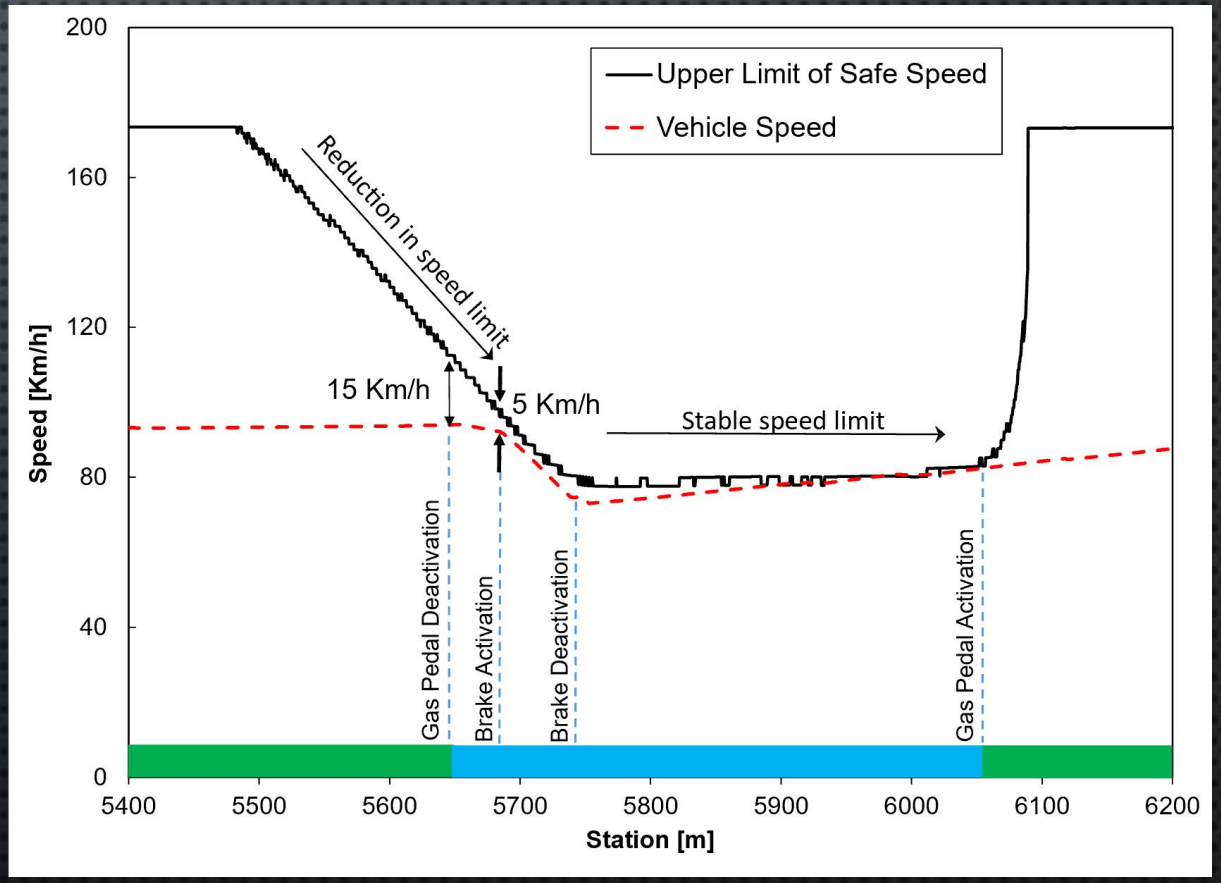
V-ISA Variant – Intervening

Intervene directly and compel the vehicle to adopt the speed (v_L) which guarantee SD = ASD.

$$v_L = -g(f+i)\cdot\left[\tau - \sqrt{\frac{2\cdot ASD}{g(f+i)} + \tau^2}\right]$$



Driver interaction with feedback modality



Real-time data processing in V-ISA Simulink model

Driving Simulator Experiments

Experimental Design

- 12.9 Km two-lane highway road alignment
  - 15 horizontal curves with four different curve radii (120, 225, 300, 430 m)
  - Sight obstruction wall at three different distances: 0, 1.5, 3 m
- 30 Participants (17 males and 13 females)
- Within Subject Experimental Design

Assigned Scenarios	No. of participants	Drives per participant	Total observations
• Baseline condition • V-ISA Information • V-ISA Warning • V-ISA Intervening	30	4	(30 x 4 x 15) 1800

