

Concept of Scenario Validation method for Lane Change

July 8–9, 2021

MLIT, Japan

Back ground

- Japan has explained in this SIG that we should consider Emergency lane change(ELC) as a top priority, when SIG considers ALKS extension. And Japan suggests that Regular lane change (RLC) should be considered with sufficient time taking account the progress of FRAV and VMAD discussion in order to avoid divergence between them.
- At the same time, Japan understood some SIG members are willing to consider RLC in parallel with ELC. We think “scenario validation” is necessary to access safety aspect of ADS function, so we propose to introduce scenario validation method into UNR157 extension, mainly for the sake of RLC, like original UNR157(Annex4) and on the base of VMAD NATM concept .
- Due to the lack of time, Japan has not yet presented detail pass/fail criterion. Japan is trying to gather technical data and to propose in coming session.
- Today, we explain our concept. Taking into account your feedback, we will continue to work.

Proposal for Functional Scenarios

- We propose at least 24 functional Scenarios for LK & LC.
- These scenarios are in line with NATM MD, so if you want to know the detail of this concept, please check NATM-MD.





Surrounding Traffic Participants' Position and Behavior

Road geometry and Ego-vehicle behavior		Road geometry	Ego-vehicle behavior	Cut in	Cut out	Acceleration	Deceleration (Stop)
		Road Geometry and Ego-vehicle behavior	Main roadway	Lane keep	No.1	No.2	No.3
Lane change	No.5			No.6	No.7	No.8	
Marge	Lane keep		No.9	No.10	No.11	No.12	
	Lane change		No.13	No.14	No.15	No.16	
Branch	Lane keep		No.17	No.18	No.19	No.20	
	Lane change		No.21	No.22	No.23	No.24	

- For validation, we need to convert from functional scenario to logical scenario. Converting to logical scenario means to add parameters into functional scenario.
- We suggest logical scenarios by using parameters such as "number of lanes", "kind of lane of ego-vehicle" and "relative position between ego and other vehicle".

