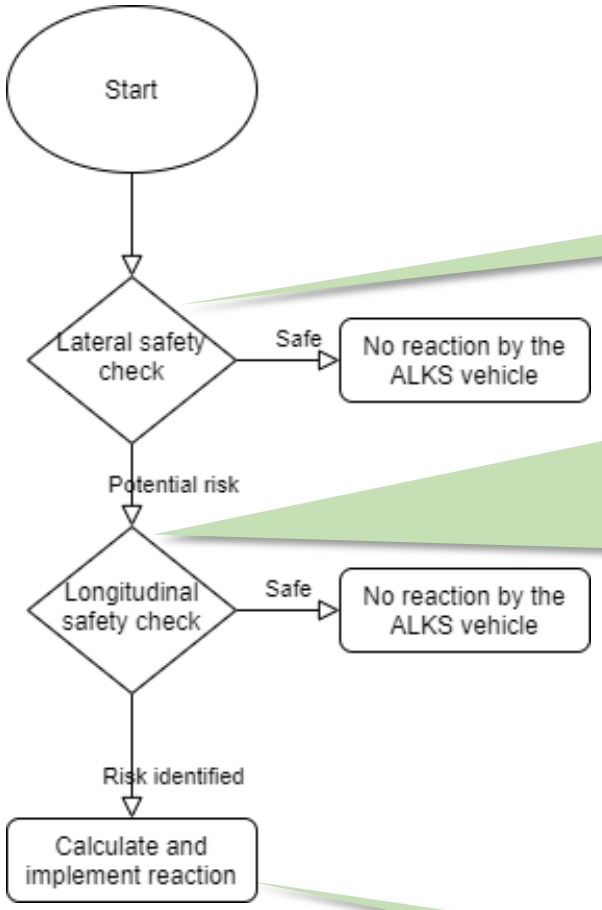
Industry's comments on UNR157-07-06

OICA/CLEPA

July 7, 2021

Computational flow of Fuzzy Safety Model



※Possible main cause of false positive decelerations

1． Lateral Distance safety check

2． Longitudinal Distance safety check

◆Calculation of PFS

(1) Calculation of PFS-d_{safe}

(2) Calculation of PFS-d_{unsafe}

◆Calculatio of CFS

(3) Calculatio of CFS-d_{safe}

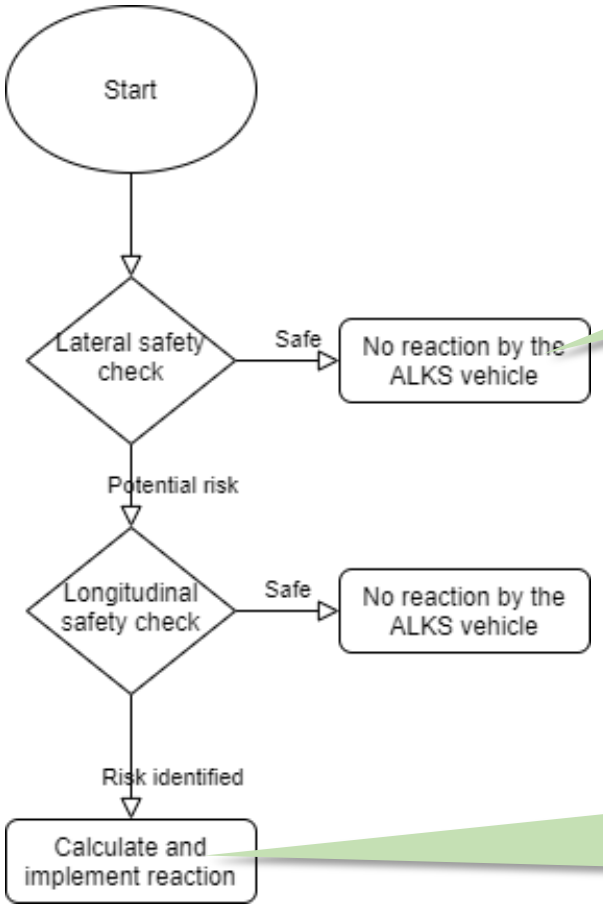
(4) Calculatio of CFS-d_{unsafe}

◆Coefficient Calculation of PFS and CFS

PFS:Proactive Fuzzy SSM
CFS:Critical Fuzzy SSM

3． Reaction Calculation ($b_{reaction}$)