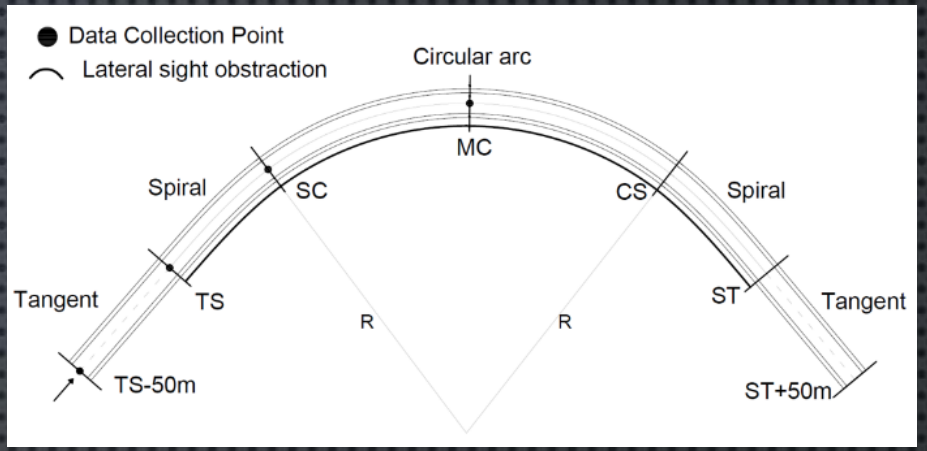
Observed variables

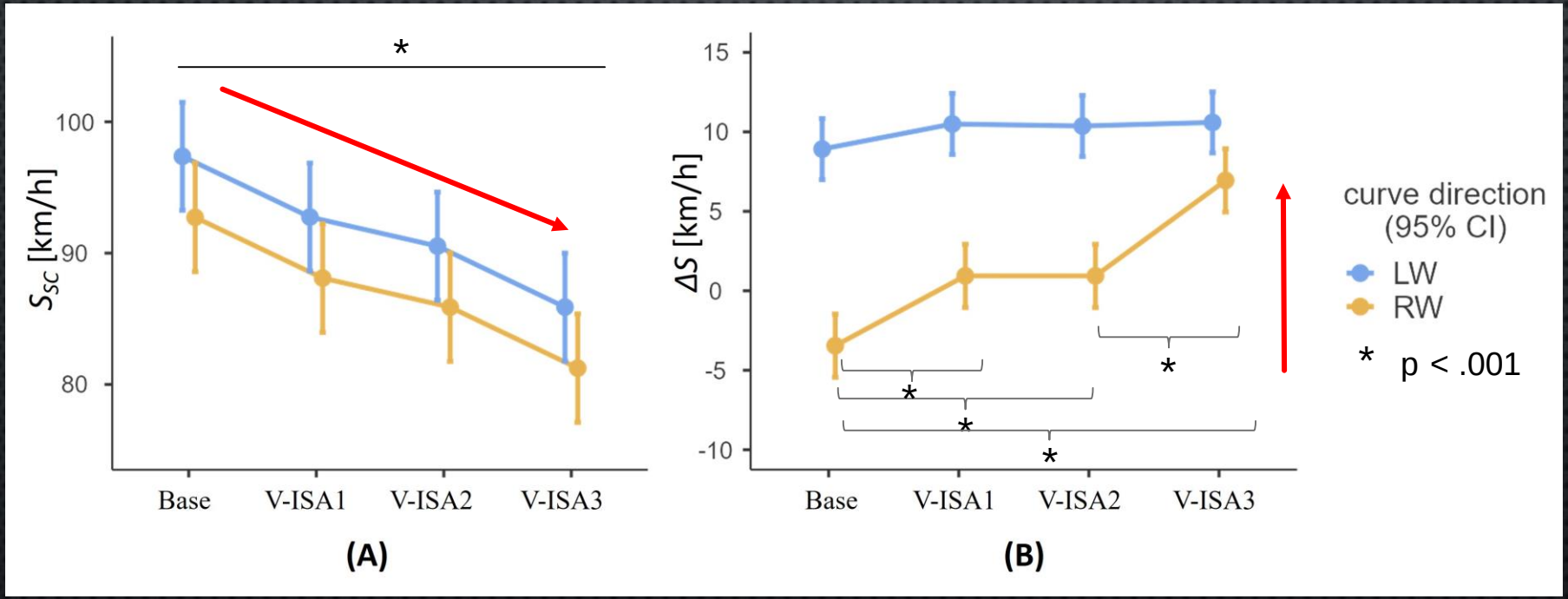
- Longitudinal Behavior (Speed)
- Lateral Behavior (Lane Gap/Lateral position)
- A series of Linear-Mixed Effect Model (LMM) was calibrated.