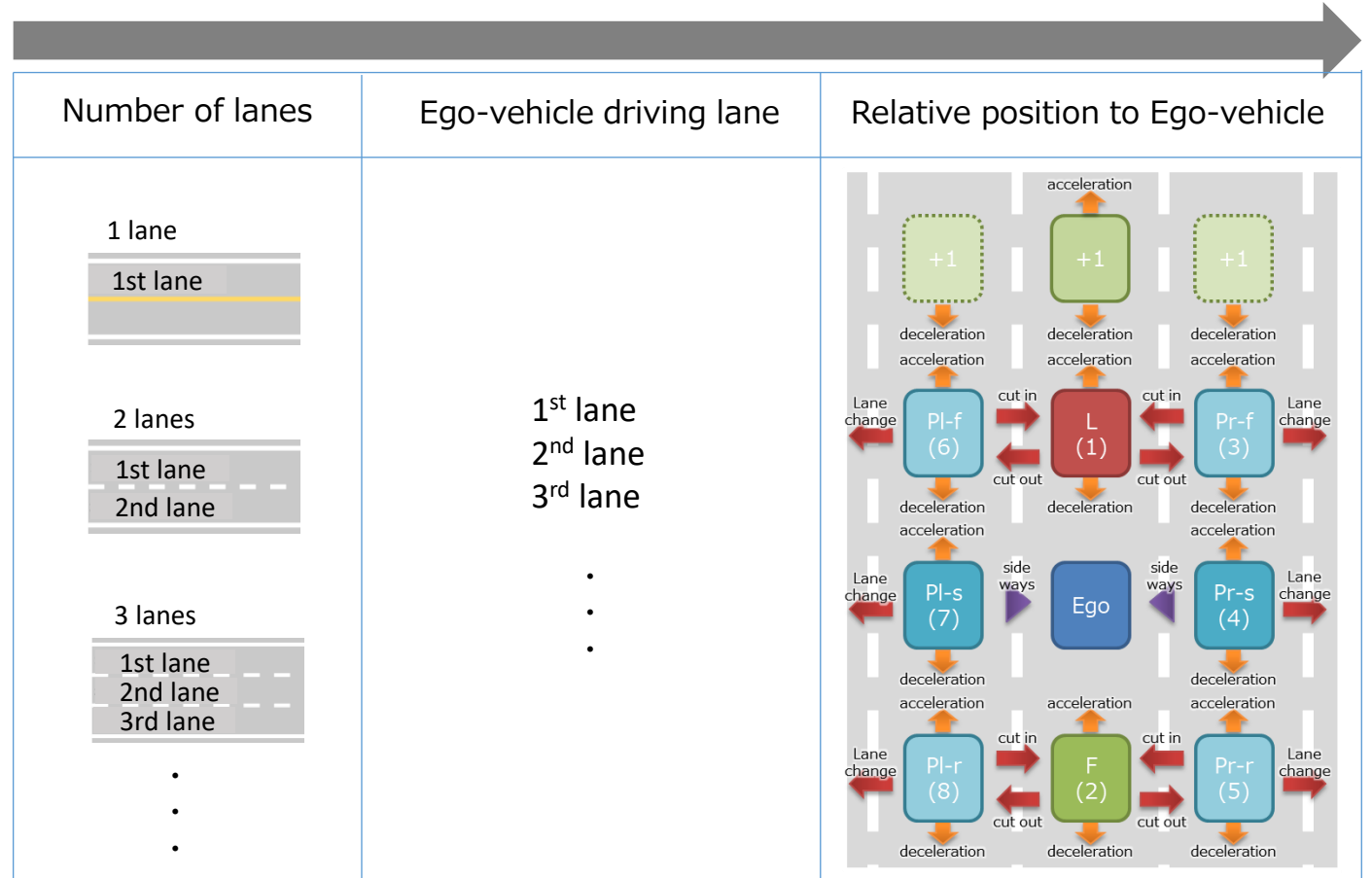


Functional Scenario

Road geometry	Ego-vehicle behavior	Surrounding Traffic Participants' behavior
3types  2types  4types Main roadway Merge Branch	LK (LaneKeep) LC (LaneChange)	CutIn* CutOut* Acceleration Deceleration
total : $3 \times 2 \times 4 = 24$scenarios		

※The LC scenario is the relative movement of the own vehicle and other vehicles. Therefore, organize in the relative direction of LC (LC in the same direction, LC in the opposite direction)