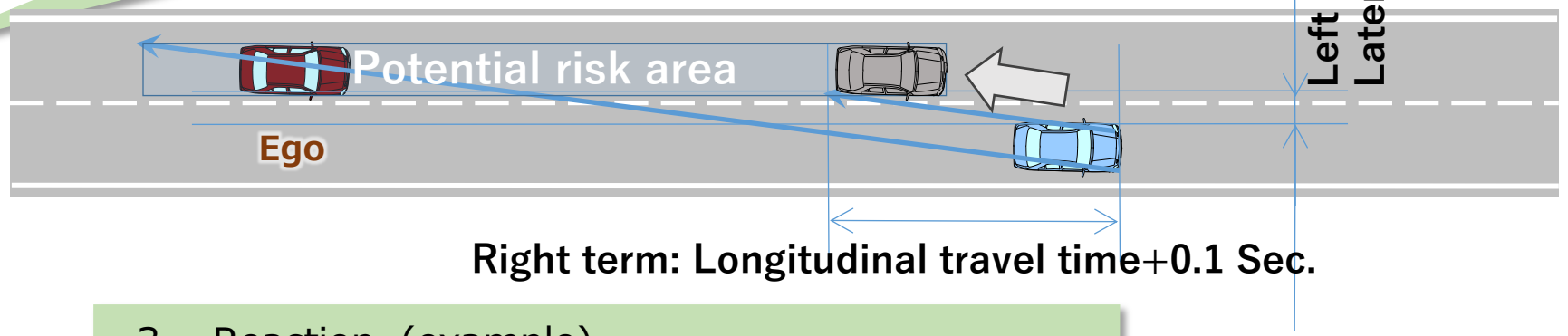
Safety Check Process



1. Lateral safety check

$$\frac{dis\ lat}{u_{cut-in,lat}} < \frac{dist_{lon}+length_{ego}+leng\ \ cut-in}{u_{ego,lon}-u_{cut-in,lon}} + 0.1$$

Check the potential risk of collision



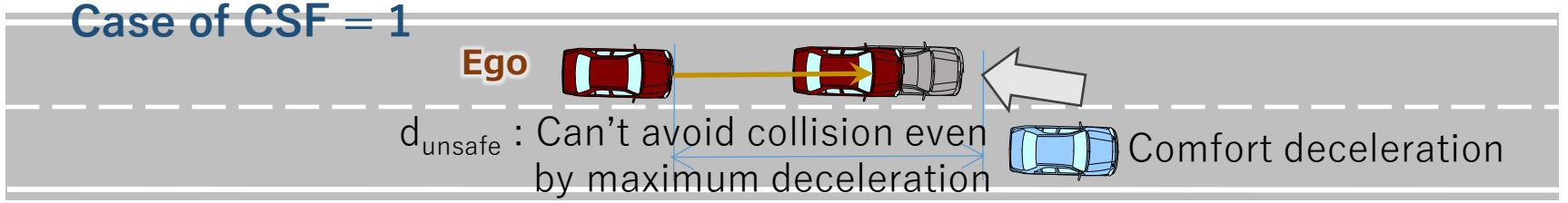
Right term: Longitudinal travel time+0.1 Sec.