Results – Longitudinal Behavior

A = Speed at the curve entrance
(Spiral to Curve, SC)

B = Speed variation (+ means reduction)
(entrance and curve center point, ΔS)



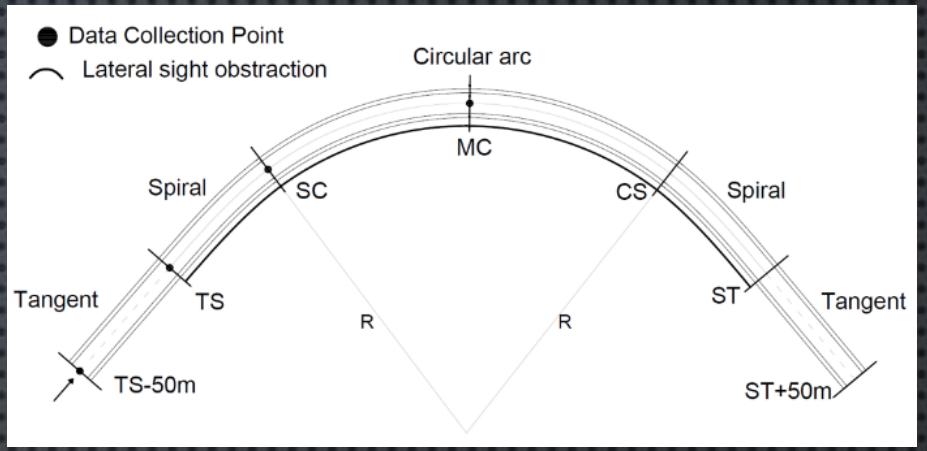


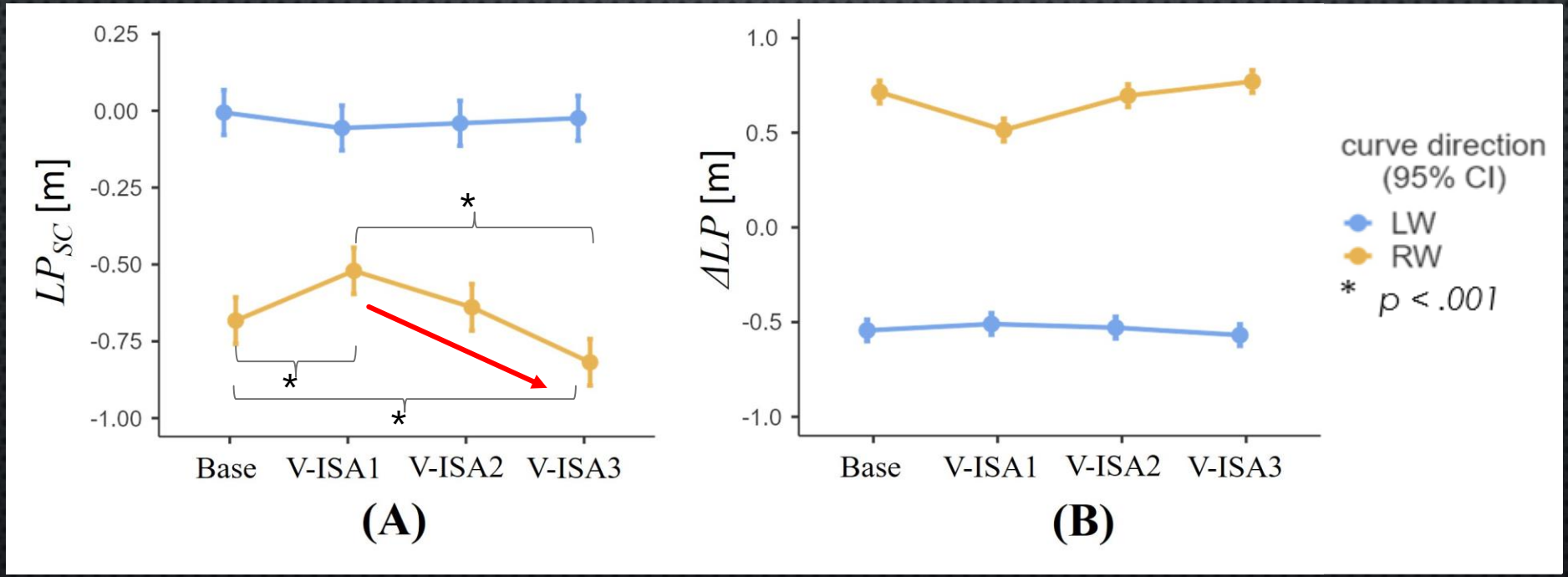
V-ISA1 = Information
V-ISA2 = Warning
V-ISA3 = Intervening

Results – Lateral Behavior

A = Lateral Position
(Spiral to Curve, SC)

B = Variation in Lateral position
(entrance and curve center point, ΔLP)