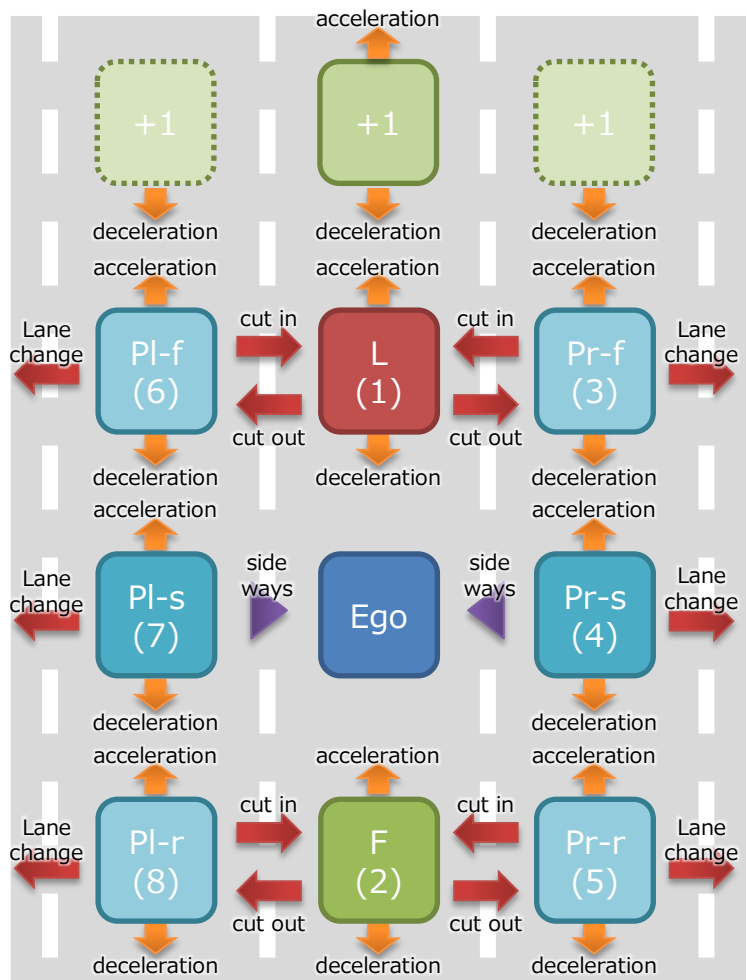
Logical Scenario



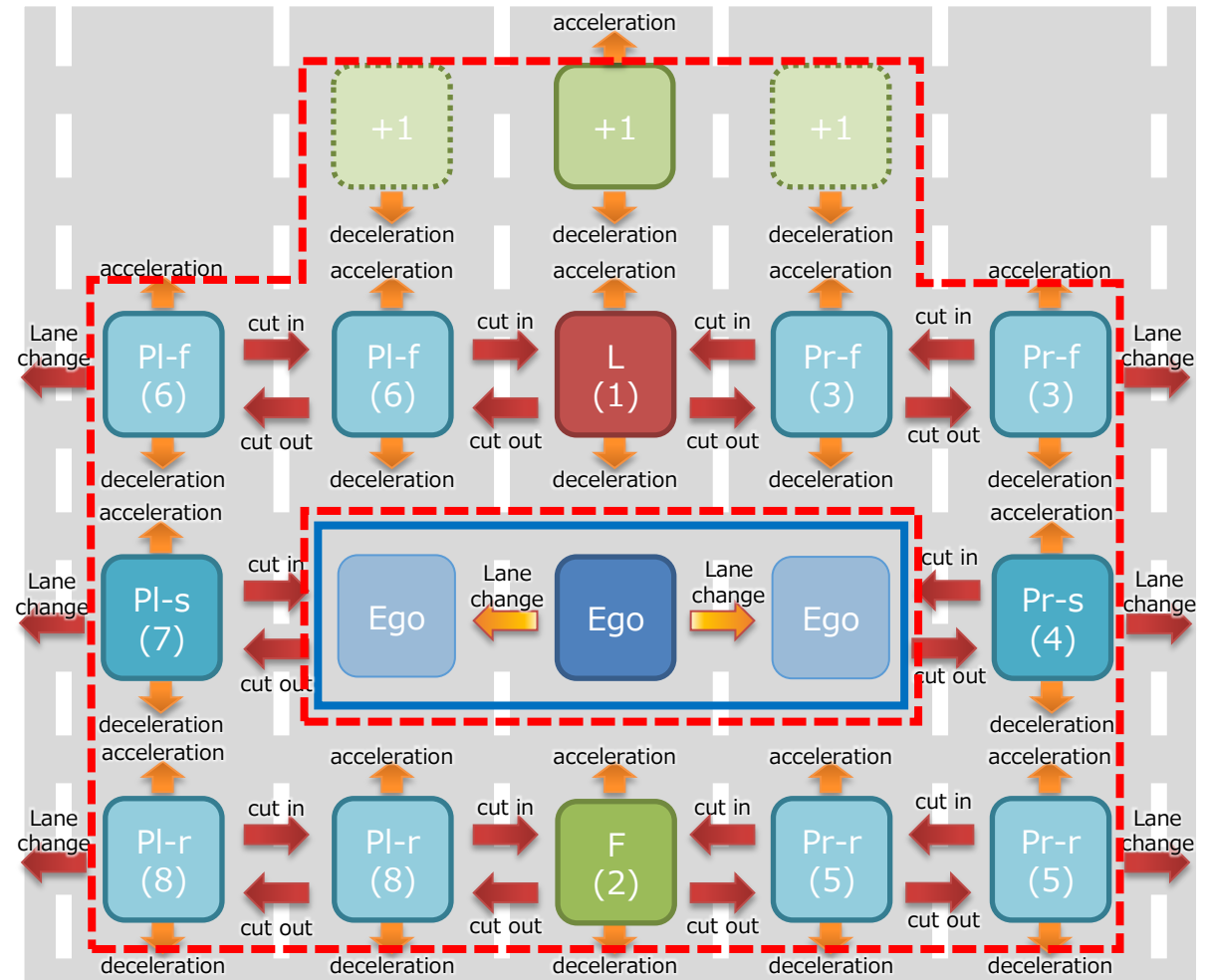
Regarding “relative position between ego and other vehicle”

- When we think about relative position between ego- vehicle and other vehicle, we should think about possibility of surrounding ego-vehicle and 2 ahead leading vehicles in case of lane keep.(see left figure)
- In addition, in case of ego-vehicle’s lane change, we need to consider more possibility of relative position of other vehicle(see right figure).