3. Reaction (example)

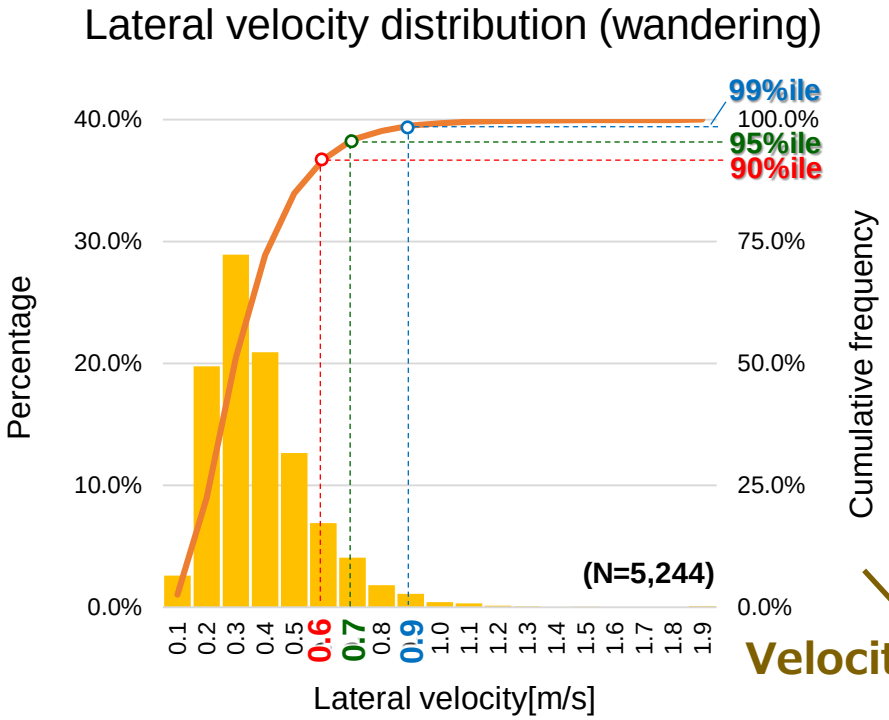
3.2.3. If a risk is identified the ALKS vehicle is assumed to plan and implement a reaction by decelerating according to the following equation:

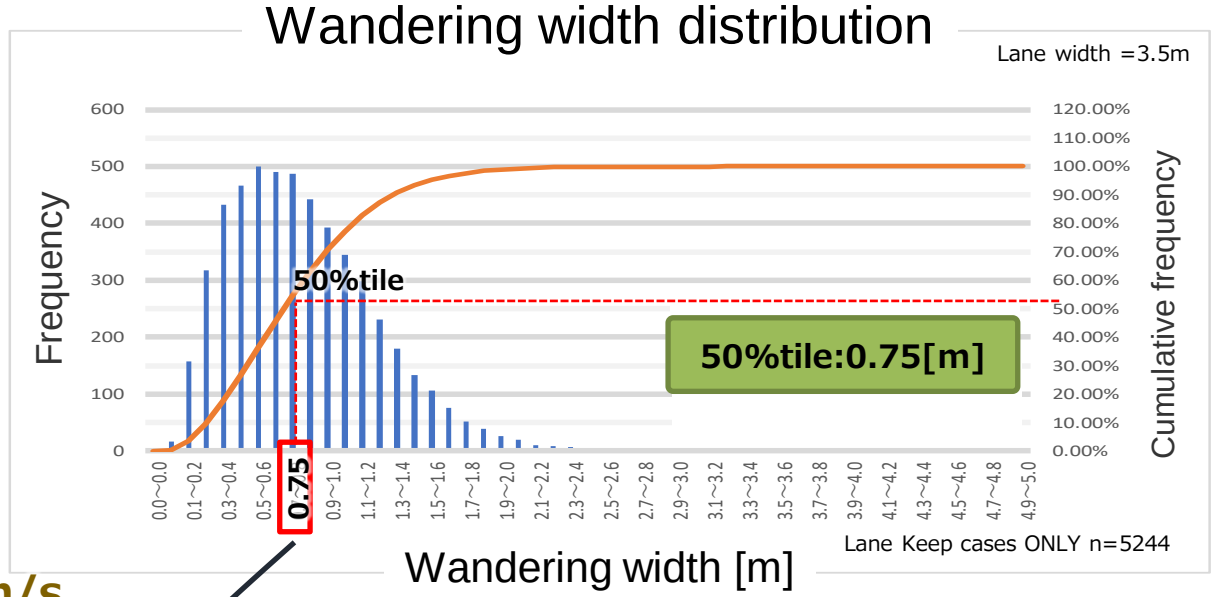
$$b_{reaction} = \begin{cases} CFS \cdot (b_{ego,max} - b_{ego,comf}) + b_{ego,comf} & \text{if } CFS > 0 \\ PFS \cdot b_{ego,comf} & \text{if } CFS = 0 \end{cases}$$