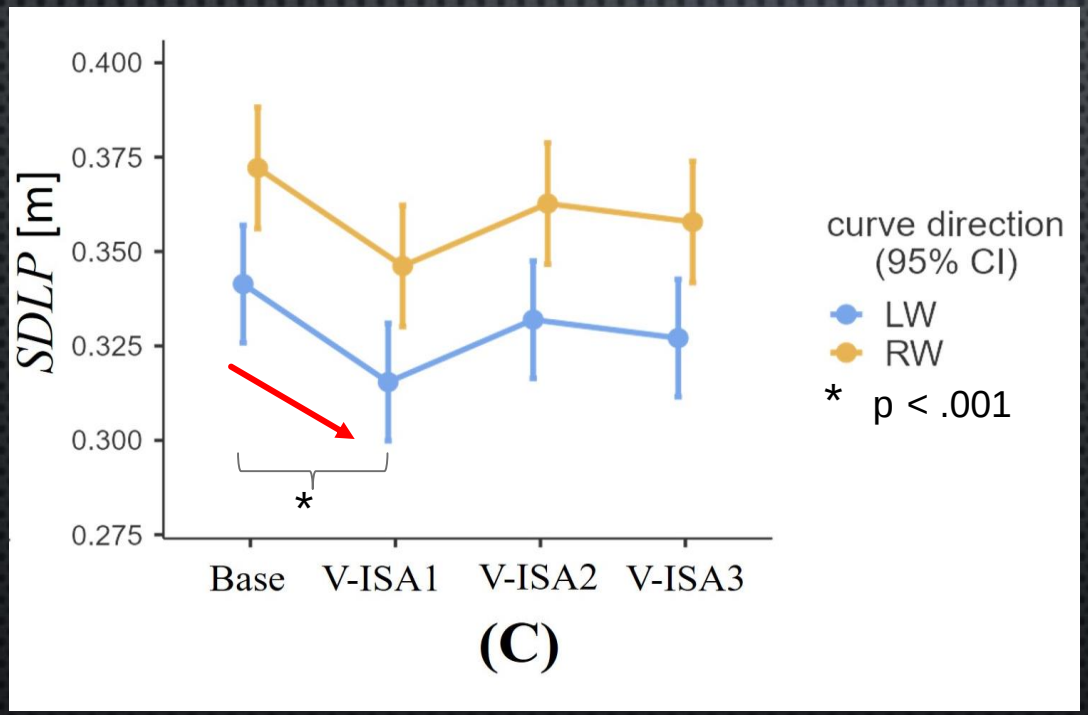
* p < .001

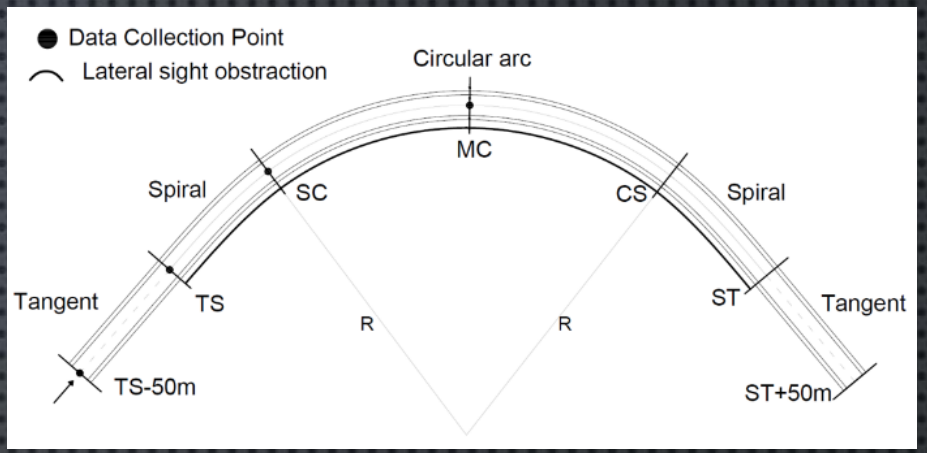
V-ISA1 = Information
V-ISA2 = Warning
V-ISA3 = Intervening

LP (-) = vehicle on the right side of the lane centerline

Results – Lateral Behavior

C = Standard Deviation of Lateral Position (SDLP)





V-ISA1 = Information
V-ISA2 = Warning
V-ISA3 = Intervening

Conclusions

- This study strengthens the idea that drivers should be assisted with a system that ensures real-time safe speed limits where sight distance is limited.
- V-ISA technology helps drivers to adopt a behavior which is consistent with the prevailing sight conditions.
- V-ISA system can enhance the functionality of the Advanced Driver Assistance System (ADAS) for vehicles.

Limitations and Future Research

- The scope of this study was limited to a simple road scenario involving only horizontal curves in free-flow conditions.
- Ongoing research for complex road configuration involving different level of traffic

Thank You
For Your Attention

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