In case of ego-vehicle’s lane keep

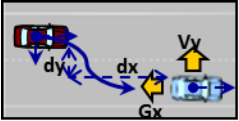
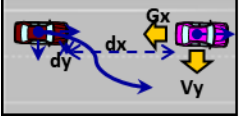
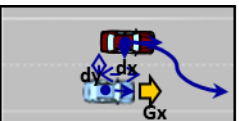
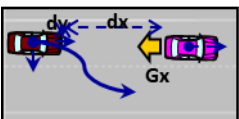


In case of ego-vehicle’s lane change



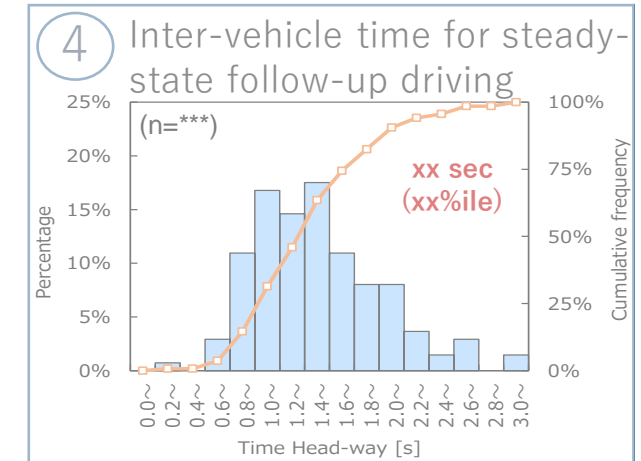
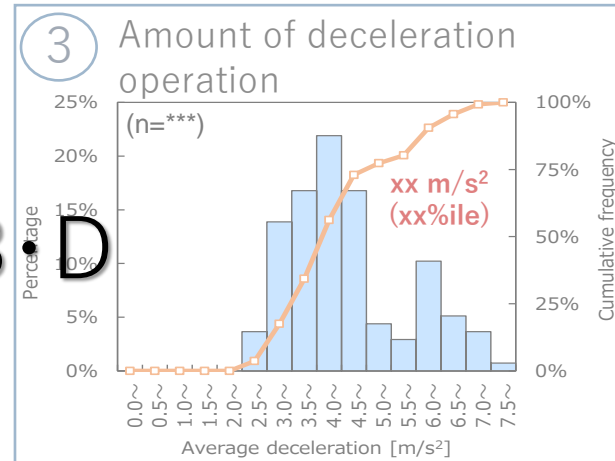
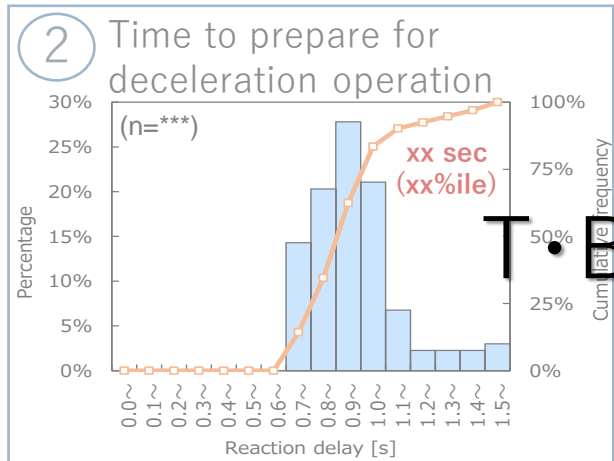
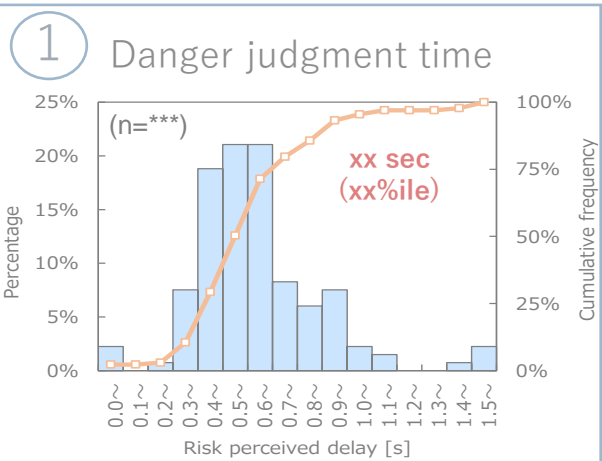
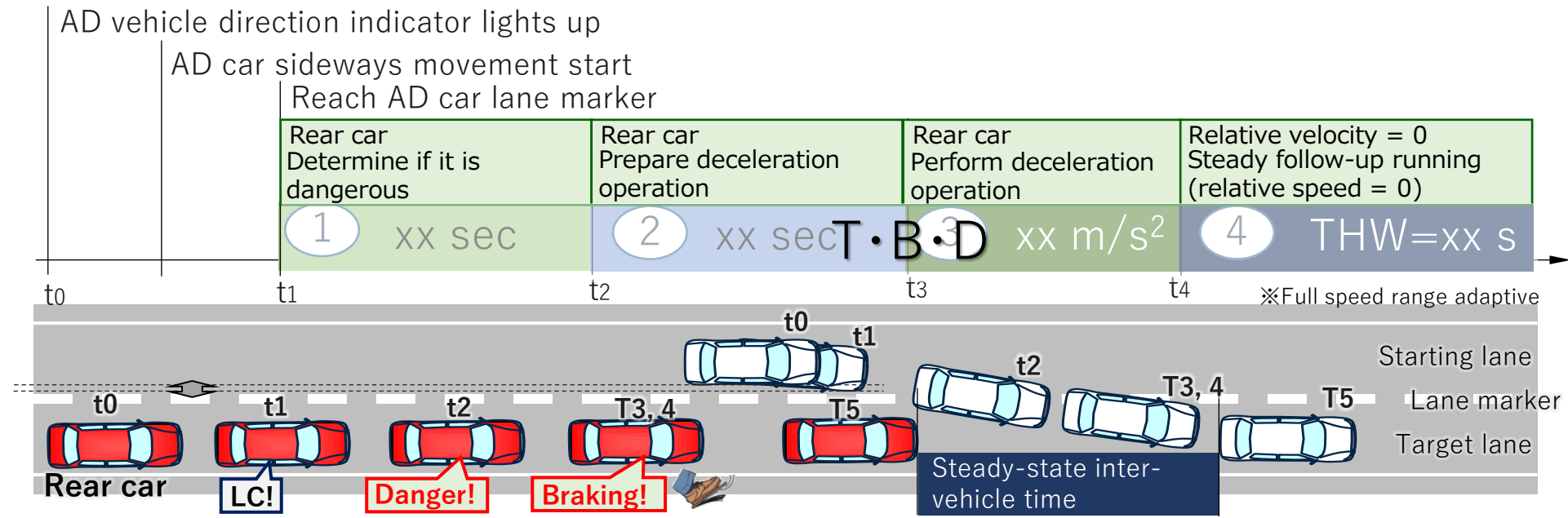
List of logical scenario to be accessed(main road case)