Case of CSF = 1



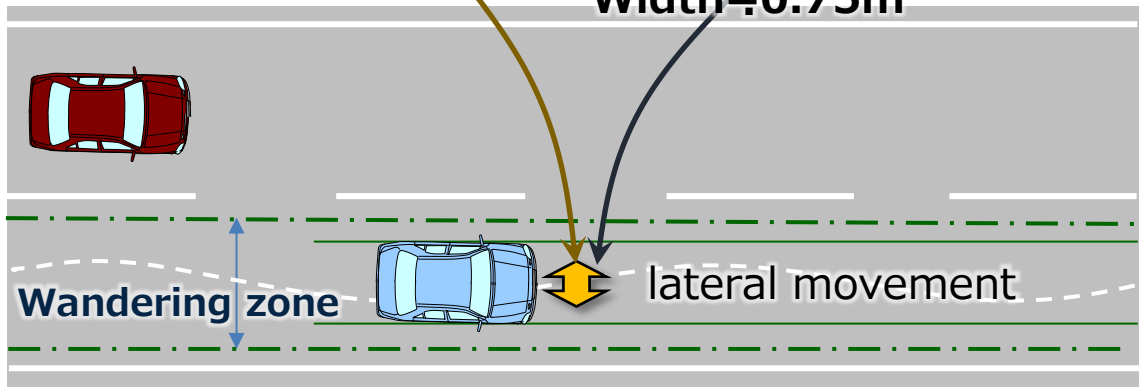
Natural human behavior in Japanese highway





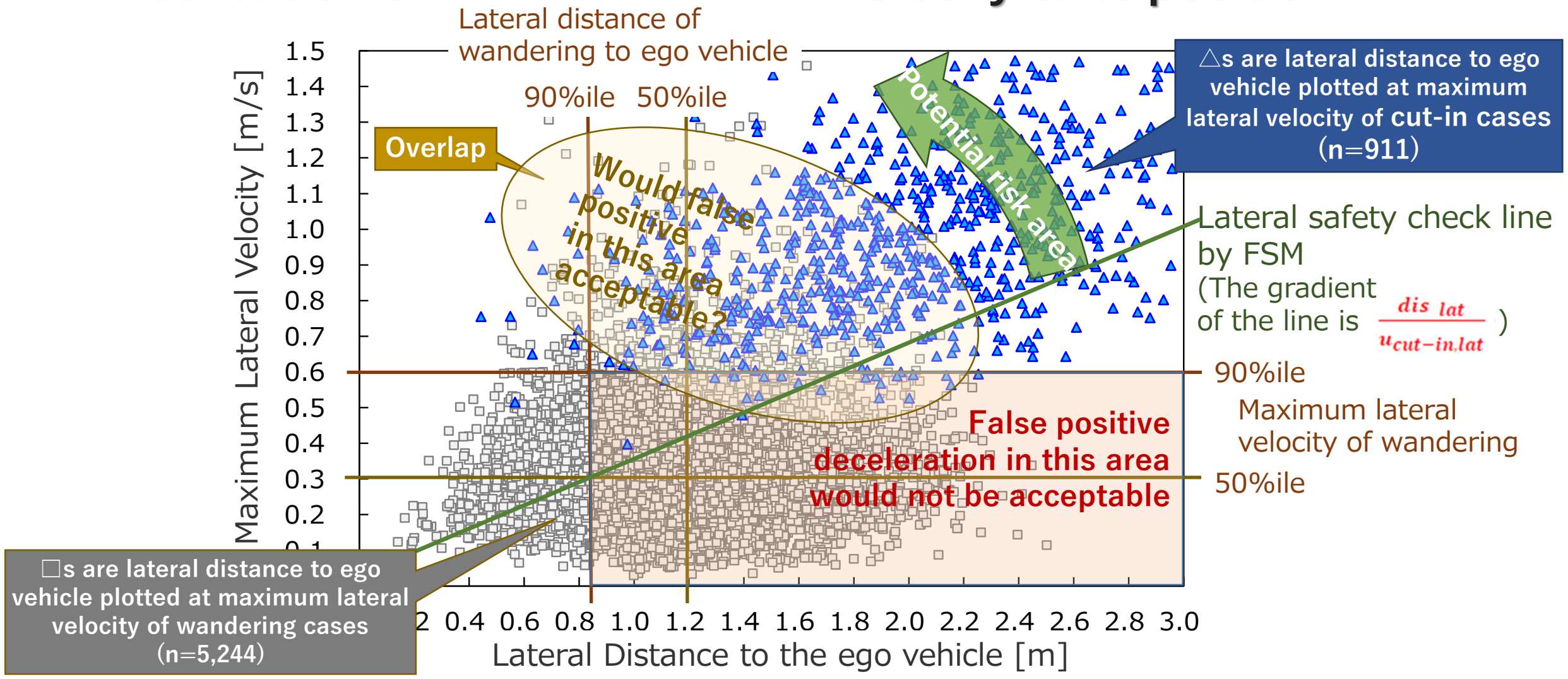
Velocity≒0.3m/s

Width≒0.75m



Natural human drivers are wandering during lane keeping
Median of Lateral velocity ≒ 0.3m/s, Median of Wandering width ≒ 0.75m

Comparison of Wandering vs Cutting-in of human driver
Distribution of maximum lateral velocity & its position



FSM's lateral safety check would induce unnecessary braking in the natural wandering cases in real traffic.

JRC has validated FSM with real traffic data

From UNR157-07-06

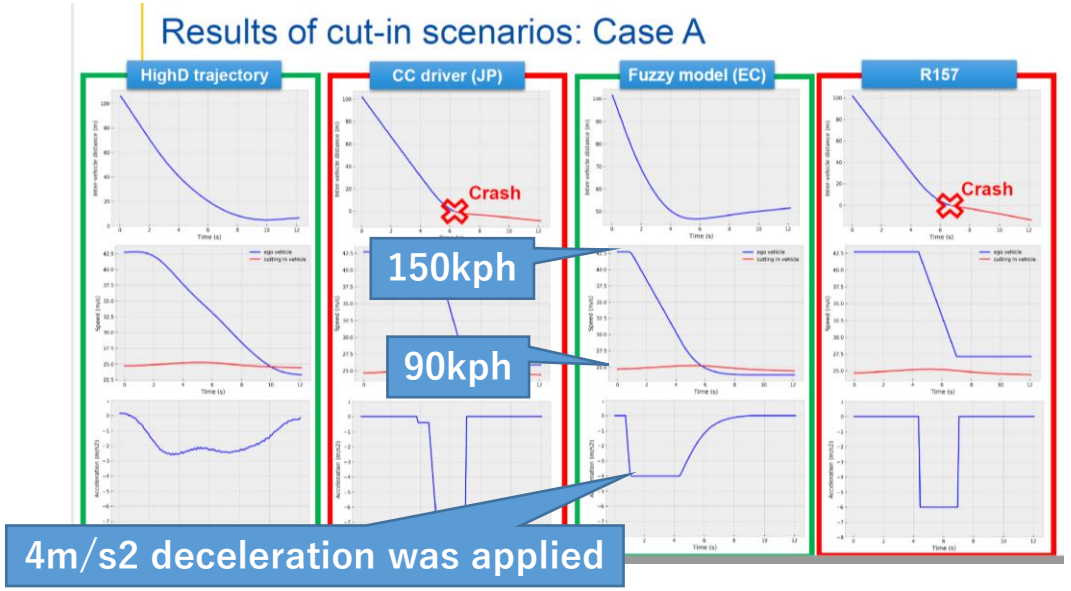
Initial validation activities

- In the spirit of the proposal, the first validation activity focused on the capability of the model to **correctly classify preventable scenarios**

- **110,500** vehicle trajectories
- **3,000** cut-in scenarios
- **50** cut-ins with minimum **TTC < 5”**
- **No accidents (all preventable scenarios)**
- **In all cases the Fuzzy Safety Model was able to classify the cut-in as preventable**