- We can select some logical scenarios to be accessed for the case of main road.
- In addition to main road case, other cases such as merged road and branched road case should be considered

	Main road 2 lanes			Main road 3 lanes		
	Forward	Parallel running	Rear	Forward	Parallel running	Rear
No.5 LC in the opposite direction 						
No.6 LC in the same direction 						
No.7 Acceleration 						
No.8 Deceleration 						

Parameters for scenario validation

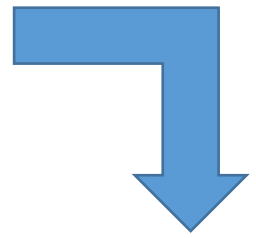
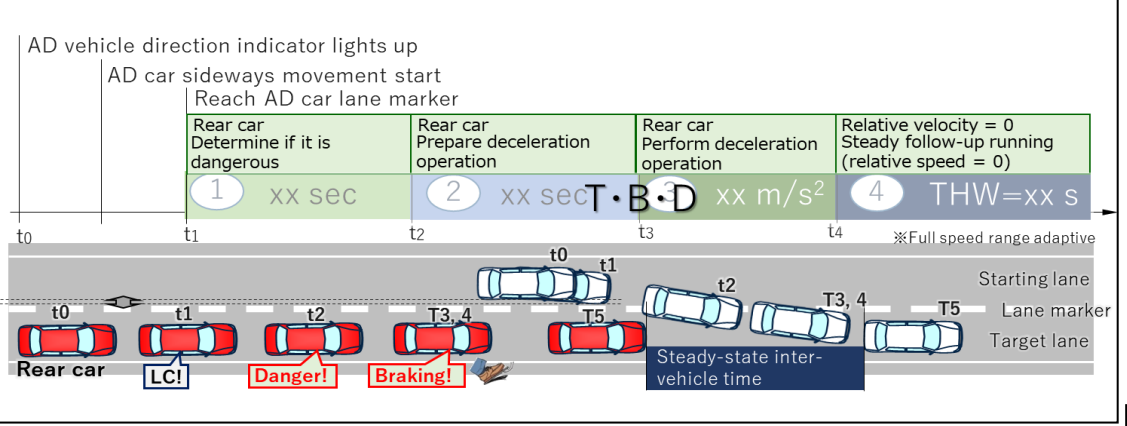
- We need to set some parameters for validation. We are now gathering technical data.
- We should define these parameters, taking into consideration the range of reasonably foreseeable actions and abilities of the driver of the other vehicle and more.