Results of cut-in scenarios

- **All cases have been correctly classified as preventable using the FSM**
- Overall FSM has shown a behavior that is more similar to a human driver, being able to decelerate earlier and softer to avoid an accident
- For both the **CC human driver model and the Reg157 model, there have been cases that would be considered to be un-preventable**



Validation results performed by JRC

From UNR157-07-06

False positives assessment

- Concerns were raised about the possibility that the model would require **too many false positive decelerations in order to achieve a lower number of unpreventable scenarios** compared to the existing performance models
- The highD was used to test false positive cases as well
  - We extracted all trajectories where two vehicles are proceeding in two different lanes without changing lane -> **158,394 observations**

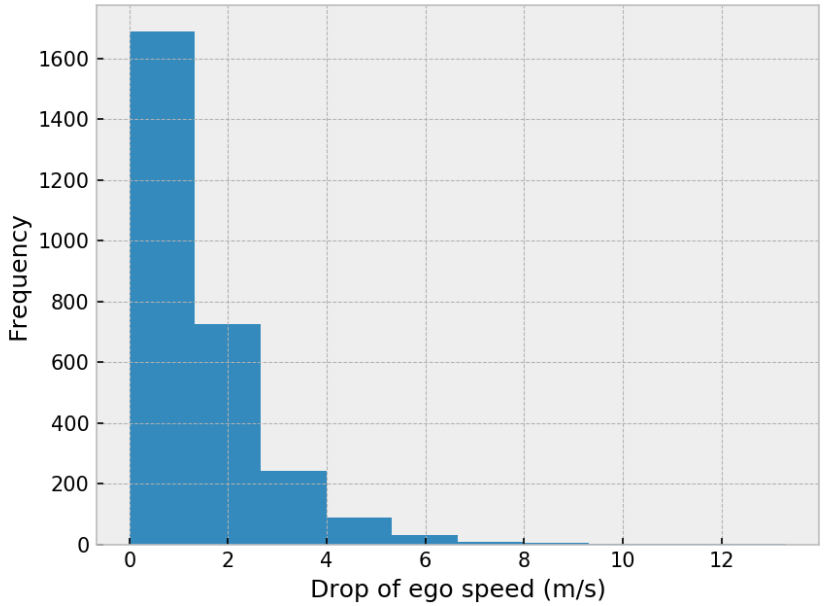
False positives assessment

- Results
  - Due to the lateral movements of the vehicle in the adjacent lane the FSM required a mild deceleration of the ego vehicle in 2,802 cases (1.51%)
  - Only in about 300 cases (0.18%) the drop in velocity was bigger than 2 m/s
  - In less than 50 (0.03%) cases it was bigger than 5 m/s
- These types of speed drops can be explained by a driver **removing the foot from the acceleration pedal** which is compatible with the strategy of a competent and careful human driver
- **Conclusion: false positives do not seem to represent a major issue for the model**

Industry's interpretation of the results

These false positives are not acceptable because;

- ✓ **Pretty big number of unnecessary decelerations were observed**
- ✓ **They could cause safety critical situations in natural flow of traffic**



How does Industry interpret the assessment

Compare to **3,000 cutting-ins actually occurred;**

- Due to the lateral movements of the vehicle in the adjacent lane the FSM required a mild deceleration of the ego vehicle in **2,802 cases** (**1.51%**)

  ⇒ **FSM triggered unnecessary deceleration almost as many as actual cutting-ins**
- Only in about **300 cases** (**0.18%**) the drop in velocity was bigger than 2 m/s

  ⇒ **FSM triggered significant unnecessary deceleration almost 10% of actual cutting-ins and its deceleration level was not declared in UNR157-07-06**
- In less than **50 cases** (**0.03%**) it was bigger than 5 m/s

  ⇒ **FSM triggered unnecessary harsh deceleration almost 2% of actual cutting-ins and the deceleration level must have been at least 4m/s²**

Conclusion: False positives caused by FSM are significant safety issues and not acceptable for customers as well ⇒ Need further investigation