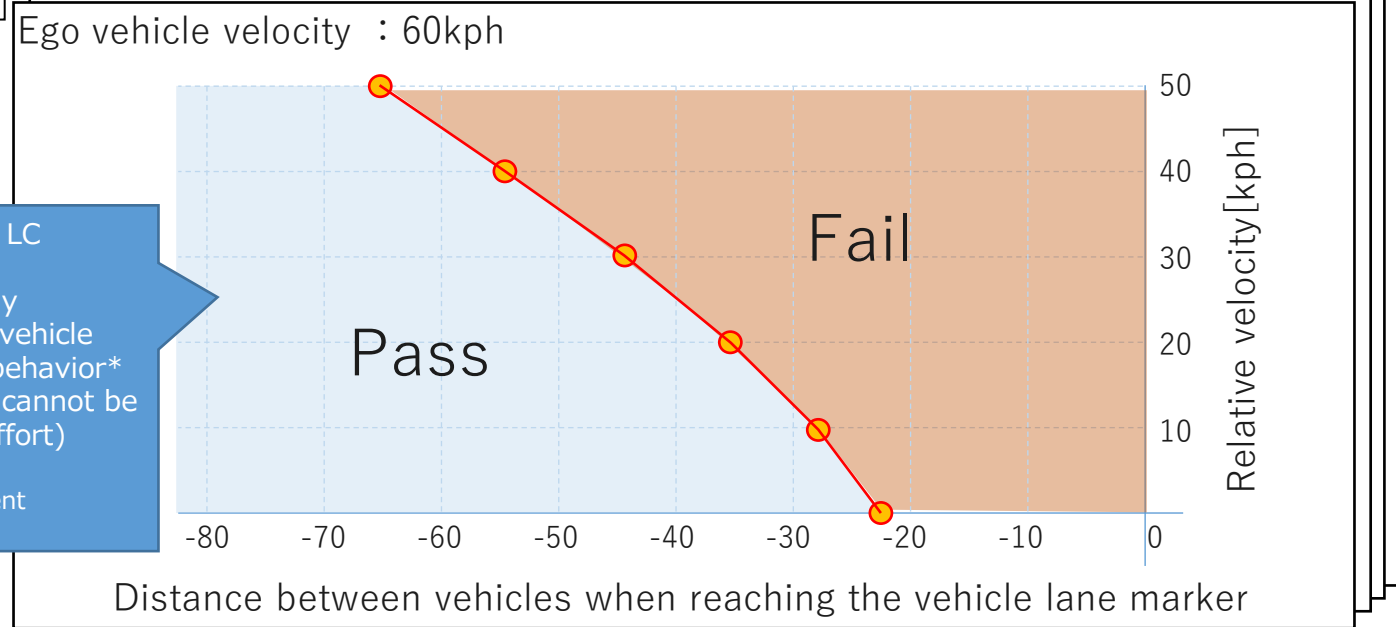
pass/fail criterion

- By using scenarios and parameters, we try to establish preventable/unpreventable area, in other words, pass/fail criterion for regulation.
- Pass/ fail criterion between ELC and RLC should be different. Especially for RLC criterion, we need sufficient analysis and discussion.

Subsequent vehicle driver parameters in a reasonably foreseeable range



Criteria (image)



In this area, AD cars can be LC
 Safe to the extent reasonably foreseeable of the following vehicle
 ⇒ It is unavoidable for the behavior* of the following vehicle that cannot be reasonably foreseen.(Best effort)
 *Malicious acceleration, insufficient deceleration, delayed response

Distance between vehicles when reaching the vehicle lane marker

Thank you for your attention.

We welcome your question and feedback.